APPENDIX J: AGENCY COORDINATION

Contents:

MSP Request from CPRA

From:	Brad Miller <Brad.Miller@LA.GOV>
Sent:	Monday, June 21, 2021 9:37 AM
To:	Sims, C N (Nick) CIV USARMY CEMVN (USA); Brannon, Charles J CTR (US); Carol Parsons Richards
Subject:	[Non-DoD Source] FW: Draft BBA Mitigation EA #576

The comment was sent by me via e-mail on January 31, 2020. Bren then forwarded it to Mark and Troy.

Brad Miller
Coastal Protection and Restoration Authority
Project Manager | Project Management Division
The Water Campus | 150 Terrace Avenue | Baton Rouge, LA 70802
o: 225.342.4122
www.coastal.la.gov

From: Bren Haase
Sent: Friday, January 31, 2020 12:12 PM
To: Gregory Grandy <Gregory.Grandy@la.gov>; Brad Miller <Brad.Miller@LA.GOV>
Subject: Fwd: Draft BBA Mitigation EA #576

Begin forwarded message:

> **From:** Bren Haase <Bren.Haase@LA.GOV>
> **Date:** January 31, 2020 at 12:04:53 PM CST
> **To:** Mark Wingate <mark.r.wingate@usace.army.mil>, Troy Constance <Troy.G.Constance@usace.army.mil>
> **Cc:** "Stephen.F.Murphy@usace.army.mil" <Stephen.F.Murphy@usace.army.mil>, Chip Kline <Chip.Kline@LA.GOV>
> **Subject: Fwd: Draft BBA Mitigation EA #576**
>
> Mark and Troy, please see initial comment on the Draft BBA mitigation EA.
>
> Bren
>
> Begin forwarded message:
>
>> **From:** Brad Miller <Brad.Miller@LA.GOV>
>> **Date:** January 31, 2020 at 11:55:07 AM CST

To: "Erwin, Patrick J CIV USARMY CEMVN (USA)" <Patrick.J.Erwin@usace.army.mil>
Cc: "Holley, Soheila N CIV USARMY CEMVN (US)" <Soheila.N.Holley@usace.army.mil>, Gregory Grandy <Gregory.Grandy@la.gov>, Bren Haase <Bren.Haase@LA.GOV>, Maury Chatellier <Maury.Chatellier@la.gov>
Subject: RE: Draft BBA Mitigation EA #576

Patrick,

CPRA is in receipt of EA #576. The River Reintroduction Into Maurepas Swamp (PO-0029) project is not included. CPRA would like to formally request that the River Reintroduction into Maurepas Swamp (P0-0029) Project be considered for implementation for all of the required swamp habitat to mitigate for unavoidable impacts to significant resources associated with the construction of the West Shore Lake Pontchartrain (WSLP), Comite River Diversion (Comite), and East Baton Rouge Flood Risk Management (EBR) projects; also known collectively as the Bipartisan Budget Act of 2018 (BBA 18) Construction Projects.

We are continuing to review EA #576 and will submit more detailed and formal correspondence.

If you have any questions please contact me at your earliest convenience.

Thank you,

Brad

Brad Miller
Coastal Protection and Restoration Authority
Project Manager | Project Management Division
The Water Campus | 150 Terrace Avenue | Baton Rouge, LA 70802
o: 225.342.4122
www.coastal.la.gov

-----Original Message-----
From: Erwin, Patrick J CIV USARMY CEMVN (USA) <Patrick.J.Erwin@usace.army.mil>
Sent: Friday, January 31, 2020 8:05 AM
To: Brad Miller <Brad.Miller@LA.GOV>
Cc: Holley, Soheila N CIV USARMY CEMVN (US) <Soheila.N.Holley@usace.army.mil>
Subject: Draft BBA Mitigation EA #576

EXTERNAL EMAIL: Please do not click on links or attachments unless you know the content is safe.

Good morning Brad,

On behalf of Soheila Holley, please see below for a link to the Draft BBA Mitigation EA #576 for Public Review:

https://urldefense.proofpoint.com/v2/url?u=https-3A__www.mvn.usace.army.mil_Missions_Environmental_NEPA-2DCompliance-2DDocuments_Bipartisan-2DBudget-2DAct-2D2018-2DBBA-2D18_BBA-2D18-2DProjects_BBA-2D18-2DMitigation_&d=DwIFAg&c=xlPCXuHzMdaH2Flc1sgyicYpGQbQbU9KDEmgNF3_wI0&r=96BFdspUacG00QUy39gNcvOzE1Z2nYpBurU6xtr8TX8&m=Dfeev5s9EjsZnFuD4Y5jNIp8h8psnwbNNm747v8jzS4&s=9PWbbaQxsNQ-Lc4zQBYKMBb-vxKVuBrA1nN3CLf86ig&e=

This a 30-day Public Review, and comments are due on March 2, 2020.

Thanks,

Patrick J. Erwin
Project Manager
U.S. Army Corps of Engineers, New Orleans District
Work: (504) 862-1948
Fax: (504) 862-2109

Endangered Species Act

Biological Assessment

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 LEAKE AVENUE
NEW ORLEANS, LOUISIANA 70118

REPLY TO ATTENTION OF

Dec 22, 2021

Regional Planning and Environment
Division South

Project Name: West Shore Lake Pontchartrain Mitigation

Mrs. Brigette Firmin
Field Supervisor
U.S. Dept. of the Interior, Mississippi Basin Region
Fish and Wildlife Service, Louisiana Ecological Services Office
200 Dulles Drive, Lafayette, LA 70506

Dear Mrs. Firmin,

The U.S. Army Corps of Engineers (USACE), New Orleans District (CEMVN) has prepared this Biological Assessment (BA) to evaluate the potential impacts associated with the proposed mitigation alternative, West Shore Lake Pontchartrain Mitigation in St. John the Baptist Parish, Louisiana. This BA provides the information required pursuant to the Endangered Species Act (ESA) and implementing regulation (50 CFR 402.13), to comply with the ESA.

The Maurepas Swamp Alternative 2 (MSA-2) is located in St. John the Baptist Parish and falls within the Maurepas Swamp Wildlife Manage Area (WMA). It is bordered in the North by Lake Maurepas, the east by Hwy 55, the south by the MS River, and the west by Gramercy and the WMA. The MSA-2 would result in approximately 1,210 AAHUs of mitigation for swamp habitat in the WMA.

Based on best scientific and commercial data available, USACE has made the following determinations. The MSA-2 would have no effect on the Gulf sturgeon; may affect but not likely to adversely affect the West Indian Manatee; may affect and would likely adversely affect the pallid sturgeon.

There would be no effect to critical habitat as it does not exist within the action area. CEMVN is submitting this BA as a request to initiate formal consultation pursuant to Section 7 of the ESA of 1973, as amended (16 U.S.C. § 1536), and the consultation procedures at 50 C.F.R. Part 402.

Eric M. Williams
Acting Chief, New Orleans District
Environmental Branch

West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study Mitigation Plan

Biological Assessment

December 2021

The purpose of this Biological Assessment (BA) is to assess the effects of the proposed project and determine whether the project may affect any Federally threatened, endangered, proposed or candidate species. This BA is prepared in accordance with legal requirements set forth under Section 7 of the Endangered Species Act (16 U.S.C. 1536 (c)).

In this document, any data provided by U.S. Fish and Wildlife Service IPaC system, is based on data as of May 18, 2021.

1 Description of The Action

1.1 Project Name

West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study Mitigation Plan.

1.2 Executive Summary

The proposed project, Maurepas Swamp Alternative-2 (MSA-2) involves a freshwater diversion that would reconnect the Mississippi River to the Maurepas Swamp, strategically delivering nutrient-laden river water to restore the health of the dying Cypress-Tupelo swamp. The Project is proposed as a 2,000 cubic foot per second (cfs) freshwater diversion with the intake of the conveyance channel located on the West Bank of the Mississippi River in St. John the Baptist Parish.

<u>Effect determination summary</u>

1.3 Project Description

The primary Project features are located in St. John the Baptist Parish and are comprised of, but not limited to, the following elements:

- an intake channel from the Mississippi River; *(Table 1, Figure 2, Figure 4)*
- an automated gate structure in the Mississippi River Levee (MRL); *(Table 1, Figure 4)*
- a sedimentation basin; *(within the conveyance channel)*
- a 5.5-mile long open conveyance channel; *(Figure 2)*
- box culverts under River Road, Canadian National Railroad (CN), and Airline Highway; *(Figure 2)*
- a bridge over the channel at Kansas City Southern Railroad (KCS); *(Table 1, Figure 2)*
- 8 lateral discharge valves between Airline Highway and I-10 to carry flow from the conveyance channel to areas east and west of the channel;
- check valving on culverts underneath I-10 to reduce or eliminate southward backflow;
- reshaping the geometry of the existing Hope Canal channel under I-10
- embankment cuts in the existing ridge of an old railroad embankment located in St. John the Baptist and Ascension Parishes; *(Table 1, Figure 2)* and
- submerged rock rip-rap weirs in Bayou Secret and Bourgeois Canal located in St. James Parish; *(Table 1, Figure 2)*

See Attachment 1 for details of each element, figures, and tables.

1.3.1 Location

Intake of the conveyance channel would be located on the West Bank of the Mississippi River in St. John the Baptist Parish, immediately west of Garyville, Louisiana, at River Mile 144 AHP. The 300 ft wide construction corridor for the conveyance channel extends from LA 44 (River Road) northwards. It extends northward for 5½ miles, terminating approximately 1,000 ft north of I-10. The outlet for the conveyance channel would be along the existing centerline of Hope Canal. Guide levee elevations from the I-10 bridges to the termination point would gradually transition to existing grade. At that point, 2-D hydrodynamic modeling results suggest the diverted water would generally spread radially outward into the area north of I-10, south of Lake Maurepas.

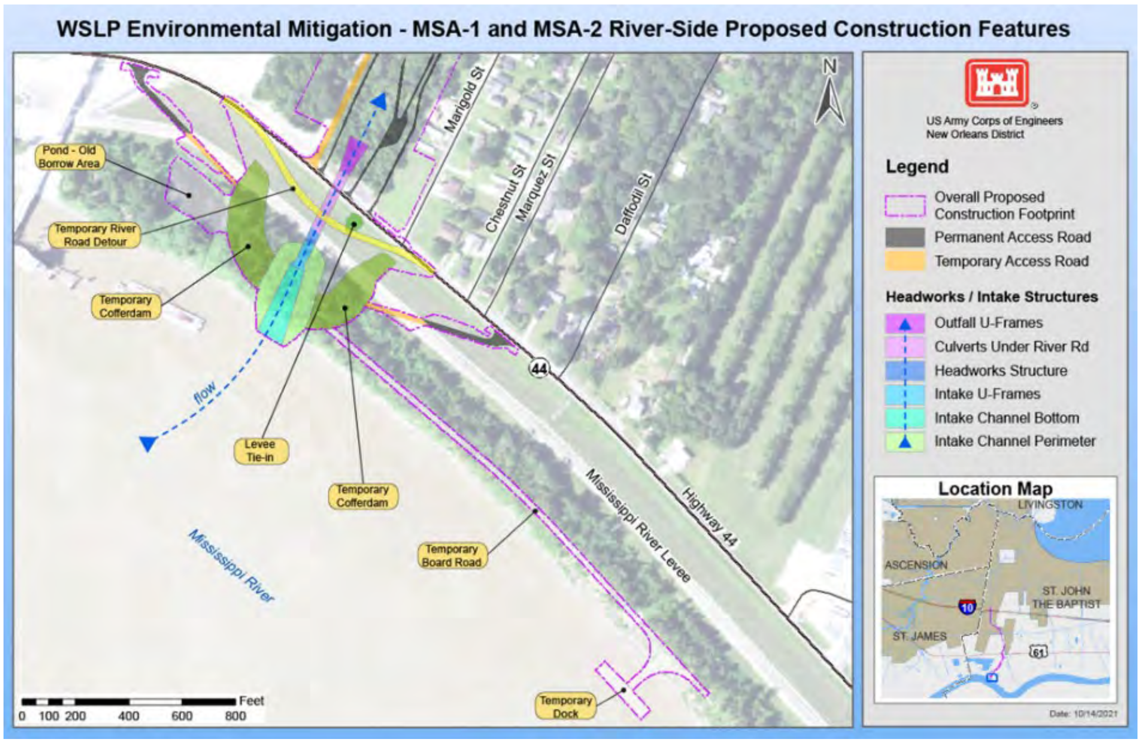

Figure 1 – River-side proposed construction features

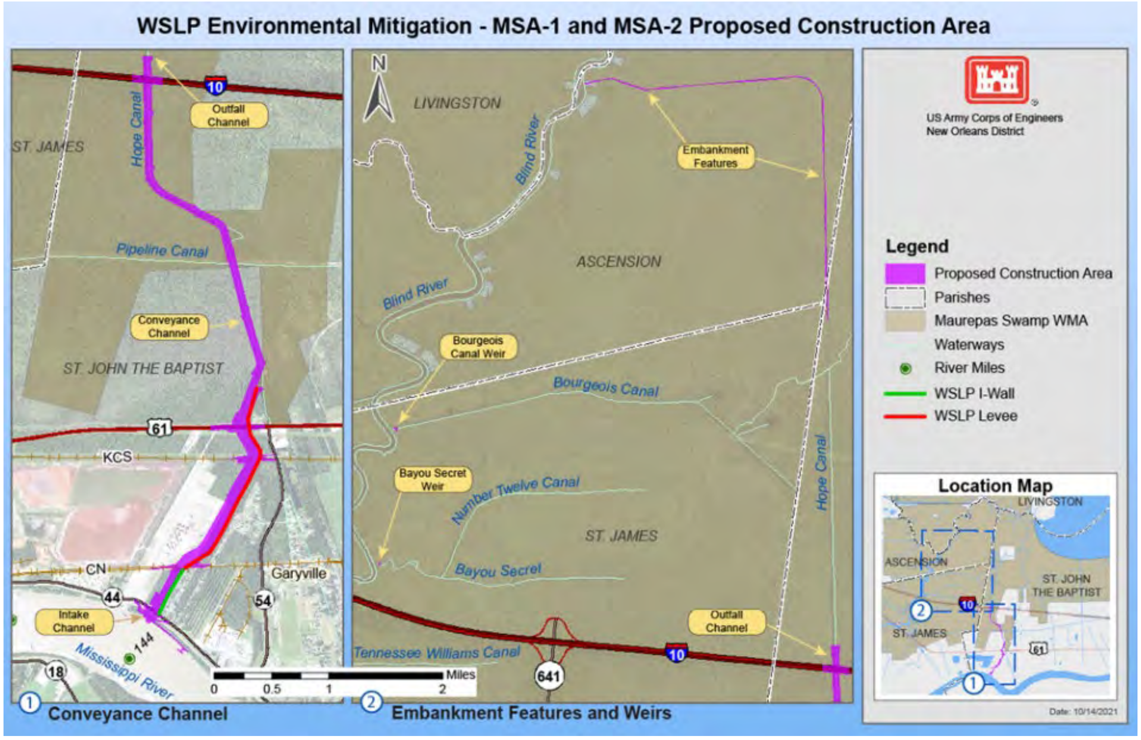

Figure 2 – Proposed Construction Area

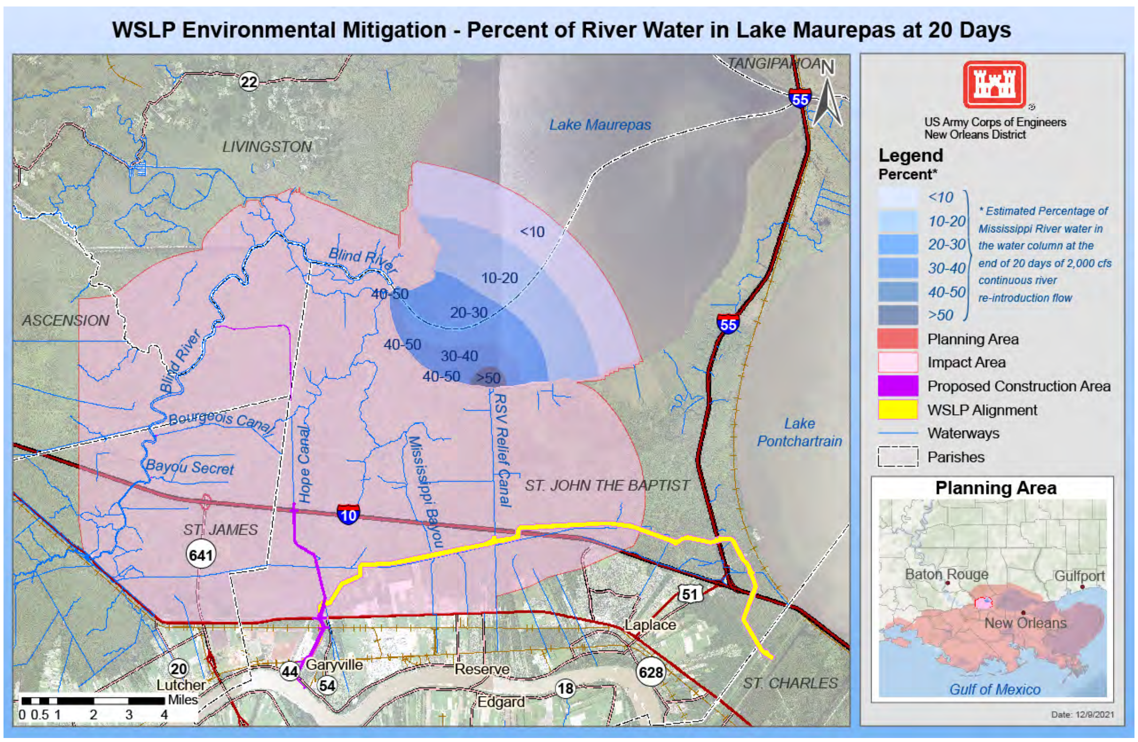

Figure 3 – Area of Freshwater Influence

1.3.2 Description of project habitat

The project footprint for direct impacts consists of roughly 105 acres of bottomland hardwoods (BLH), approximately 116 acres of swamp habitat (Suir et al. 2021), 25.06 acres of water, <0.01 acre of agriculture, and 41.56 acres of developed land. Within the mitigation area, swamp constitutes the primary vegetative cover type. The bald cypress-water tupelo swamps that compose the primary, secondary, and tertiary benefit areas consist of Transitional Canopy forest and Closed Canopy forest, as mapped and classified by Keim et al. (2010).

1.3.3 Project proponent information

The US Army Corps of Engineers (USACE) New Orleans District (MVN) would construct the project, Coastal Protection and Restoration Authority Board (CPRAB) would operate and maintain the diversion, and USACE would monitor for ecological success for up to 10 years post construction. After 10 years, or once initial success is achieved, CPRAB would monitor for ecological success in addition to operating and maintaining the diversion.

Requesting Agency

DEPT OF DEFENSE (DOD)

Army Corps of Engineers (COE)

Tammy Gilmore
7400 Leake Ave
New Orleans, LA, 70118

(504) 862-1002

Tammy.f.gilmore@usace.army.mil

Lead agency

Lead agency is the same as requesting agency

1.3.4 Project purpose

The purpose of the MSA-2 is to compensate for unavoidable swamp impacts from the West Shore Lake Pontchartrain (WSLP) risk reduction project. Ecological characteristics of environments impacted by the WSLP project are detailed in the West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study Final Integrated Feasibility Report and Environmental Impact Statement (USACE 2016) and the Draft Supplemental Environmental Assessment West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Levee System (SEA #571) (USACE 2020). In order to serve as compensatory mitigation, the MSA-2 will provide a net benefit of at approximately 1,210 Average Annual Habitat Units swamp (AAHUs) through preservation of approximately 8,838 acres of bald cypress (Taxodium distichum)–water tupelo (Nyssa aquatica) swamp habitat within the mitigation area in Ascension, St. James, and St. John the Baptist parishes, Louisiana. Preservation by the MSA-2 will be achieved by reconnecting the Mississippi River to the Maurepas Swamp, strategically improving the structure, function, and resilience of the coastal forest habitat through reintroduction of fresh oxygenated water, nutrients, and sediment.

1.3.5 Project type and deconstruction

Project timeline and sequencing

construction

The MSA-2 construction is expected to last around 3 years and is scheduled to start November 2022.

operation

Year 1 – Start operations at 250-cfs on January 1 and increase by 250-cfs increments to 1,000-cfs over the course of six weeks. After five weeks at 1,000-cfs, increase to 1,500-cfs for one week, then to 2,000-cfs for one week, then shut the flow off on April 1. Restart operations at 500-cfs on May 13, let it run for 15 days, and increase to 750-cfs. Then increase again to 1,000-cfs, let it run for 20 days and shut it off on June 30.

Year 2 – Start operations at 250-cfs on January 1 and increase by 250-cfs every 10 days until 2,000-cfs is achieved. Let it run at 2,000-cfs until April 1 and then shut the flow off. Restart operations at 500-cfs on May 13 and increase it by 500-cfs every 10 days until 2,000-cfs is achieved. Let it run until June 30 and then shut it off.

Year 3 – Start operations at 500-cfs on January 1 and increase by 500-cfs every 15 days until 2,000-cfs is achieved. Let it run at 2,000-cfs until April 1 and then shut the diversion off. Restart operations at 500-cfs on May 13 and increase flow by 500-cfs every 10 days until 2,000-cfs or maximum operating capacity based on river conditions is achieved. Let it run until June 30 and then shut it off.

Years 4–50 – Start operations at 2,000-cfs or maximum operating capacity based on river conditions on January 1, let it run until April 1, and then shut it off. Restart operations at 2,000-cfs on May 13, let it run until June 30 and then shut it off.

The timing and duration of the pulses may be adaptively managed based on river hydrographs and swamp conditions and timing. Project monitoring data, as well as assessments of river stage and discharge, will collectively guide future operations through the project life. This Operations Plan will be a living document and will be adjusted based on site conditions, a review of project monitoring data, and an adaptive management approach.

More detail can be found in the Operation Plan located in Attachment 2.

maintenance

Maintenance tasks will be conducted based on inspection findings. Floating debris removal will be conducted on an annual basis. Removal of deposited material is anticipated to be required every five years. Structural repairs of damage to the concrete channels are anticipated every twenty-five years.

Annual maintenance at the intake channel would include the removal of debris, which is anticipated to consist primarily of floating material. The need for removal of deposited sediment is estimated to be required every five years. It is anticipated that riprap replacement at the intake channel will be required every five years and revetment repair every ten years.

More detail can be found in the Maintenance Plan located in Attachment 2.

adaptive management and monitoring

The MSA-2 included both monitoring and AM (contingency plan) for taking corrective AM actions in cases where monitoring demonstrates that the mitigation project is not achieving ecological success and objectives. The plan for the MSA-2 further includes AM triggers to specify when AM may be needed; a trigger indicates that the monitoring data has not met or is not expected to meet the success criteria without an AM action. If the mitigation project triggers a needed for AM, USACE and the NFS will consult with the other agencies through an Interagency Advisory Committee (IAC) to confirm the AM actions needed to achieve ecological success criteria. This decision-making process is further explained in the Adaptive Management Plan located in Attachment 3.

The proposed design and operation of the diversion is based on current understanding of the existing conditions at the site location. Pre-construction monitoring and site assessments will be conducted and could be used to make any necessary adjustments to the diversion design and or operations in accordance with the Adaptive Management Plan.

Site preparation

construction

Site preparation will include the installation of a temporary cofferdam (construction elements of the cofferdam can be found in Attachment 1) on the Mississippi River batture in the dry area to temporarily isolate the intake structure during construction. Additionally, the construction area would be cleared, grubbed, and graded to establish a stable base upon which to construct.

operation

Not applicable

maintenance

Not applicable

adaptive management and monitoring

New information obtained during construction site preparation may be used to inform any potential adjustments that are needed to the diversion design and or operation. Actions could be taken to make adjustments as needed to reduce resource impacts based on changing conditions in accordance with the Adaptive Management Plan.

Construction access and staging

construction

Typical development of staging areas includes clearing and installing gravel or other appropriate substrate pads, either with or without geotextile fabric. Standard establishment of temporary access roads involves clearing and installing gravel and/or sand base materials, either with or without geotextile fabric. The construction of the permanent access roads would include clearing and grubbing, installing impermeable material to build the guide levees, the tops of which will serve as the permanent access roads. A temporary dock would be constructed in the MSR for offloading equipment and supplies. Details of construction of the temporary dock can be found in Attachment 1.

operation

Not applicable.

maintenance

Access for maintenance will be from public boat launches, public roadways, permanent access roads and project right of way (ROW).

adaptive management and monitoring

Pre-implementation monitoring is being conducted and will be used to inform any potential adjustments that are needed to the placement of access and staging areas. Actions could be taken to make adjustments as needed to reduce resource impacts based on changing conditions.

Post-project site restoration

construction

All access roads and staging impacts, temporary and permanent, were considered permanent impacts for the development of the wetland value assessments (WVAs). These impacts will be mitigated for and therefore are not currently planned to be returned to pre-construction conditions.

operation

Not applicable

maintenance

Not applicable

adaptive management and monitoring

Once constructed, and operation begins, it is anticipated that the freshwater introduction would increase swamp health in the MSA-2 benefit areas. General success criteria, monitoring guidelines and AM Actions for the MSA-2 can be found in Attachment 3.

Conservation and compensation activities (both on- and off-site)

construction

The MSA-2 is a mitigation project and therefore this information is captured in the previous sub-categories.

operation

If challenges are identified post project implementation, for any specific resource, for example wildlife impingement, entrainment, entrapments etc., adjustments would be made to the operations.

Maintenance

The MSA-2 is a mitigation project and therefore this information is captured in the previous sub-categories.

adaptive management and monitoring

If challenges are identified post project implementation, for any specific resource, for example wildlife impingement, entrainment, entrapments etc, adjustments would be made to the operations, weirs or embankments cuts to address those impacts.

1.3.6 Anticipated environmental stressors

Land

Construction

Construction of MSA-2 would result in approximately 116 acres of direct, negative impacts to swamp habitat and approximately 105 acres of direct, negative impacts to BLH habitats. These impacts would result from construction of project right-of-way and associated project features.

Operation

MSA-2 would result in approximately 8,838 acres of positive impacts to swamp in the three benefit areas combined. Additionally, there would be negative impacts to swamp, BLH, and marsh habitats outside of the benefit areas (south of I-10). These impacts would be minimized by installation and operation of 8 lateral discharge valves between Airline Highway and I-10.

Maintenance

Anticipated maintenance would include management of invasive and nuisance species such as Chinese tallow and black willow along levees and spoil banks and any invasive species that might affect the operation of the diversion such as zebra mussels, floating aquatic vegetation, and nutria. Management will primarily consist of mechanical removal.

Adaptive management and monitoring

If challenges are identified post project implementation, adjustments would be made to the operations plan to address.

Air

Construction

During construction of this alternative, an increase in air emissions could be expected. These emissions could include 1) exhaust emissions from operations of various types of non-road construction equipment and 2) fugitive dust due to earth disturbance. Emission of fugitive dust near the proposed construction area is not anticipated to be a problem as the site is rural and not highly populated. The areas of Ascension and Livingston Parishes which could be affected by this alternative are remote, isolated, and not likely to contribute to the 8-hour ozone concentration. This alternative is not likely to adversely affect the air quality in these four parishes.

Any site-specific construction effects would be temporary and dust emissions, if any, would be controlled using standard BMPs. Air quality would return to pre-construction conditions shortly after the completion of construction activities. The alternative is within or adjacent to four parishes that are in attainment of NAAQS, therefore, a conformity determination is not required.

Operation

The operation of the mitigation would not cause enough exhaust or dust disturbance to exceed ‘de minimis’ standards either in the short term or over yearly accumulation. The operation of the structures would be temporary vehicle exhaust and dust temporarily during access and egress of minimally populated or remote locations.

Maintenance

This activity near populated locations would cause temporary emissions from the equipment but would not exceed ‘de minimis’ standards.

Adaptive management and monitoring

AM would have similar, but less frequent, effects than operation of the structures.

<u>*Water*</u>

Construction

Potential construction impacts on water quality would occur within the immediate vicinity (within 0.5-mile) of all active construction areas. Direct impacts would also occur in the area downstream or down gradient of construction in both the Mississippi River and the Pontchartrain Basin, respectively. No impacts are anticipated on water quality in the Mississippi River.

Operation

During operations, direct impacts would occur to water quality in the Pontchartrain Basin from the outflow from the Mississippi River to the Pontchartrain Basin. Operation of the proposed MSA-2, water quality benefits would result from nutrient cycling in Maurepas Swamp and an increase in dissolved oxygen within the impact area. No impacts are anticipated on water quality in the Mississippi River.

Maintenance

Maintenance activities includes potential sediment removal and disposal dredging with the sedimentation basin, the conveyance channel, as well as maintenance dredging and/or filling of scour holes around bridge piers of the Interstate 10 Crossing. Such activities would result in short-term turbidity impacts to water quality, while maintaining maximum flow-through capacity in the diversion structure.

Adaptive management and monitoring

Water quality impacts over the project life would vary with adaptive management actions requiring adjustments to operation procedures. Operational adjustments may be needed due to a variety of factors, including Mississippi River conditions, seasonal environmental trends, and weather patterns. Operational changes may be made to the timing, flow rate, duration, and frequency of operations. Any changes in water quality within the Mississippi River watershed would cumulatively interact with operational changes.

Besides operational changes, other proposed potential adaptive management features could impact water quality. These include, but are not limited to, additional spoil bank gapping, water control structures (i.e., weirs), or cuts in railroad embankments to assist with establishing the desired hydrology and meeting the success criteria targets.

1.3.6.1 Animal Features

Emergent fresh, intermediate, and brackish wetlands are typically used by many different wildlife species, including seabirds; wading birds; shorebirds; dabbling and diving ducks; raptors; rails; coots; and gallinules; nutria; muskrat; mink, river otter, and raccoon; rabbit; white-tailed deer; and American alligator. Emergent saline marshes are typically utilized by seabirds; wading birds; shore birds; dabbling and diving ducks; rails, coots, and gallinules; other saline marsh residents and migrants; nutria; muskrat; mink, river otter, and raccoon; rabbits; deer; and American alligator (LCWCRTF & WCRA, 1999).

Open water habitats such as Lake Borgne provide wintering and multiple use functions for brown pelicans, seabirds, and other open water residents and migrants. Various species of freshwater fish utilize Lake Borgne for multiple functions. Gulf sturgeon (GS) migrate through Lake Borgne on their way to the Amite River where they spawn.

1.3.6.2 Aquatic Features

The following bodies of water fall within the MSA-2 area and would receive some kind of influence due to the MSA-2. Further information can be found in Attachment 4.

Body of water	Influence	Source of data	Depth (ft)	Current ft^3/s	Turbidity (FNU)
Maurepas Swamp	Fresh water introduction	No Data Found			
MSR	Construction of intake structure; removal of water	USGS	x	x	x
Bayou Secret	Rip-rap weir	No Data Found	20.27	700,360	x
Bourgeois Canal	Rip-rap weir	LDEQ	x	x	x
Hope Canal (1)	Reshape geometry	USGS	9.84	x	6.38
Hope Canal (2)	Reshape geometry	CPRA	1.811	x	x
Blind River (1)	Mouth may experience increased turbidity	LDEQ	5.85	x	4.87
Blind River (2)	Mouth may experience increased turbidity	CPRA	x	x	21.07

Lake Maurepas	Increased turbidity due to freshwater introduction	LDEQ	20.86	x	9.98

1.3.6.3 Environmental Quality Features

The area is located within a subtropical latitude. The climate is influenced by the many water surfaces of the nearby wetlands, rivers, lakes, streams, and the Gulf of Mexico. Throughout the year, these water areas modify relative humidity and temperature conditions, decreasing the range between the extremes. Summers are long and hot, with an average daily temperature of 82° Fahrenheit (°F), average daily maximum of 91°F, and high average humidity. Winters are influenced by cold, dry polar air masses moving southward from Canada, with an average daily temperature of 54°F and an average daily minimum of 44°F. Annual precipitation averages 54 inches.

Lane et al. (2003) found that the Maurepas swamps are nitrogen limited compared to phosphorus, and dissolved inorganic nitrogen, especially nitrate, is the most important nutrient in the formation of phytoplankton blooms in Lake Maurepas. Nitrates in Mississippi River runoff from the MSA-2 would likely be removed via denitrification in the water column or uptake in wetland plants. Operating the diversion with 2,000 cfs outflow, majority of the introduced nutrients in the impact area would be removed from the water column within approximately 3-4 miles from the diversion outflow north of Interstate 10. By the time the outflow reaches Lake Maurepas, any remaining nutrients would consist mostly of organic nitrogen, which is not available for algal uptake unless it is first converted back to inorganic nitrogen (i.e. ammonium) through the slow process of mineralization.

The following table represents the best data available on the bodies of water within the MSA-2 area. Further information can be found in Attachment 4.

Body of water	Influence	Source of data	Ph	Temp (C)	Dissolved Oxygen (mg/L)	Salinity (ppt)
Maurepas Swamp	Fresh water introduction	No Data Found	x	x	x	x
MSR	Construction of intake structure; removal of water	USGS	x	18.17	8.33	0.2
Bayou Secret	Rip-rap weir	No Data Found	x	x	x	x
Bourgeois Canal	Rip-rap weir	LDEQ	6.66	27.35	2.95	0.18
Hope Canal (1)	Reshape geometry	USGS	x	20.6	x	0.148
Hope Canal (2)	Reshape geometry	CPRA	x	20.25	2.76	0.114
Blind River (1)	Mouth may experience increased turbidity	LDEQ	7.01	21.76	5.82	0.11
Blind River (2)	Mouth may experience increased turbidity	CPRA	x	22.07	4.22	0.084
Lake Maurepas	Increased turbidity due to freshwater introduction	LDEQ	20.86	x	9.98	0.18

Within the Maurepas Swamp, interstitial soil pH is slightly acidic, typical of organic soils with low bulk densities, and higher bulk densities were found in areas receiving agricultural and other runoff (Shaffer et al., 2003).

1.3.6.4 Landform (topographic) Features

There are no natural topographic features within the MSA-2 area.

1.3.6.5 Soil and Sediment

The topmost layer of earth on the landscape and its components (e.g., rock, sand, gravel, silt, etc.). This feature includes the physical characteristics of soil, such as depth, compaction, etc. Regarding soils in the Maurepas Swamp, the accumulation of organic material in the surficial soil horizon is evident across most of the project wetland areas due to slow decomposition under anaerobic, water saturated conditions. Shaffer et al. (2003) noted atypical low soil bulk densities for Maurepas Swamp (0.05-0.15 g/cm3) that are more typical of fresh and intermediate marshes (Hatton, 1981). The primary soil mapping unit within the mitigation area and portions of the impact area within Maurepas Swamp consists of Barbary soils, 0 to 1 percent slopes, frequently flooded (Ba) (U.S. Department of Agriculture [USDA] Natural Resources Conservation Service [NRCS] 2020).

Within the project impact footprint, soils are generally characterized as silt loams or clays, often with hydric rating and flood hazard. Schriever clay, 0 to 1 percent slopes, frequently flood (Sm) soils occur north and south of U.S. 61, extending south to approximately the KCS railroad. Located in backswamp on delta plain, Sm soils are very poorly drained, nearly impermeable hydric soils derived from clayey alluvium, with very high shrink-swell, frequent flood hazard, negligible runoff, and depth to seasonal water saturation of 0 to 24 inches. From the KCS railroad to the MRL, mapped soils include Schriever clay, 0 to 1 percent slops (SkA); Gramercy silty clay, 0 to 1 percent slopes (GrA); and Cancienne silt loam, 0 to 1 percent slopes (CmA). SkA soils are similar in characterization to Sm soils with the exception that they are rarely flooded and have high runoff. The MRL within the project impact footprint is mapped as Lp soils, as previously described. Riverward, the batture is mapped as overlying Cancienne and Carville soils, gently undulating, frequently flooded (CT). (USDA-NRCS 2021).

1.4 Action Area

The Action Area includes the MS River from approximate mile149 to approximate mile 140 (the extended river miles account for potential noise impacts to PS); a developed area in Garyville, LA; the Maurepas Swamp Wildlife Manage Area (WMA); and Lake Maurepas. Several smaller water bodies are located within the WMA that also fall within the action area. These include the Bayou Secret, Bourgeois Canal, Hope canal, and Blind River.

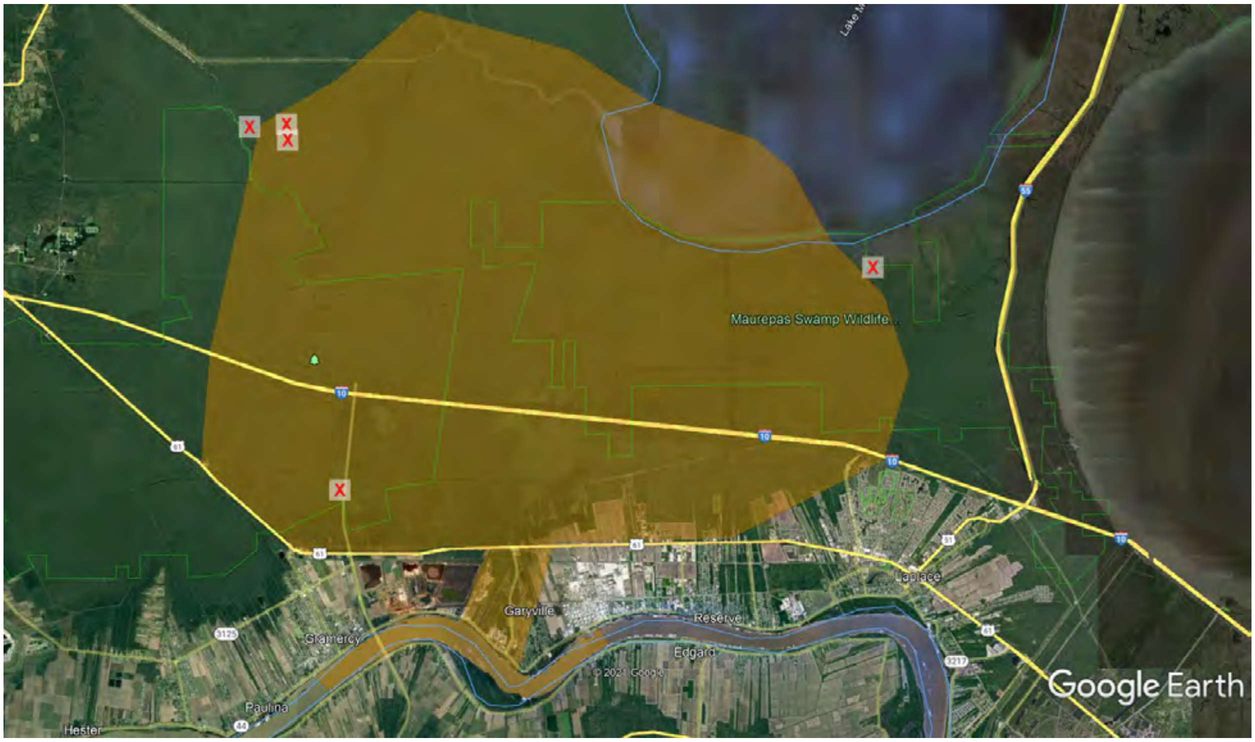

Figure 4 - Action Area

1.5 Conservation Measures

<u>Gulf Sturgeon</u>

- If bucket dredging is performed, the Contractor should induce GS to leave the immediate work area prior to any bucket dredging work regardless of water depth.
- The bucket will be dropped into the water and retrieved empty one (1) time.
- After the bucket has been dropped and retrieved, a one (1)-minute no work period must be observed.
- During this no dredging period, personnel should carefully observe the work area in an effort to visually detect GS.
- If GS are sighted, no work should be initiated until the sturgeon have left the work area.
- If the water turbidity makes such visual sighting impossible, work may proceed after the one (1)-minute no work period has elapsed.
- If more than fifteen minutes elapses with no work, then the empty bucket drop/retrieval process shall be performed again prior to re-initiating work efforts.

- If cutterhead dredging is performed, the contractor should minimize disturbance to GS.

- The cutterhead should remain completely buried in the bottom material during dredging operations.

- If pumping water through the cutterhead is necessary to dislodge material or to clean the pumps or cutterhead, etc., the pumping rate should be reduced to the lowest rate possible until the cutterhead is at mid-depth, where the pumping rate can then be increased.

- During dredging, the pumping rates should be reduced to the slowest speed feasible while the cutterhead is descending to the channel bottom.

Pallid Sturgeon

- Withdrawal of water from near the surface of the river (based upon river stage and season) to make entrainment less likely.

- The diversion was designed to make it possible for sturgeon to resist flow by increasing the size and/or number of gates at the intake structure to distribute flow (and reduce velocity of water through any single gate) creating water velocities lower than escape speeds of most fish.

- The diversion was designed to include rough or complex substrates directly in front of the intake gates to enable PS to resist entraining flows.

- A local study should be conducted over several fall and winter periods to determine acceptable levels of entrainment using estimates of abundance, mortality, and recruitment in age-structure population models.

Construction Avoidance Measures

- All contract personnel associated with the project would be informed of the potential presence of Pallid sturgeon.

- If dredging, when lowering the ladder, the pumping rate should be reduced to the slowest speed feasible while the cutterhead is being lowered to the channel bottom.

- If dredging, the cutterhead should remain completely buried in the channel bottom during dredging operations.

- If dredging, if pumping water through the cutterhead is deemed necessary to dislodge material, or to clean the pumps, the pumping rate should be reduced to the lowest rate feasible while raising the ladder until the cutterhead is at least at mid-depth at which point the pumping rate can then be increased.

West Indian Manatee

- All contract personnel associated with the project would be informed of the potential presence of manatees and the need to avoid collisions with manatees.

- All construction personnel would be responsible for observing water-related activities for the presence of manatees.

- Temporary signs would be posted prior to and during all construction/dredging activities to remind personnel to be observant for manatees during active construction/dredging operations or within vessel movement zones (i.e., the work area), and at least one sign would be placed where it is visible to the vessel operator.

- Siltation barriers, if used, would be made of material in which manatees could not become entangled and would be properly secured and monitored.

- If a manatee is sighted within 100 yards of the active work zone, special operating conditions would be implemented, including: moving equipment would not operate within 50 ft of a manatee; all vessels would operate at no wake/idle speeds within 100 yards of the work area; and siltation barriers, if used, would be re-secured and monitored. Once the manatee has left the 100-yard buffer zone around the work area of its own accord, special operating conditions would no longer be necessary, but careful observations would be resumed.

- Any manatee sighting would be immediately reported to the U.S. Fish and Wildlife Service (337/291-3100) and the Louisiana Department of Wildlife and Fisheries (LDWF), Natural Heritage Program (225/765-2821).

1.6 Prior Consultation History

There has been no previous consultation with USFWS on this project.

1.7 Other Agency Partners and Interested Parties

Non-federal Sponsors

As a non-federal sponsor CPRA would be responsible for O&M of the diversion structure immediately after construction and for the life of the project. Once initial ecological success is achieved, CPRA would be responsible for O&M and monitoring of the entire project, including the benefit areas. The POCs for CPRA are Brad Miller, Brad.Miller@LA.GOV, 225-936-4820, and Travis Byland, Travis.Byland@LA.GOV, 225-572-8192.

As a non-federal sponsor, the Lake Pontchartrain Levee District (LPLD) would be responsible for the O&M of the WSLP flood risk management portion of the WSLP project. The POC for LPLD is Monica Gorman, mgorman@leveedistrict.org, 225-869-9721.

Cooperating Agencies

The following agencies have agreed to being cooperating agencies. NRCS, NMFS, EPA, USFWS, LDWF, and Mississippi Band of Choctaw Indians. As cooperating agencies, they have been involved during the planning and analysis phase and will continue to be involved during design and implementation. USFWS has played an integral role in analyzing the impacts and benefits of the project. LDWF is the landowner and must be coordinated with throughout the project life.

1.8 Other Reports and Helpful Information

The following documents were helpful in preparing this BA and can be found in Attachment 5.

- *Evaluation of Potential Impacts of the Lake Maurepas Diversion Project to Gulf and Pallid Sturgeon*
- *Entrainment Studies of Pallid Sturgeon Associated with Water Diversions in the Lower Mississippi River DRAFT*
- *Biological Assessment Bonnet Carré Spillway 2019 Emergency Operation*
- *Biological Opinion Bonnet Carré Spillway 2019 Emergency Operations*
- *U.S. Fish and Wildlife Service. 2021. Biological Opinion Mid-Barataria Sediment Diversion*

2 Species Effects Analysis

2.1 Gulf Sturgeon

2.1.1 Status of the species

2.1.1.1 Legal status

The U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) designated the GS to be a threatened subspecies, pursuant to the Endangered Species Act of 1973, as amended (ESA) on September 30, 1991.

2.1.1.2 Recovery plans

The most recent recovery plan is dated 1995. The information below was taken from the Gulf Sturgeon Recovery/Management Plan which can be found in Attachment 6.

The primary strategy for recovery of GS is to:

- Develop and implement standardized population sampling and monitoring techniques

- Develop and implement regulatory framework to eliminate introductions of nonindigenous stock or other sturgeon species
- Reduce or eliminate incidental mortality
- Restore the benefits of natural riverine habitats
- Utilize existing authorities to protect habitat and where inadequate, recommend new laws and regulations

2.1.1.3 Life history information

Habitat, Movement, and Feeding

The GS is an anadromous fish; adults spawn in freshwater then migrate to feed and grow in estuarine and marine habitats. After spawning in the upper river reaches, both adult and subadult GS migrate from the estuaries, bays, and the Gulf of Mexico to the coastal rivers in early spring (i.e., March through May) when river water temperatures range from 16° to 23°C. Fall downstream migration from the river into the estuary/Gulf of Mexico begins in September (at water temperatures around 23°C) and continues through November.

Most subadult and adult GS spend cool months (October or November through March or April) in estuarine areas, bays, or in the Gulf of Mexico. Research indicates that in the estuary/marine environment both subadult and adult GS show a preference for sandy shoreline habitats with water depths less than 3.5 m and salinity less than 6.1 parts per thousand. The predominantly sandy areas support a variety of potential prey items including marine crustaceans, small bivalve mollusks, ghost shrimp, small crabs, various polychaete worms, and lancelets. Once subadult and adult GS migrate from the river to the estuarine/marine environment, having spent at least 6 months in the river fasting, it is presumed that they immediately begin foraging. Upon exiting the rivers, GS are found in high concentrations near their natural river mouths; these lakes and bays at the mouth of the river are important because they offer the first opportunity for GS to forage. Spawning occurs in the upper river reaches in the spring when water temperature is around 15° to 20°C.

Genetic studies conclude that GS exhibit river-specific fidelity. Five regional or river-specific stocks (from west to east) have been identified: (I) Lake Pontchartrain and Pearl River, (2) Pascagoula River, (3) Escambia and Yellow Rivers, (4) Choctawhatchee River, and (5) Apalachicola, Ochlockonee, and Suwannee Rivers.

2.1.1.4 Conservation needs

There is currently no conservation plan for the GS. However, there are best management practices and avoidance measures that when implemented during dredging operations would reduce impacts to the species. These are discussed in section 1.5 of this BA; however, they do not apply to the MSA-2.

2.1.2 Environmental baseline

2.1.2.1 Species presence and use

The present range of the GS extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida. The GS is an anadromous fish; adults spawn in freshwater then migrate to feed and grow in estuarine and marine habitats. After spawning in the upper river reaches, both adult and subadult GS migrate from the estuaries, bays, and the Gulf of Mexico to the coastal rivers in early spring (i.e., March through May) when river water temperatures range from 16 to 23°C. Fall downstream migration from the river into the estuary/Gulf of Mexico begins in September (at water temperatures around 23°C) and continues through November. GS are known to migrate through Lake Maurepas and upstream into the Amite River. GS do not feed during in and out migrations. GS are known to seasonally use Lake Maurepas from October to November and again from February through April during these migrations (Kirk et al., 2008). GS occur in the northern reaches of Blind River during their migration to the Amite River, but do not occur in the southern reaches. GS do occur in the Mississippi River, but they would not be anticipated to occur as far upstream as the proposed project (Kirk et al., 2008). A lack of spawning habitat at any distance upstream from the Gulf of Mexico likely limits their frequency in the Mississippi River (Danube Watch, 2009). GS are not known to occur in Hope Canal.

2.1.2.2 Species conservation needs within the action area

According to ECOS, there is no Conservation Plan currently available for this species. Since GS are not found the portion of the action area where construction activities would occur, the conservation measures discussed in section 1.5 do not apply.

2.1.2.3 Habitat condition (general)

Lake Maurepas is a 59,302-acre freshwater lake that is utilized by GS during migration to the Amite River. GS do not feed during migration through Lake Maurepas and therefore Lake Maurepas does not offer any feeding ground for the GS.

2.1.2.4 Influences

During heavy rain events, there is potential for river flows to increase turbidity in Lake Maurepas. Since GS only utilize Lake Maurepas during migration to the Amite River, and since GS do not feed during this migration, this influence has minimal to no effect on the species.

2.1.2.5 Additional baseline information

There is no additional baseline information.

2.1.3 Effects of the action

2.1.3.1 Indirect interactions

The GS would suffer indirect effects due to a slight increase in turbidity in Lake Maurepas near the Blind River. This increase in turbidity would be no different from what the GS experiences during heavy rain events, high river flow, or storm events. Since GS only utilize Lake Maurepas during migration to the Amite River, and since GS do not feed during migration, increased turbidity has minimal to no effect on the species.

2.1.3.2 Direct interactions

There would be no direct interactions with GS as the species is not known to occur in the MSA-2 construction area.

2.1.4 Cumulative effects

ESA defines cumulative effects as those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation. That being said, the USACE is not aware of any projects within the action area that would contribute to cumulative impacts to the GS.

2.1.5 Discussion and conclusion

As previously discussed, the MSA-2 would slightly increase the turbidity in Lake Maurepas near the mouth of the blind river. GS migrate through Lake Maurepas and into the Blind River during their migration to the Amite River. This increase in turbidity would be no different from the increase in turbidity during high rain events and high river flow. Also previously stated, the GS does not forage during the in and out migration through Lake Maurepas and so the increase in turbidity would have no impact on foraging. Because a slight increase in turbidity in Lake Maurepas would have minimal to no impact on the GS, the USACE has made the determination that the MSA-2 would have no effect on the GS.

2.2 Pallid Sturgeon

2.2.1 Status of the species

2.2.1.1 Legal status

The Service published its decision to list the Pallid sturgeon (PS) as endangered on October 9, 1990 (55 FR 36641-36647). The reasons for listing were habitat modification, apparent lack of natural reproduction, commercial harvest, and hybridization in parts of its range. Critical habitat has not been proposed or designated for the PS.

2.2.1.2 Recovery plans

The following information was taken from the U.S. Fish & Wildlife Service Revised Recovery Plan for the Pallid Sturgeon (Scaphirhynchus albus) which can be found in Attachment 6 and all citations can be found in that document.

The primary strategy for recovery of PS is to:

- conserve the range of genetic and morphological diversity of the species across its historical range;
- fully quantify population demographics and status within each management unit;
- improve population size and viability within each management unit;
- reduce threats having the greatest impact on the species within each management unit; and,
- use artificial propagation to prevent local extirpation within management units where recruitment failure is occurring. (USFWS 2014)

The recovery objectives include the implementation of effective management actions that will reduce or alleviate the impacts from threats to the species within each management unit and across the species' range. Recovery actions to address threats within management units should be informed by adequate knowledge of PS abundance, population structure, life history, ecology, mortality, and habitat requirements specific to those units. (USFWS 2014)

2.2.1.3 Life history information

The following information was taken from the Biological Opinion, Bonnet Carré Spillway 2019 Emergency Operations which can be found in Attachment 5 and all citations can be found in that document.

Habitat

PS habitats can generally be described as large, free-flowing, warm water, turbid river habitats with a diverse assemblage of physical attributes that are in a constant state of change (Service 1993, 2014). Floodplains, backwaters, chutes, sloughs, islands, sandbars and main channel waters form the large river ecosystem that provide the macrohabitat requirements for all life stages of PS. Throughout its range, PS tend to select main channel habitats (Bramblett 1996; Sheehan et al. 1998; Service 2014a; Schramm et al. 2017); in the Lower Mississippi River (LMR), they have been found in a variety of main channel habitats, including natural and engineered habitats (Herrala et al. 2014).

PS are thought to occupy the sandy main channel in the Mississippi, Missouri, and Yellowstone rivers most commonly, but also are collected over gravel substrates (Service 2014a; Bramblett and White 200l; Hurley et al. 2004; Garvey et al. 2009; Koch et al. 2012). Several studies have documented PS near islands and dikes, and these habitats are thought to provide a break in water velocity and an increased area of depositional substrates for foraging (Garvey et al. 2009; Koch et al. 2012). Increased use of side channel and main channel islands has been noted in spring, and it is hypothesized that these habitats may be used as refugia during periods of increased flow (Garvey et al. 2009; Koch et al. 2012; Herrala et al. 2014). Recent telemetry monitoring of adult PS in the LMR indicates use of most channel habitats, including dikes, revetment, islands, secondary channels, etc. (Kroboth et al. 2013; Herrala et al. 2014). Islands and secondary channels are important in recruitment of larval sturgeon in the LMR (Hartfield et al. 2013).

PS occur within a variety of flow regimes (Garvey et al. 2009). In their upper range, adult PS are collected in depths that vary between 1.97-47.57 ft with bottom water velocities ranging from 2.20 ft/s and 2.62 ft/s (Service 2014a; Bramblett and White 2001; Gerrity 2005). PS in the LMR have been collected at depths greater than 65 ft with a mean value of 32.81 ft, and water velocities greater than 5.91 ft/s with a mean value of 2.30 ft/s (ERDC unpublished data; Herrala et al. 2014). Turbidity is thought to be an important factor in habitat selection by PS, which have a tendency to occupy more turbid habitats than SS (Blevins 2011). In the LMR, PS have been collected in turbidities up to 340 Nephelometric Turbidity Units (NTU's) with a mean value of 90 NTU's (ERDC unpublished data).

Much of the natural habitat throughout the range of PS has been altered by humans, and this is thought to have had a negative impact on this species (Service 2014a). Habitats were once very diverse and provided a variety of substrates and flow conditions (Baker et al. 1991; Service 1993). Extensive modification of the Missouri and Mississippi rivers over the last 100 years has drastically changed the form and function of the river (Baker et al. 1991; Prato 2003). Today, habitats are reduced and fragmented and much of the Mississippi River basin has been channelized to aid in navigation and flood control (Baker et al. 1991). The extent of impacts from range-wide habitat alteration on the PS is unknown, but recent studies have shown that in the un-impounded reaches (i.e., LMR), suitable habitat is available and supports a diverse aquatic community (Service 2007).

Movement

Like other sturgeon, PS is a migratory fish species that moves upstream annually to spawn (Koch et al. 2012). Movements are thought to be triggered by increased water temperature and flow in spring months (Garvey et al. 2009; Blevins 2011). PS may remain sedentary or remain in one area for much of the year, and then move either upstream or downstream during spring (Garvey et al. 2009; Herrala and Schramm 2017). It is possible that because movement in large, swift rivers requires a great amount of energy, this relatively inactive period may be a means to conserve energy (Garvey et al. 2009). Most active periods of movement in the upper Missouri River were between March 20 and June 20 (Bramblett and White 2001). In one study, individual fish traveled an average of 3.73 mi/day and one individual traveled over 9.94 mi/day (Garvey et al. 2009). PS in the Missouri River have been reported to travel up to 5.90 mi/hour and 13.30 mi/day during active periods (Bramblett and White 2001). Based on a surrogate study that documented recaptures of SS in the Missouri River originally tagged in the LMR, PS may similarly undertake long-distance, multi- year upstream movements. Upstream distances approaching 1,245 mi have been recorded (ERDC unpublished data) and similar distances have been recorded for downstream movements (Service unpublished data).

Aggregations of PS have been reported in several locations in the middle Mississippi River, particularly around gravel bars, including one annual aggregation at the Chain of Rocks Dam, which is thought to be related to spawning activities (Garvey et al. 2009). Aggregations of PS in the lower 8.70 mi of the Yellowstone River are also thought to be related to spawning activities of sturgeon from the Missouri River (Bramblett and White 2001). PS have been found to have active movement patterns during both the day and night, but they move mostly during the day (Bramblett and White 2001). There have been no verified spawning areas located in the LMR.

Feeding

Sturgeon are benthic feeders and are well adapted morphologically (ventral positioning of the mouth, laterally compressed body) for the benthic lifestyle (Service 1993; Findeis 1997). Adult PS are primarily piscivorous (but still consume invertebrates) and are thought to switch to piscivory around age 5 or 6 (Kallemeyn 1983; Carlson et al. 1985; Hoover et al. 2007; Grohs et al. 2009). In a study of PS in the middle and lower Mississippi River, fish were a common dietary component and were represented primarily by Cyprinidae, Sciaenidae, and Clupeidae (Hoover et al. 2007). Other important dietary items for PS in the Mississippi River were larval Hydropsychidae (Insecta: Trichoptera), Ephemeridae (Insecta: Ephemeroptera), and Chironomidae (Insecta: Diptera) (Hoover et al. 2007). PS diet varies depending on season and location, and these differences probably are related to prey availability (Hoover et al. 2007). In a Mississippi River dietary study, Trichoptera and Ephemeroptera were consumed in greater quantities in winter months in the lower Mississippi River, while the opposite trend was observed in the middle Mississippi River (Hoover et al. 2007). Hoover et al. (2007) also found that in both the middle Mississippi River and the lower Mississippi River, dietary richness is greatest in winter months.

2.2.1.4 Conservation needs

The following information was taken from the USFWS Biological Opinion, Mid-Barataria Sediment Diversion which can be found in Attachment 5 and all citations can be found in that document.

Much of the following information is taken from Service documents (Service 2000, 2007, 2014b, 2018). The PS was listed due to the apparent lack of recruitment for over 15 years, and the habitat threats existing at the time of listing. Destruction and alteration of habitats by human modification of the river system is believed to be the primary cause of declines in reproduction, growth, and survival of the PS. The historic range of PS as described by Bailey and Cross (1954) encompassed the middle and lower Mississippi River, the Missouri River, and the lower reaches of the Platte, Kansas, and Yellowstone Rivers. Bailey and Cross (1954) noted a PS was captured at Keokuk, Iowa, at the Iowa and Missouri state border. Duffy et al. (1996) stated that the historic range of PS once

included the Mississippi River upstream to Keokuk, Iowa, before that reach of the river was
converted into a series of locks and dams for commercial navigation (Coker 1930).

Habitat destruction/modification and the curtailment of range were primarily attributed to the construction and operation of dams on the upper Missouri River and modification of riverine habitat by channelization of the lower main stems of the Missouri and Mississippi Rivers. Dams substantially fragmented PS range in the upper Missouri River. However, free flowing riverine conditions currently exist throughout the lower 2,000 mi (3,218 km) (60 percent) of the PS historical range. Although the lower Missouri River continues to be impacted by regulated flows and modified habitats, actions have been developed and are being implemented to address habitat issues. Recent studies and data from the Mississippi River suggest that riverine habitats are less degraded than previously believed, and that they continue to support diverse and productive aquatic communities, including PS. Although
there are ongoing programs to protect and improve habitat conditions in the four management units, positive effects from these programs on PS have not been quantified.

Carlson and Pflieger (1981) stated that PS are rare but widely distributed in both the Missouri River and in the Mississippi River downstream from the mouth of the Missouri River. A comparison of PS and shovelnose sturgeon catch records provides an indication of the rarity of PS. At the time of their original description, PS composed 1 in 500 river sturgeon captured in the Mississippi River at Grafton, Illinois (Forbes and Richardson 1905). PS were more abundant in the lower Missouri River near West Alton, Missouri, representing one-fifth of the river sturgeon captured (Forbes and Richardson 1905). Carlson et al. (1985) captured 4,355 river sturgeon in 12 sampling stations on the Missouri and Mississippi Rivers. Field identification revealed 11 (0.25 percent) PS.

Grady et al. (2001) collected 4,435 river sturgeon in the lower 850 mi (1,367 km) of the Missouri River and 100 mi (161 km) of the middle Mississippi River from November 1997 to April 2000. Field identification revealed nine wild (0.20 percent) and nine hatchery-origin PS. Today, PS, although variable in abundance, are ubiquitous throughout most of the free-flowing Mississippi River. When the PS was listed as endangered, they were only occasionally found in the following areas; from the Missouri River: 1) between the Marias River and Fort Peck Reservoir in Montana; 2) between Fort Peck Dam and Lake Sakakawea (near Williston, North Dakota); 3) within the lower 70 mi (113 km) of the Yellowstone River downstream of Fallon, Montana; 4) in the headwaters of Lake Sharpe in South Dakota; 5) near
the mouth of the Platte River near Plattsmouth, Nebraska; and 6) below River Mile 218 to the mouth in the State of Missouri.

Keenlyne (1989) updated previously published and unpublished information on distribution and abundance of PS. He reported pre-1980 catch records for the Mississippi River from its mouth upstream to its confluence with the Missouri River, a length of 1,153 mi (1,857 km); in the lower 35 mi (56 km) of the Yazoo/Big Sunflower and St. Francis Rivers (tributaries to the Mississippi); in the Missouri River from its mouth to Fort Benton, Montana, a length of 2,063 mi (3,323 km); and, in the lower 40 mi (64 km) of the Kansas River, the lower 21 mi (34 km) of the Platte River, and the lower 200 mi (322 km) of the Yellowstone River (tributaries to the Missouri River). The total range is approximately 3,500 mi (5,635 km) of river.

Currently, the Missouri River (1,154 mi) (1,857 km) has been modified significantly with approximately 36 percent of the riverine habitat inundated by reservoirs, 40 percent channelized, and the remaining 24 percent altered due to dam operations (Service 1993). Most of the major tributaries of the Missouri and Mississippi Rivers have also been altered to various degrees by dams, water depletions, channelization, and riparian corridor modifications.

The middle Mississippi River, from the mouth of the Missouri River to the mouth of the Ohio River, is principally channelized with few remaining secondary channels, sand bars, islands and abandoned channels. The middle Mississippi River has been extensively diked; navigation channels and flood control levees have reduced the size of the floodplain by 39 percent.

Levee construction along the lower Mississippi River, from the Ohio River to the Gulf, has eliminated major natural floodways and reduced the land area of the floodplain by more than 90 percent (Fremling et al. 1989). Fremling et al. (1989) also report that levee construction isolated many floodplain lakes and raised riverbanks. As a result of levee construction, 15 meander loops were severed between 1933 and 1942.

Destruction and alteration of big-river ecological functions and habitats once provided by the Missouri and Mississippi Rivers were believed to be the primary cause of declines in reproduction, growth, and survival of PS (Service 2014a). The physical and chemical elements of channel morphology, flow regime, water temperature, sediment transport, turbidity, and nutrient inputs once functioned within the big-river ecosystem to provide habitat for PS and other native species. On the main stem of the Missouri River today, approximately 36 percent of riverine habitat within the PS range has been transformed from river to lake by construction of six massive earthen dams by the USACE between 1926 and 1952 (Service 1993). Another 40 percent of the river downstream of the dams has been channelized. The remaining 24 percent of river habitat has been altered by changes in water temperature and flow caused by dam operations.

The channelized reach of the Missouri River downstream of Ponca, Nebraska, once a diverse assemblage of braided channels, sandbars, and backwaters, is now confined within a narrow channel of rather uniform width and swift current. Morris et al. (1968) found that channelization of the Missouri River reduced the surface area by approximately 67 percent. Funk and Robinson (1974) calculated that, following channelization, the length of the Missouri River between Rulo, Nebraska, and its mouth (~500 river miles) (310 km) had been reduced by 8 percent, and the water surface area had been reduced by 50 percent.

Missouri River aquatic habitat between and downstream of main stem dams has been altered by reductions in sediment and organic matter transport/deposition, flow modification, hypolimnetic releases, and narrowing of the river through channel degradation. Those activities have adversely impacted the natural river dynamics by reducing the diversity of bottom contours and substrates, slowing accumulation of organic matter, reducing overbank flooding, changing seasonal patterns, severing flows to backwater areas, and reducing turbidity and water temperature (Hesse 1987). The Missouri River dams also are believed to have adversely affected PS by blocking migration routes and fragmenting habitats (Service 2014a).

The pattern of flow velocity, volume, and timing of the pre-development rivers provided the essential life requirements of native large-river fishes like the PS and paddlefish. Hesse and Mestl (1993) found a significant relationship between the density of paddlefish larvae and two indices (timing and volume) of discharge from Fort Randall Dam. They concluded that when dam operations caused discharge to fluctuate widely during spring spawning, the density of drifting larvae was lower, and when annual runoff volume was highest, paddlefish larval density was highest. Hesse and Mestl (1987) also modeled these same two indices of discharge from Fort Randall Dam with an index of year-class strength. They demonstrated significant negative relationships between artificial flow fluctuations in the spring and poor year-class development for several native and introduced fish species including river carpsucker, shorthead redhorse, channel catfish, flathead catfish, sauger, smallmouth buffalo, and bigmouth buffalo. The sample size of sturgeon was too small to model in that study; however, a clear relationship existed between poor year-class development in most native species studied and the artificial hydrograph.

Modde and Schmulbach (1973) found that during periods of low dam releases, the secondary subsidiary channels, which normally feed into the river channel, become exposed to the atmosphere and thus cease to contribute littoral benthic organisms into the drift. Schmulbach (1974) states that use of sandbar habitats were second only to cattail marsh habitats as nursery ground for immature fishes of many species.

Even though extensive flood control, water supply, and navigation projects constrict and control the Missouri and Mississippi Rivers with reservoirs, stabilized banks, jetties, dikes, levees, and revetments, relatively unaltered remnant reaches of the Missouri River and the Mississippi River from the Missouri River confluence to the Gulf of Mexico still provide habitat useable by PS. However, anthropogenic alterations (i.e., levee construction) effectively increased river stage and velocities at higher discharges by preventing overbank flows on the adjacent floodplains (Baker et al. 1991).

The upper ends of the reservoirs in the upper basin may be influencing the recruitment of larval sturgeon. Both shovelnose sturgeon and PS larvae have a propensity to drift after hatching (Kynard et al. 1998a, 1998b). Bramblett (1996) found that the PS may be spawning in the Yellowstone River between River Mile 9 and River Rile 20 upriver, and that from historic catch records, there is some evidence to indicate that the occurrence of PS catches coincides with the spring spawning at the mouth of the Tongue River (Service 2000). Shovelnose sturgeon have been found to spawn in the tributaries of the Yellowstone River as well as such areas as the Marias, Teton, Powder and Tongue Rivers (Service 2000). Shovelnose sturgeon are successfully recruiting and reproducing in the river stretches in the upper basin and this may be directly related to the amount of larval and juvenile habitat they have available downstream of the spawning sites.

Early indications in culturing PS indicate that sturgeon larvae will not survive in a silty substrate. In 1998, most of the larval sturgeon held in tanks at Gavins Point National Fish Hatchery (NFH), experienced high mortality when the water supply contained a large amount of silt which settled on the bottom of the tanks. Migration routes to spawning sites on the lower Yellowstone River have been fragmented by low-head dams used for water supply intakes. Such habitat fragmentation has forced PS to spawn closer to reservoir habitats and reduced the distance larval sturgeon can drift after hatching.

Historically, pallid, shovelnose, and lake sturgeon were commercially harvested in all States on the Missouri and Mississippi Rivers (Helms 1974). The larger lake sturgeon and PS were sought for their eggs which were sold as caviar, whereas shovelnose sturgeon were historically destroyed as bycatch. Commercial harvest of all sturgeon has declined substantially since record-keeping began in the late 1800s. Most commercial catch records for sturgeon have not differentiated between species and combined harvests as high as 430,889 lb (195,450 kg) were recorded in the Mississippi River in the early 1890s but had declined to less than 20,061 lb (9,100 kg) by 1950 (Carlander 1954). Lower harvests reflected a decline in shovelnose sturgeon abundance since the early 1900s (Pflieger 1975). Today, commercial harvest of SS is still allowed in 5 of the 13 states where PS occur.

Mortality of PS occurs as a result of illegal and incidental harvest from both sport and commercial fishing activities (Service 2000). Sturgeon species, in general, are highly vulnerable to impacts from fishing mortality due to unusual combinations of morphology, habits, and life history characteristics (Boreman 1997). In 1990, the head of a PS was found at a sport-fish cleaning station in South Dakota, and in 1992 a PS was found dead in a commercial fisherman's hoop net in Louisiana. In 1997, four PS were found in an Illinois fish market (Sheehan et al. 1997). It is probable that PS are affected by the illegal take of eggs for the caviar market. In 1999, a PS that was part of a movement and habitat study on the lower Platte River was harvested by a recreational angler (Service
2000). Bettoli et al. (2008) found 1.8 percent of the total sturgeon catch in Tennessee caviar harvest were composed of PS. In addition, such illegal and incidental harvest may skew PS sex ratios such that hybridization with shovelnose is exacerbated. Killgore et al. (2007) indicated that higher mortality rates for PS in the Middle Mississippi River may be a result of habitat limitation and incidental take by the commercial shovelnose fishery.

Currently, only a sport and/or aboriginal fishery exist for lake sturgeon, due to such low population levels (Todd 1998). SS are commercially harvested in eight states and a sport fishing season exists in a number of states (Mosher 1998). Although information on the commercial harvest of shovelnose sturgeon is limited, Illinois reported the commercial harvest of shovelnose sturgeon was 43,406 lbs (19,689 kg) of flesh and 233 lbs (106 kg) of eggs in 1997 and Missouri reported a 52-year mean annual harvest of 8,157 lbs (3,700 kg) of flesh (Todd 1998) and an unknown quantity of eggs for 1998. Missouri also has a sport fishery for shovelnose sturgeon but has limited data on the quantities harvested (Mosher 1998).

The previous lack of genetic information on the PS and shovelnose sturgeon led to a hybridization debate. In recent years, however, several studies have increased our knowledge of the genetic, morphological, and habitat differences of those two species. Campton et al. (1995) collected data that support the hypothesis that PS and shovelnose sturgeon are reproductively isolated in less altered habitats, such as the upper Missouri River. Campton et al. (2000) suggested that natural hybridization, backcrossing, and genetic introgression between PS and shovelnose sturgeon may be reducing the genetic divergence between those species. Sheehan has identified 86 separate loci for microsatellite analysis that are being used to differentiate between PS, shovelnose sturgeon, and suspected hybrid sturgeon (Service 2000).

Bramblett (1996) found substantial differences in habitat use and movements between adult PS and shovelnose sturgeon in less altered habitats. Presumably, the loss of habitat diversity caused by human-induced environmental changes inhibits naturally occurring reproductive isolating mechanisms. Campton et al. (1995) and Sheehan et al. (1997) note that hybridization suggests that similar areas are currently being used by both species for spawning.

Carlson et al. (1985) studied morphological characteristics of 4,332 sturgeon from the Missouri and middle Mississippi Rivers. Of that group, they identified 11 PS and 12 PS /shovelnose sturgeon hybrids. Suspected hybrids have recently been observed in commercial fish catches on the lower Missouri and the middle and lower Mississippi Rivers (Service 2000). Bailey and Cross (1954) did not report hybrids, which may indicate that hybridization is a recent phenomenon resulting from environmental changes caused by human induced reductions in habitat diversity and measurable changes in environmental variables such as turbidity, flow regimes, and substrate types (Carlson et al. 1985). A study by Keenlyne et al. (1994) concluded that hybridization may be occurring in half the river reaches within the range of PS and that hybrids may represent a high proportion of remaining sturgeon stocks.

Hartfield and Kuhajda (2009) stated that hybridization rates in the Mississippi River have been overestimated, and there is no direct evidence linking the morphological or genetic variation defined as hybridization between PS and shovelnose sturgeon in the lower Missouri, Mississippi, or Atchafalaya Rivers with recent anthropogenic activities. Hybridization could present a threat to the survival of PS through genetic swamping if the hybrids are fertile, and through competition for limited habitat (Carlson et al. 1985). Keenlyne et al. (1994) noted few hybrids showing intermediacy in all characteristics as would be expected in a first generation cross, indicating the hybrids are fertile and reproducing.

Hubbs (1955) indicated that the frequency of natural hybridization in fish was a function of the environment, and the seriousness of the consequences of hybridization depends on hybrid viability. Hybridization can occur in fish if spawning habitat is limited, if many individuals of one potential parent species lives in proximity to a limited number of the other parent species, if spawning habitat is modified and rendered intermediate, if spawning seasons overlap, or where movement to reach suitable spawning habitat is limited (Hubbs 1955). Any of those conditions, or a combination of them, could be causing the apparent breakdown of isolating mechanisms that prevented hybridization between these species in the past (Keenlyne et al. 1994). Hartfield and Kuhajada (2009) examined three of the five original specimens used to describe the pallid sturgeon and found that the character indices currently used to distinguish the fish identify some of the type specimens as hybrids. In conclusion, they stated they found no evidence directly linking habitat modification and hybridization particularly in the Mississippi River and no evidence that hybridization constitutes an anthropogenic threat to the PS.

More recent studies have documented extensive hybridization between PS and shovelnose sturgeon in the Lower Mississippi River (Coastal Plain Management Unit) (Jordan et al. 2019). These studies also confirmed that small numbers of genetically pure PS continue to occupy the Lower Mississippi River; however, genetic analysis is required for their accurate identification. Please refer to Section 3.1 Species Description for an explanation of why we consider all phenotypic PS as protected under the Act for the purposes of management and consultation.

Although more information is needed, pollution is also likely an exacerbating threat to the species over much of its range. Pollution of the Missouri River by organic wastes from towns, packing houses, and stockyards was evident by the early 1900s and continued to increase as populations grew and additional industries were established along the river. Due to the presence of a variety of pollutants, numerous fish-harvest and consumption advisories have been issued over the last decade or two from Kansas City, Missouri, to the mouth of the Mississippi River. That distance represents about 45 percent of the PS total range. Currently there are no advisories listed by the U.S. Environmental Protection Agency (EPA) south of Tennessee (approximately 710 miles).

Polychlorinated biphenyls (PCBs), cadmium, mercury, and selenium have been detected at elevated, but far below lethal, concentrations in tissue of three PS collected from the Missouri River in North Dakota and Nebraska. Detectable concentrations of chlordane, dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyltrichloroethane (DDT), and dieldrin also were found (Ruelle and Keenlyne 1994). The prolonged egg maturation cycle of PS, combined with bioaccumulation of certain contaminants in eggs, could make contaminants a likely agent adversely affecting eggs and embryos, as well as development or survival of fry, thereby reducing reproductive success.

In examining the similarities and differences between shovelnose sturgeon and PS, Ruelle and Keenlyne (1994) concluded that, while the shovelnose sturgeon may not meet all the traits desired for a surrogate, it may be the best available for contaminant studies. Conzelmann et al. (1997) reported that trace element concentrations in Old River Control Complex (ORCC) shovelnose sturgeon in Louisiana were generally higher than in shovelnose sturgeon from other areas. Certain trace elements can adversely affect reproduction, development, and may ultimately be lethal if concentrations are excessive. Most trace element levels were unremarkable; however, cadmium, copper, lead, and selenium concentrations were elevated in
ORCC samples and may warrant concern (Conzelmann et al. 1997).

Conzelmann et al. (1997) also reported that organochlorine (OC) pesticide concentrations are the main environmental concern in Louisiana's shovelnose sturgeon, and consequently, in the PS. Shovelnose sturgeon OC concentrations were generally greater than were observed in fishes from other areas, and ORCC shovelnose sturgeon toxaphene levels were elevated compared to the National Contaminants Biomonitoring Program. Toxaphene possesses known carcinogenic, teratogenic, xenotoxic, and mutagenic properties; can cause suppression of the immune system; and may function as an endocrine system imitator, blocker, or disrupter
(Colburn and Clements 1992). Those factors make toxaphene the greatest OC concern in ORCC SS and, by extension, the ORCC PS (Conzelmann et al. 1997). Further investigations are needed to identify contaminant sources in the Mississippi and Atchafalaya Rivers and to assess the role, if any, of contaminants in the decline of PS populations.

Another issue that is negatively impacting PS throughout its range is entrainment. The loss of PS associated with water intake structures has not been accurately quantified. The EPA published final regulations on Cooling Water Intake Structures for Existing Facilities per requirements of Section 316(b) of the Clean Water Act. The rule making was divided into three phases. However, only Phase I and II appear applicable to inland facilities; Phase III applies to coastal and offshore cooling intake structures associated with coastal and offshore oil and gas extraction facilities. The following rule summaries are based on information found at https://www.epa.gov/cooling-water-intakes. Phase I rules, completed in 2001, require
permit holders to develop and implement techniques that will minimize impingement mortality and entrainment. Phase II, completed in 2004, covers existing power generation facilities that are designed to withdraw 50 million gallons per day or more with 25 percent of that water used for cooling purposes only. Phase II and the existing facility portion of Phase III were remanded to EPA for reconsideration and a final rule combined the remands into one rule in 2014. This rule, implemented through National Pollutant Discharge Elimination System permits, is intended to minimize negative effects associated with water cooling structures.

Section 316(b) of the Clean Water Act requires the EPA to ensure that aquatic organisms are protected from impingement or entrainment. As part of the Phase II ruling, some power plants have begun conducting required entrainment studies. Preliminary data on the Missouri River suggests that entrainment may be a serious threat that warrants more investigation. Initial results from work conducted by Mid-America at their Neal Smith power facilities found hatchery-reared PS were being entrained (Jordan in litt. 2006; Ledwin in litt. 2006; Williams in litt. 2006). Over a 5-month period, four known hatchery-reared PS have been entrained, of which two were released alive and two were found dead. Ongoing entrainment studies required by the Clean Water Act will provide more data on the effects of entrainment. However, addressing entrainment issues may not occur immediately and continued take of hatchery reared or wild PS will limit the effectiveness of recovery efforts.

In addition to cooling intake structures for power facilities, concerns have been raised regarding entrainment associated with dredge operations and irrigation diversions. Currently little data are available regarding the effects of dredge operations. However, the USACE St. Louis District, and the Dredging Operations and Environmental Research Program have initiated work to assess dredge entrainment of fish species and the potential effects that these operations may have on larval and juvenile *Scaphirhynchus*. Data for escape speed, station-holding ability, rheotaxis and response to noise, and dredge flow fields are being used to develop a risk assessment model for entrainment of sturgeon by dredges. Entrainment has been documented in the irrigation canal supplied by the Intake Dam on the Yellowstone River (Jaeger et al. 2004). Given that entrainment has been documented to occur in the few instances it has been studied, further evaluation of entrainment at other water withdrawal points is warranted across the PS range to adequately evaluate this threat. Entrainment of PS stocked in the Mississippi River into the Atchafalaya River via the ORCC has been documented by the capture of a tagged stocked sturgeon that was released into the Mississippi River.

BOs which allow the take of PS also represent a factor that should be considered when examining factors that could have an influence on the PS population.

2.2.2 Environmental baseline

2.2.2.1 Species presence and use

The PS is endemic to the turbid waters of the Missouri River and the Lower Mississippi River (Wildhaber et al., 2007). Extensive sampling in the lower Mississippi River was undertaken by the ERDC so that a better understanding of population size, population density, habitat preference, extent of range in lower Mississippi River, and impacts from entrainment.

After accounting for survival, movement, and habitat use, ERDC estimated that the total abundance of age-3+ PS in the Lower and Middle Mississippi River is at least 3,400-4,100 with probability 0.99; 5,900-7,000 with probability 0.95; and 17,000-20,000 with probability 0.75 (ERDC-EL, 2013).

2.2.2.2 Species conservation needs within the action area

The following information was taken from the USFWS Biological Opinion, Mid-Barataria Sediment Diversion which can be found in Attachment 5 and all citations can be found in that document.

The action area conservation needs and threats would be among those previously discussed, but would include only those pertaining to the southern portion (LMR) of the species' range as previously described. This section of the river has been heavily modified for the purposes of navigation and has few remaining natural features necessary for the PS. Contaminants in water, sediments, or prey species could float down river and be in the vicinity of the action area which could affect any PS present.

While the Action Area would occur at RM approximate mile 149 to approximate mile 140 of the MSR, in other areas of the MSR other diversion structures are in operation that either are known to (Old River Control Complex and Bonnet Carré Spillway) or are suspected to (Caernarvon and Davis Pond) entrain PS. Since the PS has been listed, the Bonnet Carré Spillway has been opened nine times (1994, 1997, 2008, 2011, 2016, 2018, twice in 2019, and 2020). Entrainment rates of PS through the Bonnet Carré Spillway depend on water volume and velocity through structure, length of operation, and time of year of operation. At RM 50, above the Action Area, the USACE constructs a temporary sand weir using dredge material during low water months to manage salinity. It is believed that individuals below the temporary weir may be lost from the population due to low quality habitat as well as seasonal inhibition to upstream movement due to the weir.

2.2.2.3 Habitat condition (general)

This section of the river has been heavily modified for the purposes of navigation and has few remaining natural features necessary for the PS. Contaminants in water, sediments, or prey species could float down river and be in the vicinity of the action area which could affect any PS present. However, the LMR offers some of the PS's preferred habitat. It is a large, turbid river with diverse assemblages of PS habitats can generally be described as large, free-flowing, warm water, turbid river habitats with a diverse assemblage physical attributes. Floodplains, backwaters, chutes, sloughs, islands, sandbars and main channel waters form the large river ecosystem that provide the macrohabitat requirements for all life stages of PS.

PS are thought to occupy the sandy main channel in the Mississippi river, but also are collected over gravel substrates (Service 2014a; Bramblett and White 200l; Hurley et al. 2004; Garvey et al. 2009; Koch et al. 2012). Recent telemetry monitoring of adult PS in the LMR indicates use of most channel habitats, including dikes, revetment, islands, secondary channels, etc. (Kroboth et al. 2013; Herrala et al. 2014). Islands and secondary channels are important in recruitment of larval sturgeon in the LMR (Hartfield et al. 2013). PS in the LMR have been collected at depths greater than 65 ft with a mean value of 32.81 ft, and water velocities greater than 5.91 ft/s with a mean value of

2.30 ft/s (ERDC unpublished data; Herrala et al. 2014). Turbidity is thought to be an important factor in habitat selection by PS (Blevins 2011). In the LMR, PS have been collected in turbidities up to 340 Nephelometric Turbidity Units (NTU's) with a mean value of 90 NTU's (ERDC unpublished data).

2.2.2.4 Influences

Influences in the action area include MSR modifications, other diversions on the MSR, maintenance dredging in the MSR, and cooling water intake structures for existing facilities along the MSR. These influences have both direct and indirect impacts on the PS. Section 2.2.1.4 of this BA discusses these influences and the effects they might have on the PS.

2.2.2.5 Additional baseline information

There is no additional baseline information.

2.2.3 Effects of the action

2.2.3.1 Indirect interactions

Indirect impacts to PS would result from construction activities stirring up pollutants, contaminants, and debris. As stated in section 2.2.1.4 of this BA, this could result in adverse impacts to eggs and embryos, as well as development or survival of fry. Certain trace elements can adversely affect reproduction, development, and may ultimately be lethal if concentrations are excessive. Toxaphene possesses known carcinogenic, teratogenic, xenotoxic, and mutagenic properties; can cause suppression of the immune system; and may function as an endocrine system imitator, blocker, or disrupter (Colburn and Clements 1992). There is potential of PS colliding with debris if any becomes un-lodged or introduced into the MSR. This could result in injury or death.

2.2.3.2 Direct interactions

The following information was taken from the USFWS Biological Opinion, Mid-Barataria Sediment Diversion which can be found in Attachment 5 and all citations can be found in that document.

Adult and subadult PS are relatively abundant in the proposed area and could be directly affected by the proposed diversion due to construction activities including noise, vibration, and presence of construction personnel and equipment.

PS are known to occur within the Mississippi River near the MSA-2 intake structure. During construction activities in the Mississippi River, such as dredging, vessel operations, pile driving and pier construction, there is a potential to disturb or injure PS near the action area. These sounds would be added to the baseline sound conditions of the Mississippi River. Noises from natural sources, such as wind-driven waves, storms, fish, currents, and vocalizing marine mammals are represented as ambient underwater sound levels. Underwater noise levels increase when anthropogenic sources are added to ambient noises. Anthropogenic underwater sound in the Mississippi River could be generated by fishing and recreational vessels, large commercial vessels, pile-driving, and dredging.

Collaboratively, NOAA, the Service, and the U.S. Federal Highway Administration established underwater sound levels for noise thresholds for fish behavior disruption and injury. “Effective quiet” or safe exposure levels recognized by the NMFS are as low as 150 decibels (dB); therefore, sounds below that level of effective quiet will not harass fish (NMFS 2016b). In-water construction and maintenance activities could potentially increase underwater sound levels. While vessel operations that occur in the river could produce in-water noise disturbance, those noise levels are less than the injury effects threshold (i.e., 206 dBPEAK) and are composed of a different sound signature than pile driving activities.

Underwater noise calculations for impact pile driving in the Mississippi River are expected to produce underwater sound levels of up to 208 dBPeak, 190 dBRMS, and 180 dB SEL, while vibratory pile driving is expected to produce underwater sounds levels of 182 dBPeak, 165 dBRms, and 165 dB SEL (NOAA 2018). Over a duration of approximately 2 months, an unknown number of pilings are anticipated to be installeed for construction of the temporary dock and pier and up to 32 sheet piles are proposed to be installed for the temporary cofferdam construction. These pile driving activities will occur in the river and the batture using impact pile driving.

Underwater sounds that would be generated from impact pile driving activities to construct a pier and the cofferdam may be encountered by sturgeon within 3,281ft of these activities which could potentially injure those sturgeon, while behavioral impacts could extend to approximately 15,230 ft. The sounds from the impact pile driving activities would be the loudest underwater sound the species will encounter. These activities will be located along the eastern bank of the Mississippi River, where the river is approximately one-half mile wide near RM 43, which might not allow for unobstructed passage by fish through the areas of higher noise. Barotraumas (injuries caused by pressure waves, such as hemorrhage and rupture of internal organs), temporary stunning, and alterations in behavior are known to be caused by high underwater sound pressure levels (SPL) which can injure and/or kill fish (Turnpenny et al. 1994, Turnpenny and Nedwell 1994, Popper 2003, Hastings and Popper 2005). Sturgeon have swim bladders which makes them more susceptible to barotraumas from impulsive sounds than fish without swim bladders. Juvenile white sturgeon have been found to be more susceptible to barotrauma after initial feeding due to the potential for herniation in their intestines. While the swim bladders partially inflate later in development because of the physiology of the swim bladder in sturgeon, gas transfers from the swim bladder can be released through the sturgeon’s mouth (Brown et al. 2013).

Although behavioral responses in fish due to elevated underwater sound are not well understood, the responses could include a startle response, delayed foraging, or avoidance of the area. Feist et al. (1992) found that broad-band pulsed noise, such as impact pile driving noise, rather than continuous, pure tone noise like vibratory pile driving were more effective at altering fish behavior. Studies found that juvenile salmonids (40- to 60-millimeter in length) exhibit a startle response followed by an adjustment to low frequency noise in the 7 to 14 hertz (Hz) range (Knudsen et al. 1992 and 1994, Mueller et al. 1998). Those same studies also showed that noise intensity level must be 70 dB to 80 dB above the hearing threshold of 150 Hz to achieve a behavior response. To produce a behavioral response in herring, Olsen (1969) found ambient sound must be at least 24 dB less than the minimum audible field of the fish, and pile driving noise levels have to be 20 dB to 30 dB higher than sound levels. Juvenile sturgeon and herring are of similar size; therefore, herring can serve as a surrogate. Behavioral responses of PS are expected to be short-term and intermittent while construction is being conducted (approximately 8-12 hours/day).

A temporary cofferdam with a maximum bottom width of approximately 140-foot would be constructed to isolate approximately 4 acres of the Mississippi River batture, of which about 3 acres of the isolated area will be excavated for the intake structure development. The isolated area of the river using the cofferdam could reduce habitat available to sturgeon, and any fish within the cofferdam area during installation may be lost. Temporary construction activities of the MSA-2 could potentially alter PS habitat downstream, such as scour holes, sandbars, and flow refugia, due to the alteration of the Mississippi River flow volumes downstream of the construction area; however, because of the dynamic system of the river these alterations are not likely to be significant. Habitats used by larvae, juveniles, or migrating adults could be altered but spawning habitat for PS is not known to occur in the area of the river near the proposed project area so spawning habitat will not be altered.

A temporary dock and pier would be constructed for material and equipment offloading. Over a duration of approximately 1 month, pilings are proposed to be installed in the river and batture using impact hammer pile driving. Prior to driving piles, pre-excavation of pile drive lines would occur to identify and remove obstructions. Over a duration of approximately 3 months, a total of approximately 100 cy of material are proposed to be excavated from the river and batture using a barge mounted bucket dredge.

Studies have collected PS from a range of turbidity conditions, including highly altered areas with consistently low turbidities (i.e., 5-100 nephelometric turbidity units (NTU)) to comparatively natural systems such as the Yellowstone River that has seasonally high turbidity levels (>1,000 NTU) (Braaten and Fuller 2002, 2003; Erickson 1992, Jordan et al. 2006, Peters and Parham 2008). Highly turbid river systems such as the Mississippi River are components of natural ecological processes in which PS evolved. Therefore, increased turbidity in the river from the construction activities is not anticipated to directly impact the PS.

PS would also be directly impacted by the operation of the diversion by way of entrainment. This impact would be reoccurring over the 50-year project life. Juvenile PS are assumed to have a “low” entrainment risk due to low likelihood of their occurrence in the project area. There is an assumed “medium” risk of entrainment by adults and subadults due to the likelihood of presence and their relatively low burst swimming speeds compared to intake velocities (Kirk et al., 2008).

2.2.4 Cumulative effects

ESA defines cumulative effects as those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation. That being said, the USACE is not aware of any projects within the action area that would contribute to cumulative impacts to the PS.

2.2.5 Discussion and conclusion

As previously discussed, the PS would be directly impacted during construction and during operation of the MSA-2. These impacts would be through potential injury due to noise, collision with construction equipment, and entrapment. Due to the likelihood of impacts during construction and operation of the MSA-2, and the fact that the impact would be recurring of the 50-year project life, the USACE has made a May affect and is likely to adversely affect determination for the PS due to the construction and operation of MSA-2.

2.3 West Indian Manatee

2.3.1 Status of the species

2.3.1.1 Legal status

The West Indian manatee, Trichechus manatus, was listed as endangered throughout its range for both the Florida and Antillean subspecies (T. manatus latirostris and T. manatus manatus) in 1967 (32 FR 4061) and received federal protection with the passage of the ESA in 1973. In 2017 the West Indian manatee was reclassified as threatened throughout its range.

2.3.1.2 Recovery plans

Reduce or remove threats to manatee habitat or range, as well as threats from natural and manmade factors by enacting and implementing federal, state or local regulations. Further detail can be found in the Florida Manatee Recovery Plan found in Attachment 6.

2.3.1.3 Life history information

The following information was taken from the ECOS website on 12/3/2021.

Habitat

Florida and Antillean manatees range freely between marine and freshwater habitats. Specific habitat types/use areas include foraging and drinking sites, resting areas, travel corridors and others. Florida manatees, living at the northern limit of the species' range, have little tolerance for cold. Historically, this sub-species has sought out natural, warm-water sites, including springs, deep water areas, and areas thermally influenced by the Gulf Stream, as refuges from the cold. In the 1930s and 40s, industrial plants, including power plants, paper mills, etc., were built along coastal and riverine shoreline areas. Plants discharging large volumes of heated discharge water into areas accessible to manatees have attracted large numbers of wintering manatees to these warm-water sites ever since. In the spring, manatees leave the warm-water sites and may travel great distances during the summer, only to return to warm water sites in the fall.

Movement

The Florida manatees' range is generally restricted to the southeastern United States; individuals occasionally range as far north as Massachusetts and as far west as Texas. Antillean manatees are found in coastal and riverine systems in South and Central America (from Brazil to Mexico) and in the Greater and Lesser Antilles throughout the Caribbean Basin. Due to a variety of human activities (hunting, loss of habitat, etc.), manatees have been extirpated from many areas and their distribution is patchy throughout the region. USFWS recovery activities primarily focus on manatees in Florida and Puerto Rico, although the species is managed throughout its range.

Feeding

Manatees are herbivores that feed opportunistically on a wide variety of marine, estuarine, and freshwater plants, including submerged, floating, and emergent vegetation. Common forage plants include and are not limited to: cord grass, alga, turtle grass, shoal grass, manatee grass, eel grass, and other plant types. (Calves initially suckle and may start feeding on plants when a few months of age. Weaning generally takes place within a year of birth.) Manatees also require sources of freshwater, obtained from both natural and anthropogenic sources.

2.3.1.4 Conservation needs

According to ECOS, there is no Conservation Plan currently available for this species. However, there are general best management practices and avoidance measures that when implemented would avoid/reduce impacts to the species.

2.3.2 Environmental baseline

2.3.2.1 Species presence and use

The manatee is not a year-round resident in Louisiana, but it may migrate there during warmer months. Sightings of West Indian manatees in Louisiana have occurred in the Amite, Blind, Tchefuncte, Tickfaw, and Atchafalaya rivers, the MRGO, Lake Maurepas, Lake Pontchartrain, and in canals within the adjacent coastal marshes. There are no known sightings of West Indian manatee in Hope Canal. Manatees have not been recorded in the Mississippi River within the vicinity of the intake structure (Fertl et al., 2005; LDWF, 2020a, pers. comm.).

2.3.2.2 Species conservation needs within the action area

According to ECOS, there is no Conservation Plan currently available for this species. However, the manatee avoidance measures discussed in section 1.5 of this BA would be implemented during construction.

2.3.2.3 Habitat condition (general)

The manatee is not a year-round resident in Louisiana, but it may migrate through the action area during warmer months. The action area offers warm fresh water and submerged vegetation for feeding during migration.

2.3.2.4 Influences

Cold stress is an increasing concern with the West Indian manatee due to climate change. During winters 2009–2010 and 2010–2011, unusually cold temperatures occurred in many parts of Florida resulting in increased mortality of Florida manatees. (Hardy et al, 2019) Cold stress stems from physiological events and diseases initiated by cold water and manatees' limited ability to adapt to low temperature extremes. An article published in Science Daily suggests that the animal's metabolism slows, leading to digestion problems, decreased appetite, and associated weight loss. These events, along with the possible release of certain hormones, weaken manatees' immune systems, making them vulnerable to environmental toxins as well as a variety of diseases, including pneumonia, intestinal infections. (Science Daily, 2003)

2.3.2.5 Additional baseline information

There is no additional baseline information.

2.3.3 Effects of the action

2.3.3.1 Indirect interactions

Increased turbidity could occur during construction of the weirs in Bourgeois Canal and Bayou Secret and the embankment cuts in the existing RR ridges but would be reduced by the movement of the tides. Additionally, any manatee that might be present would likely avoid the construction area and therefore would not be impacted by the increase in turbidity. The operation of the diversion is anticipated to slightly increase turbidity in the western most portion of Lake Maurepas. This would continue throughout the life of the project. As discussed in section 2.3.1.3 of this BA, manatee forage on marine, estuarine, and freshwater plants, including submerged, floating, and emergent vegetation. The permanent increase in turbidity could impact the light source beneath the water surface and therefore the food source for the manatee. However, this increase in turbidity would not be much different from the naturally occurring increase in turbidity during heavy rains and heavy fiver flow into the lake.

2.3.3.2 Direct interactions

Direct interactions with manatees would be avoided/minimized by implementing the avoidance measures discussed in section 1.5 of this BA. A temporary direct impact by way of avoidance due to presence of construction activities is possible.

2.3.4 Cumulative effects

ESA defines cumulative effects as those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation. That being said, the USACE is not aware of any projects within the action area that would contribute to cumulative impacts to the West Indian manatee.

2.3.5 Discussion and conclusion

Conservation measures discussed in section 1.5 would be implemented to avoid/minimize direct impacts. Most of the indirect impacts would be temporary due to species avoiding the area during construction and slight increase in turbidity at the construction site. There could be permanent indirect impacts due to a slight increase in turbidity in Lake Maurepas during operation. This permanent increase in turbidity could potentially impact the food source of the manatee. However, this increase in turbidity would not be much different from the naturally occurring increase in turbidity during heavy rains and heavy fiver flow into the lake. Based on available scientific data, USACE has made the determination that the MSA-2 may affect but is not likely to adversely affect the west Indian manatee.

3 Critical Habitat Effects Analysis

No critical habitats intersect with the MSA-2 action area.

4 Summary Discussion, Conclusion, And Effect Determinations

4.1 Effect Determination Summary

SPECIES (COMMON NAME)	SCIENTIFIC NAME	LISTING STATUS	PRESENT IN ACTION AREA	EFFECT DETERMINATION
Gulf Sturgeon	*Acipenser oxyrinchus (=oxyrhynchus) desotoi*	Threatened	Yes	NE
Pallid Sturgeon	*Scaphirhynchus albus*	Endangered	Yes	LAA
Red-cockaded Woodpecker	*Picoides borealis*	Endangered	No	NE
West Indian Manatee	*Trichechus manatus*	Threatened	Yes	NLAA

4.2 Summary Discussion

As previously discussed, the MSA-2 would slightly increase the turbidity in Lake Maurepas near the mouth of the blind river. GS migrate through Lake Maurepas and into the Blind River during their migration to the Amite River. This increase in turbidity would be no different from the increase in turbidity during high rain events and high river flow. Also previously stated, the GS does not forage during the in and out migration through Lake Maurepas and so the increase in turbidity would have no impact on foraging. Because a slight increase in turbidity in Lake Maurepas would have minimal to no impact on the GS, the USACE has made the determination that the MSA-2 would have no effect on the GS.

The PS would be directly impacted during construction and during operation of the MSA-2. These impacts would be through potential injury due to noise, collision with construction equipment, and entrapment during operations. Avoidance measures discussed in section 1.5 would be implemented during construction to minimize direct impacts. Conservation measures discussed in section 1.5 would be implemented to minimize impacts. Due to the likelihood of impacts during construction and operation of the MSA-2, and the fact that potential entrapment would be recurring of the 50-year project life, the USACE has made a May affect and is likely to adversely affect determination for the PS due to the construction and operation of MSA-2.

Conservation measures discussed in section 1.5 would be implemented to avoid/minimize direct impacts to the West Indian manatee. Most of the indirect impacts would be temporary due to species avoiding the area during construction and slight increase in turbidity at the construction site. There could be permanent indirect impacts due to a slight increase in turbidity in Lake Maurepas during operation. However, those permanent impacts would be lessened by regular tidal exchange and would be no more than the natural increase in turbidity from high river flow into the lake. USACE has made the determination that the MSA-2 may affect but is not likely to adversely affect the west Indian manatee.

4.3 Conclusion

Based on best scientific and commercial data available, USACE has made the following determinations. The MSA-2 would have no effect on the Gulf sturgeon; may affect but not likely to adversely affect the West Indian Manatee; May affect and would likely adversely affect the pallid sturgeon. There would be no effect to critical habitat as it does not exist within the action area.

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ATTACHMENT 1

PROJECT DESCRIPTION

This document is currently under review and subject to minor changes.

Mississippi River Valley Division,
Regional Planning and Environment Division South

Supplemental Environmental Impact Statement to West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study

Appendix F – Project Description Continued

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Project Description Continued

1. EARTHWORK

Required earthwork would consist of clearing, grubbing, excavation, and removal of approximately 1,279,232 CY of earthen material for the proposed diversion's conveyance channel and disposal at an approved disposal site. If a borrow study in subsequent design phases indicates sufficient suitability within the excavated material, the Contractor may elect to use that material on-site. Any material used on site would stay within the right-of-way (ROW) and would be used to construct features as described in the Plans and Specs. Most of the fill material used throughout the proposed construction area would be imported from an USACE approved borrow sources as described in SEA 571.

Table 1: Material Quantities.

Activity	Cubic Yards (CY)	Description
Excavation	1,279,232	Intake channel, conveyance channel, outfall channel, and all crossings.
Excavation	5,345	Embankment cuts where spoil would not be removed
Fill	756,060	Intake channel, conveyance channel, outfall channel, and all crossings.

Project features within the construction ROW would be cleared, grubbed, and graded to establish a stable base upon which to construct. With the relatively flat topography of the area, the primary erosion control measure used would be silt fencing around all affected areas during construction and a turbidity curtain adjacent to the river. Seeding and grassing would also be conducted on compacted earthen slopes and areas disturbed by construction activity at the end of construction. Other erosion control measures may be implemented as needs are identified.

Embankment cuts would be established north of the conveyance channel in the northern part of the swamp. The cuts would occur along the existing ridge of an old railroad embankment. Water must be circulated throughout the swamp to reestablish the vitality of the wetland vegetation. Water movement into the northwest corner of the swamp is restricted by an embankment that was constructed decades ago to support a defunct Cypress logging railroad spur. Access to the embankment would be from the north, via a small reach of waterway from Blind River. The waterway ends at a stand of trees, which will require removal. There would be no clearing on or near Blind River itself (Figure 2). To establish the cuts, 7.51 acres along the old railroad embankment would be cleared for equipment access, 5 individual areas along the embankment would be excavated to existing grade to allow for water flow while all spoil would be placed in 20 individual areas along the embankment. It is anticipated that no material would be removed from the proposed construction area (Figure 1).

In order to limit the amount of diverted Mississippi River water from entering into Blind River, two submerged riprap weir features in Bayou Secret and Bourgeois Canal would be constructed. These submerged weirs would be constructed within each channel and set back from Blind River to allow shallow draft watercraft to still navigate to and from Blind River.

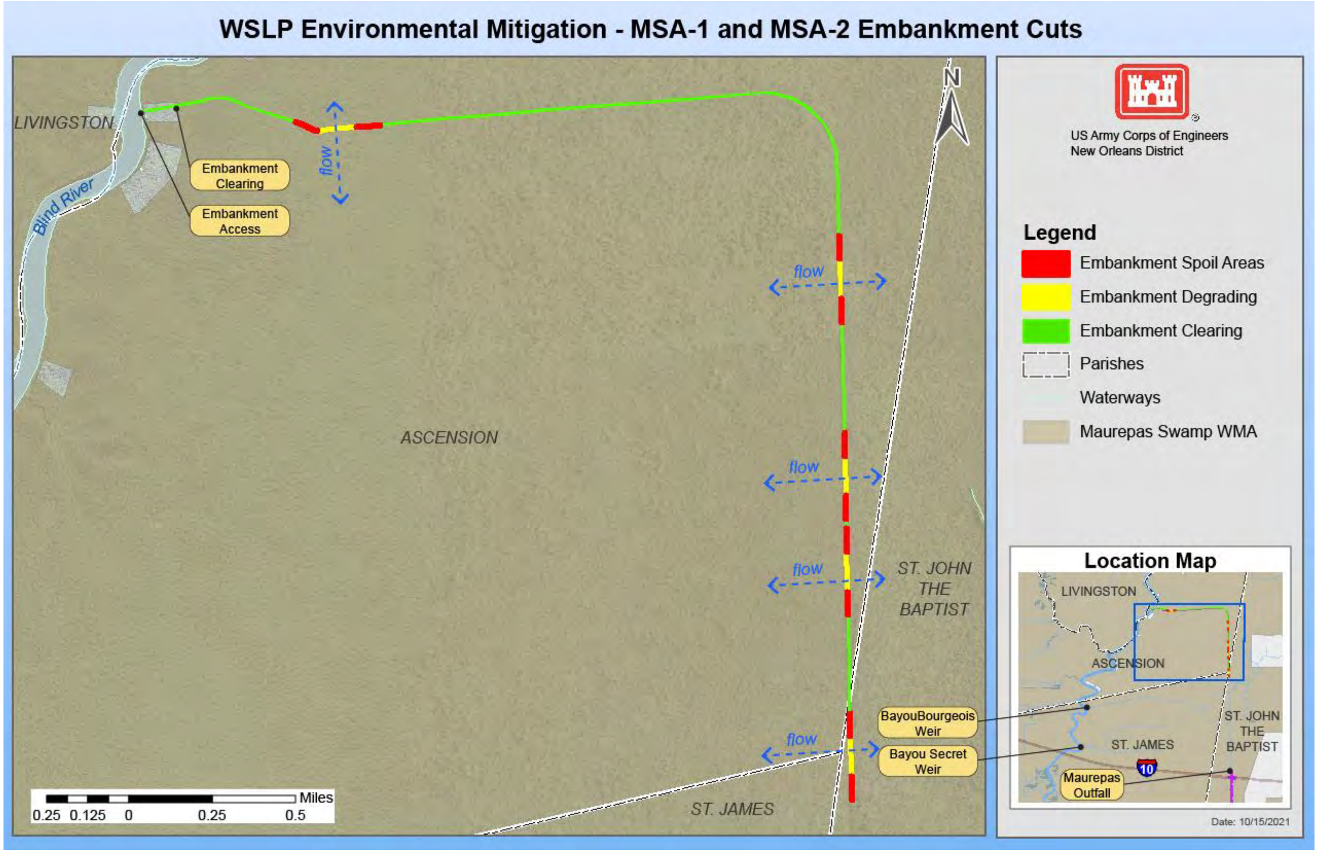


Figure 1: MSA-1 and MSA-2 Embankment Cuts.

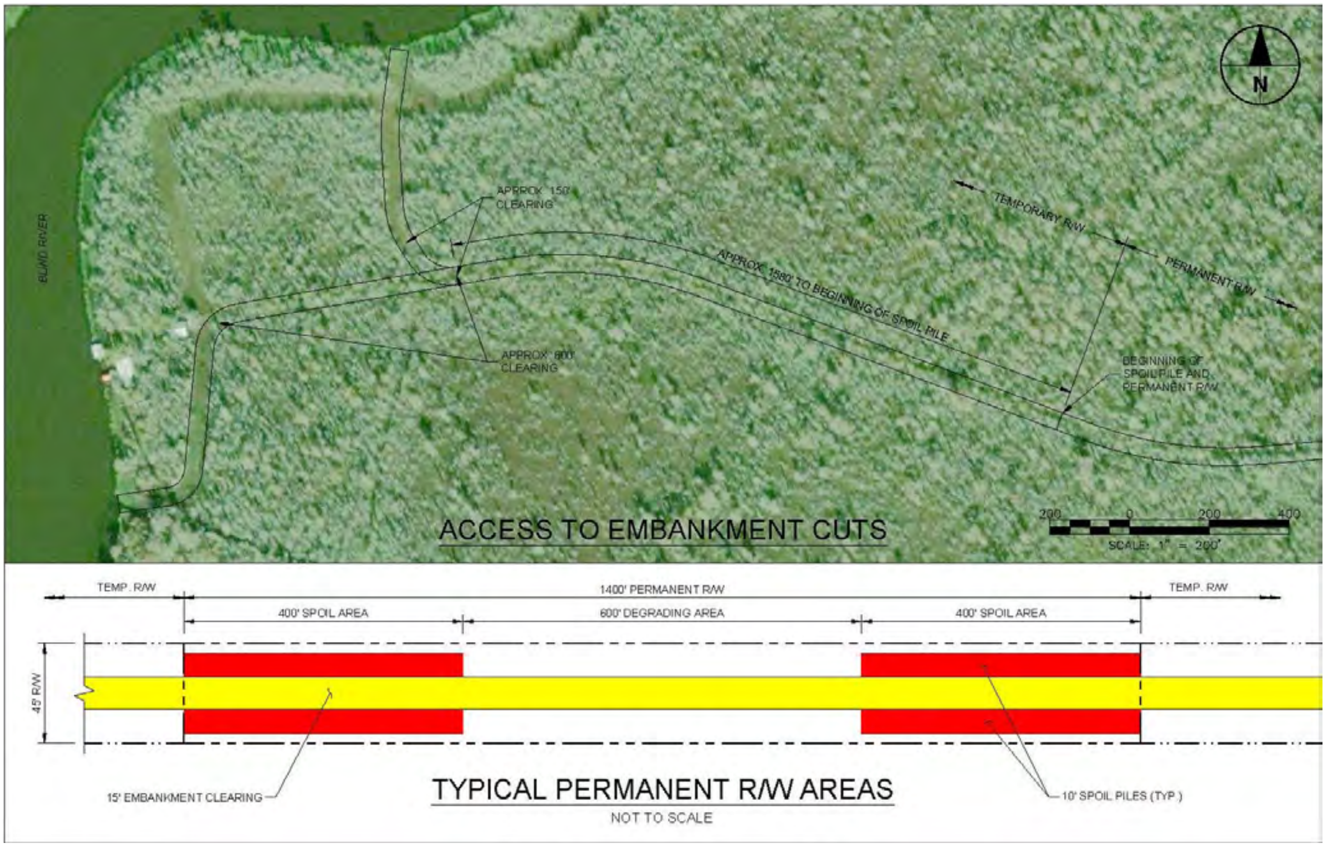


Figure 2: MSA-1 and MSA-2 Embankment Cut Access.

2. CONSTRUCTION METHODS, TIMING, AND SEQUENCE:

The following are the assumptions about equipment, methodology, and durations:

- Construction Duration would be 33 months.
- Construction is scheduled for 5 days a week, 8 hours a day.
- A haul road would be used for clearing and grubbing.
- Two Entergy transmission poles would be reinstalled, and the line will need to be raised due to elevation adjustment from construction.
- Headworks cofferdam would be constructed using a barge with a combination of land support.
- Pumps and sediment basins would be used to manage water for construction.
- Most of the fill material used throughout the project would be imported from an USACE approved borrow pit.
- Any excavated material not suitable for project construction would be removed from the site and appropriately discarded. This would likely be the case for most of the material excavated from the project site.
- Excavated material suitable for construction could be left on the site. Such material would be worked to obtain the proper moisture content, and could mixed with imported

material, to meet the USACE requirements for levee construction. The excavated material worked and/or mixed with imported material to the required technical specifications could be used for levee construction according to the final designs and specifications. All such working and/or mixing of materials would take place within the designated staging areas.

- Table 2 details the equipment anticipated to be utilized and the utilization duration by location for the construction of the MSA-1 or MSA-2 /WSLP Project.

Table 2: Equipment Anticipated to be Utilized and Utilization Duration by Location.

Item No.	Project Component	Duration (days)	Equipment Used
1	**River Side of Levee**		
1a	Cofferdam	111	Dump Trucks
			Bull Dozers
			Fuel Tanks
			Pumps
			Air Compressor
			Fill Compactor
			Front-End Loader/Backhoe
			Auger Equipment
			Generator
1b	Headworks Structure	280	150-Ton Crane
			80-Ton Crane
			Excavator
			Pile Driver
			Concrete Trucks
			Concrete Vibrators
			Welding Machine, Cutting Torch
1c	River Intake	150	Dump Trucks
			Bull Dozers
			Fuel Tanks
			Front-End Loader/Backhoe
			80-Ton Crane
			Barges
			Tug Boats
2	**Conveyance Channel**		
	Pump Sta. to End of Project	427	Dump Trucks
			Bull Dozers
	River Rd to CN RR	129	Fuel Tanks
			Pumps
	CN RR to KCS RR	319	Air Compressor
			Fill Compactor
	KCS RR to Airline Hwy	126	Front-End Loader/Backhoe
			Auger Equipment
	Airline Hwy to Pump Sta.	229	Generator
	Sedimentation Basin	178	Tree Sheer
3	**Roadways**		Jackhammers
	River Rd Detour	153	Dump Trucks
	River Rd Restoration	180	Bull Dozers
	Airline Hwy Detours	300	Fuel Tanks

Item No.	Project Component	Duration (days)	Equipment Used
			Asphalt Mixing Trucks
	Airline Hwy Reconstruction	204	Asphalt Laying Equipment
			Asphalt compaction equipment
	Airline Hwy Raise	300	Dump Trucks
			Bull Dozers
			Fuel Tanks
			Fill Compactor
			Front-End Loader/Backhoe
			Auger Equipment
			Generator
4	**Flood Wall**		150-Ton Crane
	River Road to CN RR	180	80-Ton Crane
			Excavator
			Pile Driver
			Concrete Trucks
			Concrete Pumps
			Concrete Vibrators
			Welding Machine, Cutting Torch
5	**Levees**		Dump Trucks
	CN RR to KCS RR	289	Bull Dozers
			Fuel Tanks
	KCS RR to Airline Hwy	149	Fill Compactor
			Front-End Loader/Backhoe
	Airline Hwy to Pump Station	246	Auger Equipment
			Generator
6	**Floodgates**		
	River Road Floodgate	118	80-Ton Crane
			Excavator
			Pile Driver
	CN RR Floodgate	150	Concrete Mixing Trucks
			Concrete Pumps
	KCS RR Floodgate	210	Concrete Vibrators
			Welding Machine, Cutting Torch
7	**Culverts & Headwalls**		150-Ton Crane
	CN RR Crossing	167	80-Ton Crane
			Excavator
	KCS RR Crossing	227	Pile Driver
			Concrete Mixing Trucks
			Concrete Pumps
	Airline Hwy Crossing	236	Concrete Vibrators
			Welding Machine, Cutting Torch
8	**Railroads**		150-Ton Crane
	CN Shoo-fly & RR Removal	239	80-Ton Crane
			Excavator
	CN Reconstruct Railroad	124	Pile Driver
			Concrete Mixing Trucks

Item No.	Project Component	Duration (days)	Equipment Used
			Concrete Pumps
	KCS Railroad Bridge	250	Concrete Vibrators
			Welding Machine, Cutting Torch
9	**Interstate 10 Crossing**	148	Dredge Vessel
			Hydraulic Dredge
			Dump Trucks
10	**Utilities Relocations**	378	Excavator
			HDD Drill Rig
11	**Embankment Cuts**	41	Compact Excavators
			Marsh Pull Buggy
			Tree Chipper
			Flatboats
12	**Weirs at B. Secret & B. Canal**	20	Chain Saws
			Marsh Buggy Excavator
			Tree Chipper
			Flatboats
			30- Ton Crane
13	**I-10 Check Valves**	8	Compact Utility Vehicles (Bobcats)

3. SITE ACCESS:

In general, construction site access would be obtained by both barge and vehicle via the following (Figure 3):

- barge access from the Mississippi River at the intake structure.
- vehicular access at State Hwy-44/River Road.
- vehicular access from Daffodil Street immediately north of CN RR.
- vehicular access from State Hwy 54/ Garyville Northern St. both North and south of KCS RR.
- vehicular access from eastbound and westbound US Hwy 61/Airline Hwy.
- vehicular access from eastbound and westbound Interstate 10.
- barge access from the Hope Canal and Blind River for the embankment cuts and weirs.

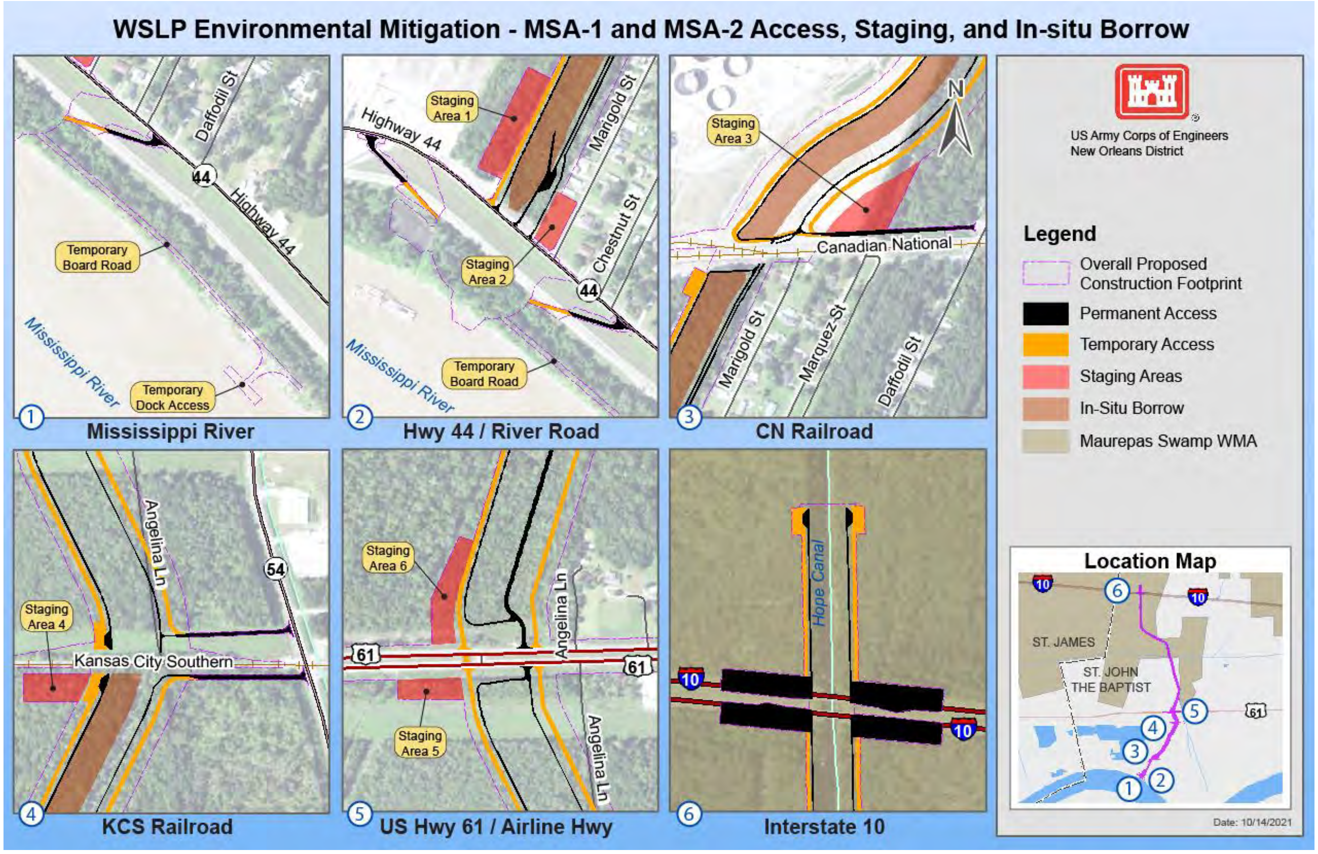


Figure 3: Access, Staging, and In-Situ Borrow Features.

4. STAGING

In general, construction staging areas would be in the vicinity of the site access locations. Staging areas are as follows:

Table 3: Access, Staging, and Borrow Features.

Access, Staging, Borrow	Acres	Description
Permanent Access Roads	**22.53**	Roads to remain after construction.
Temporary Access Roads	**32.83**	Areas to be restored to pre-construction condition after construction.
Temporary Staging Areas	0.79	Area 1 - WSLP River Road to CN RR
	1.95	Area 2 - Diversion Intake System and River Road Crossing
	1.67	Area 3 - North of CN RR
	1.15	Area 4 - South of KCS RR
	0.88	Area 5 - South of Airline Hwy
	1.51	Area 6 - North of Airline Hwy
	7.94	**Total**
In Situ Borrow Areas	7.32	Area between River Rd and CN RR.
	20.53	Area between CN RR and KCS RR.
	27.85	**Total**

5. MAINTENANCE/MANAGEMENT ACTIVITIES

The Project would include various maintenance and inspection activities associated with the head works and secondary features. Maintenance features and a general description of activities are as follows:

- Head Works: inspect and maintain in operable condition
- Sedimentation Basin: dredging and structural maintenance
- Access Roads: maintain in operable condition
- Outfall Channel: mowing, spraying, erosion control, etc.
- Airline Highway Culverts: maintain in operable condition
- I-10 Check Valves: inspect and maintain in operable condition
- Weirs: inspect and maintain in operable condition
- Railroad Embankment Cuts: inspect and maintain in operable condition

Ancillary Channel Maintenance would be conducted as follows:

- Routine inspections would involve visually observing the condition of the ancillary channels. Hydrographic surveying would be conducted periodically (every 5 years). The survey data would be used to evaluate whether deposition or scouring has significantly affected the channel invert elevation or the overall cross-section.
- Maintenance would include the removal of debris and deposited material as needed (every 25 years or based on inspection results).
- Maintenance would include management of invasive species, as needed, when inspections determine that invasive species are adversely affecting the structural integrity and/or functions of the project. Additional information on invasive species management is provided in the MSA-1 and MSA-2 Adaptive Management Plan.

6. BOAT LAUNCH RELOCATION

The WSLP levee and associated Hope Canal drainage features would directly impact access to a boat launch owned and operated by LDWF. This boat launch is located on the very southern portion of Hope Canal near U.S. 61 to allow access to the Maurepas WMA and consists of an earthen parking area with a gravel launch into Hope Canal. The parking area is less than 0.2 acres and can accommodate approximately 6 vehicles and boat trailers. There are no other features or facilities associated with this boat launch.

A replacement boat launch would be located along the western guide levee of the MSA-1 or MSA-2 /WSLP Project just north of U.S. 61 (Airline Hwy.) This would allow for equal public access via boat into the conveyance channel (which follows Hope Canal) and to the LDWF Maurepas WMA. A parking lot to accommodate an equal or greater than number of vehicles and trailers would be constructed.

The current boat launch is closed to recreational access due to WSLP construction activities. The timing for construction for the new, replacement boat launch is uncertain, but would be undertaken as soon as is practicable. Consequently, recreational access at this location may not be available for a maximum of 3 years (the entire construction period for the diversion).

Temporary Dock & Board Road and Cofferdam

Temporary Dock & Board Road

The transport of bulk materials to the project site is part of the Contractor's Means and Methods, so AECOM has not performed the design of project features to enable such material delivery. The recent construction of the Marathon docks across the Maurepas Diversion intake channel prevents the direct delivery of bulk materials such as riprap, piling, etc. from the river. In AECOM's estimation it will still be significantly cheaper to transport large quantities of materials by water, close to the project site, and then carry them overland, than it would be to deliver them directly to the site by land. The substantial savings of delivering the quantities of material by river is believed to more than offset the cost of constructing the temporary dock and board road.

One concept would be the construction of a temporary dock with a board road leading to the project site.

Transfer of barged materials delivered on the River would be by means of the temporary dock constructed immediately downstream from Marathon's second dock. Off-loading of riprap, aggregates, etc. from the barges would be done by excavator(s) working from the dock, and top loading directly onto dump trucks. Dump trucks will then transport the materials to the project site for final placement.

The Contractor would have to obtain a permit approving the design of the dock. The dock would be on the order of 250-ft long x 50-ft wide. It would be connected to the board road by an approximately 180-ft long pier, with an approximately 130-ft radius to enable the dump trucks to execute the required turns.

The temporary dock foundation would be designed using standard procedures for design of pile foundations per the applicable USACE standards. Soil-pile properties would be determined during the design process. Loads to be supported would be determined based on the size and capacity of the cranes, the lateral loading of barges containing construction materials, as well as other equipment that would access the dock during normal construction activities. Steel pipe piles would probably be the preferred foundation support.

The probable general construction sequence for the dock would be:

- Pre-excavate pile drive lines to identify and remove obstructions
- Install pipe pile, either by marine-based, land-based, or some combination thereof pile driving equipment, depending on factors including schedule requirements, cost, sourcing, and delivery
- Install piles by impact hammer to the design tip elevation.
- Install structural steel stringers and cross channel members
- Set precast deck panels
- Install battered timber fender pile
- Install deck curb timbers and safety railing

Pre-Excavation would likely be performed by barge-mounted bucket dredge and would likely take less than 3 months to complete, depending on river conditions. Minimal excavation anticipated (less than 100 cubic yds)

The piles would be installed through the MR revetment, which would require scour protection. The piles penetrating the revetment would have a 10-in thick riprap stone layer over all areas where the bank paving is disturbed. Pile driving will likely take about 1 month to complete. The size of riprap will vary between 6 lbs to 125 lbs, with approximately 50% within the range of 25 lbs to 75 lbs. The dimensions of the protection area would vary with the water depth, ranging from 1.5-ft by 3-ft for up to 10-ft water depths to 3-ft by 8-ft for up to 60-ft water depths.

An approximately 2,000-ft long board road along the batture would enable truck transport of the construction materials from the temporary dock to the project site. A turnaround extension of the board road downriver along the batture, of approximately 24 ft x 70 ft,. Would enable trucks returning from the project site to turnaround so that their beds would face the river side of the dock, ready to accept another load. The board road would be approximately 24-ft wide to enable two-way traffic. The board road section would consist of a geotextile fabric, a 12-in layer of sand, and 6-in layer of crushed stone, upon which the boards would be laid.

Cofferdam

The proposed phased construction of the Cofferdam, Intake Structure, and Headworks are summarized below:

- Phase I – Construct Access Ramps and Partial Cofferdam

  Construct levee access ramps, remove levee slope paving to nearest joint beyond ramps, fill east end of batture pond with select fill, and provide 10-ft bench to toe of Cofferdam at EL +18-ft NAVD88. Fill remainder of pond with site-supplied material to EL +18-ft NAVD88, construct Cofferdam to full width of approximately 140 ft bottom and 10 ft top, at EL +22-ft NAVD88 and drive 65-ft ± sheet piling along Cofferdam C/L flush to EL +22-ft NAVD88.

- Phase II – Completion of Cofferdam Construction

  Complete cofferdam construction to EL +32-ft NAVD88.

- Phase III – By-Pass Roadway and Initial Culvert Construction

  Remove section of MRL landside toe, construct by-pass roadway south of existing River Road, remove section of River Road. Install sheet piling for excavation on north side of by-pass, excavate, construct temporary access road. Install culvert sections C-4, C-5, C-6, U-4, U-5 and U-6, and remove sheet piling.

- Phase IV – Reconstruction of River Road and Removal of By-Pass

  Reconstruct removed portion of River Road in its original location, remove roadway by-pass.

- Phase V – Construction of Culvert on South End

  Install sheet piling for excavation both north and south of the culvert, partially excavate, install mechanically stabilized earthen wall on each side at north end of culvert. Complete excavation, construct temporary access roads to bottom of excavation. Install culvert sections C-1, C-2, and U3 and intake structure. Remove sheet piling and backfill.

- Phase VI – MRL Construction and Cofferdam Removal

  Reconstruct MRL to EL +33.5-ft NAVD88, providing overbuild for anticipated settlement. Tie east and west ends into original section, install slope paving except for small area adjacent to intake structure. Degrade Cofferdam to batture elevation EL +18-ft NAVD88.

- Phase VII – U-Channel Construction

  Grade area around U-1 and U-2 to EL +12-ft NAVD88. Install sheet pile wall and construct U-1 and U-2.

- Phase VIII – Final Stage

  Excavate intake channel on north side of seepage piling. Drive piling to EL +18-ft NAVD88. Cut seepage piling within channel to match design grade, armor channel with riprap (approximately 2 acres would be filled with riprap). Excavate channel south of piling to bank of MR, armor channel. Replace slope paving to original condition. Remove west levee access ramp; leave east levee ramp for permanent access.

Cofferdam Design Details

The Cofferdam side slopes were designed to a maximum finished grade of 4H:1V. The minimum elevation of the Cofferdam was set at EL +25-ft NAVD88; sheet piling was included to prevent seepage. The construction sequencing precludes use of the excavated material as fill, so imported material was designated for construction of the Cofferdam. Historical MR stage hydrographs show that the river has not surpassed EL +25-ft NAVD88 in the past 50 years. The river data also shows generally predictable seasonal patterns; critical construction operations should be scheduled during low river stages, which is typically from June to November.

The cofferdam cut-off will consist of 32 sheets of PZ-22 sheet-piles, which are each 30-ft wide, for a total running length of ~960-ft. The top of the sheets will be at EL 22; the tip elevation has not been finalized. A reasonable assumption would be that the sheets will be ~60-ft long (vertically). At this time, it is unknown if the construction contractor will use a vibratory or hammer pile driver to install the sheet-piles.

ATTACHMENT 2

OPERATION and MAINTENANCE PLAN

This document is currently under review and subject to minor changes.

MAUREPAS SWAMP PROJECT OPERATIONS PLAN

Introduction

The Maurepas Swamp Project, hereafter referred to as MSP, was considered by the United States Army Corps of Engineers (USACE) for swamp habitat compensatory mitigation through preservation for construction impacts by the West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction (WSLP) project. The MSP was converted into several viable compensatory mitigation alternatives, the Tentatively Selected Plan was Maurepas Swamp Alternative – 2 (MSA-2: Public Lands onlyu). The goal of MSA-2 is to create 947 Average Annual Habitat Units (AAHUs) of swamp habitat. When constructed, MSA-2 would include three groups of features, the conveyance channel, embankment features, and weirs (Figure 1). The goal of MSA-2 is to reduce or minimize future loss of coastal forest habitat in the mitigation areas (Figure 1) through the introduction of Mississippi River water. The river reintroduction is needed to convey fresh water, nutrients, and sediments to restore the health and essential functions of the swamp. MSA-2 can generate approximately 1,210 AAUHs in all three of the benefit areas (primary, secondary, and tertiary) combined (this meets the mitigation need of the WSLP project).

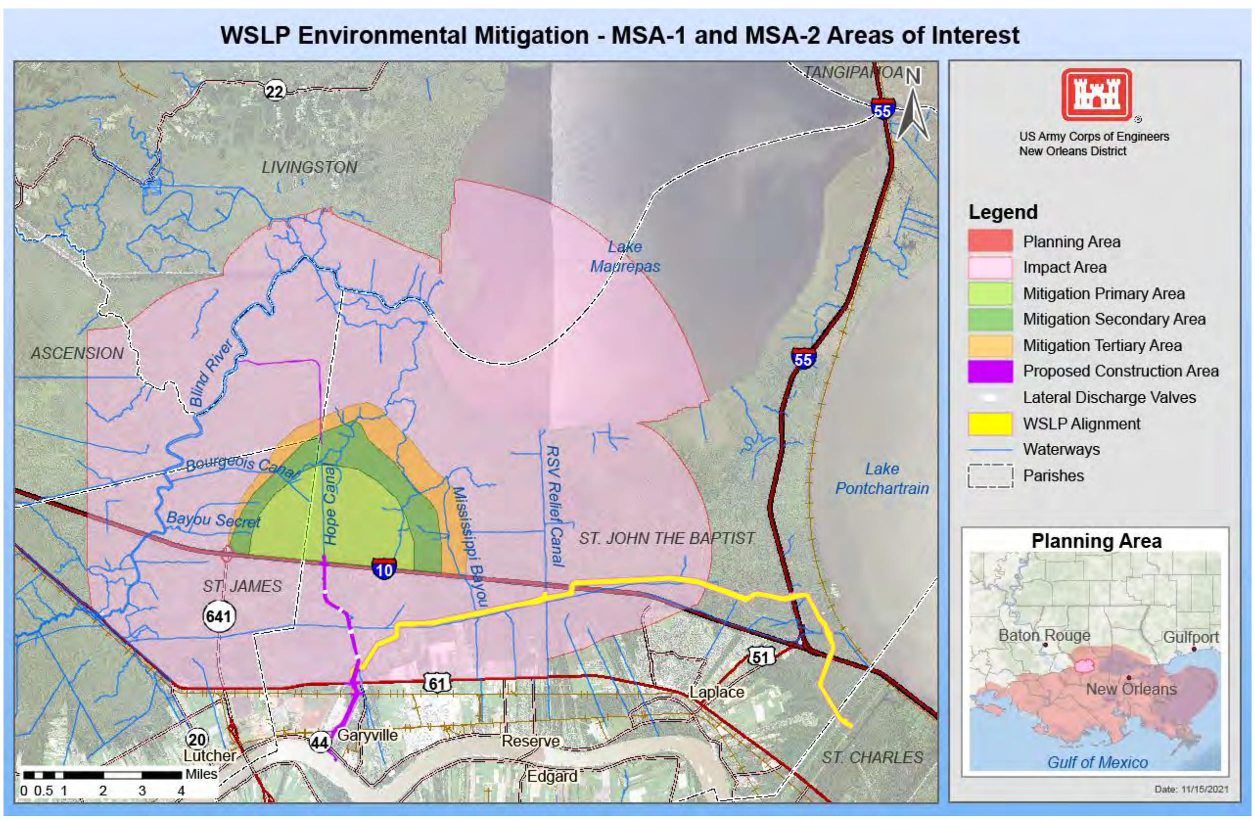


Figure 1: River Reintroduction into Maurepas Swamp (PO-0029) project area

MSP Operations Plan

This 50-year preliminary operations plan for the gated intake structure at the Mississippi River which controls discharge into the swamp via the conveyance channel have been developed to achieve the compensatory mitigation benefits determined in the wetland value assessment (WVA). The benefit areas for the MSA-2 are near the conveyance channel outfall where the benefits are anticipated to be greatest. However, the structure will be operated for the benefit of the larger swamp as shown in Figure 1 (i.e. the impact area north of I-10).

The CPRA and U.S. Fish and Wildlife Service (USFWS), with input from the Habitat Evaluation Team (HET) and the Maurepas Technical Advisory Group (TAG), created project operational assumptions for the MSA-2 benefit WVA. The assumptions include two pulses that coincide with anticipated high Mississippi River discharge and to maximize benefits during the swamp forest growing season in the first half of the calendar year. Non-flow periods are included to reduce flooding stress and allow for occasional swamp floor dewatering. This variability in discharge is expected to improve swamp health. Typical discharges for the assumptions of the WVA (years 4-50) are shown in the hydrographs below with the operations hydrograph (red-dashed line) based on Mississippi River discharge year (solid black line) reflecting the fortieth percentile maximum flow rate hydrograph (1997–present; Mississippi River at Reserve Gauge 01260). This river discharge was referenced to determine a conservative estimate of when the gated intake structure can be operated with maximum discharge (2000 cubic feet per second, cfs) into the swamp. The CPRA recognizes that environmental conditions will vary widely year to year. The conservative nature of the average hydrograph is intended to incorporate operational flexibility which cannot be determined in advance.

The expected annual operational period for the diversion will be between January 1 and July 1. The precise timing, discharge rate, and duration of the pulses will be modified to maximize benefit to the swamp. The CPRA has also proposed that the first 3 years of operation consist of gradually increasing flow duration and magnitude (i.e., a “ramp-up” period). This ramp-up period (Figures 3-5) is intended to reduce the initial shock to the system and enable adaptive management based upon observed water flow and environmental responses.

The current Operations Plan is as follows:

> Year 1 – Start operations at 250-cfs on January 1 and increase by 250-cfs increments to 1,000-cfs over the course of six weeks. After five weeks at 1,000-cfs, increase to 1,500-cfs for one week, then to 2,000-cfs for one week, then shut the flow off on April 1. Restart operations at 500-cfs on May 13, let it run for 15 days, and increase to 750-cfs. Then increase again to 1,000-cfs, let it run for 20 days and shut it off on June 30 (Figure 2).

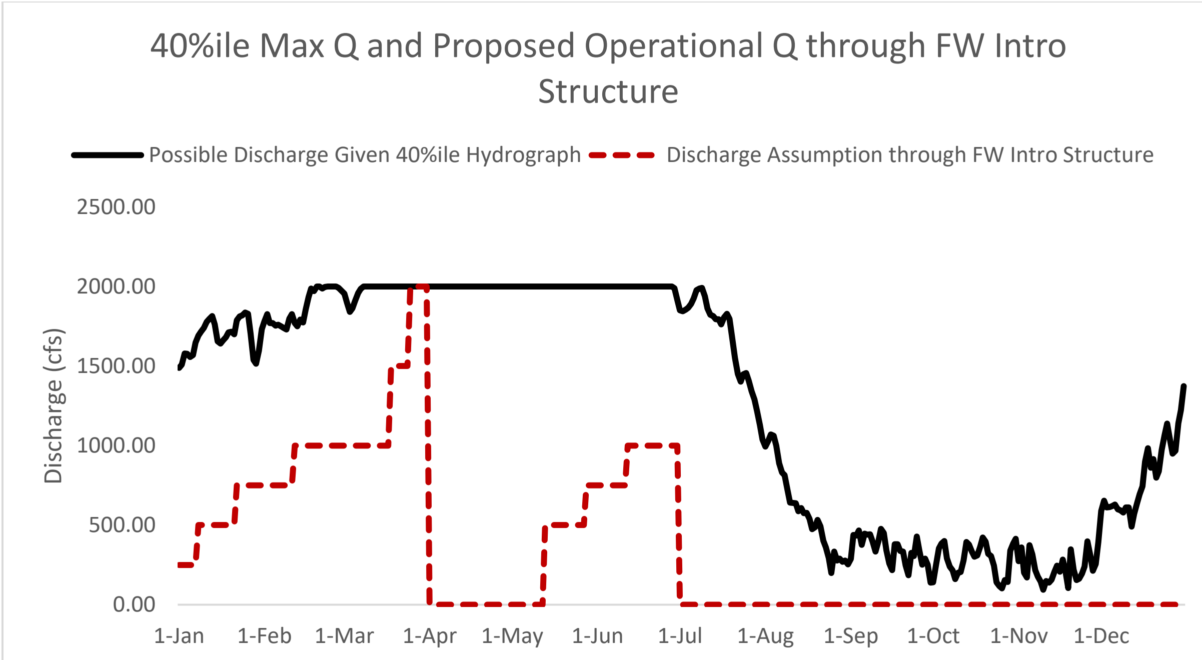


Figure 2. Year 1 operations plotted with the fortieth percentile maximum flow rate hydrograph of the Mississippi River. *

Year 2 – Start operations at 250-cfs on January 1 and increase by 250-cfs every 10 days until 2,000-cfs is achieved. Let it run at 2,000-cfs until April 1 and then shut the flow off. Restart operations at 500-cfs on May 13 and increase it by 500-cfs every 10 days until 2,000-cfs is achieved. Let it run until June 30 and then shut it off (Figure 3).

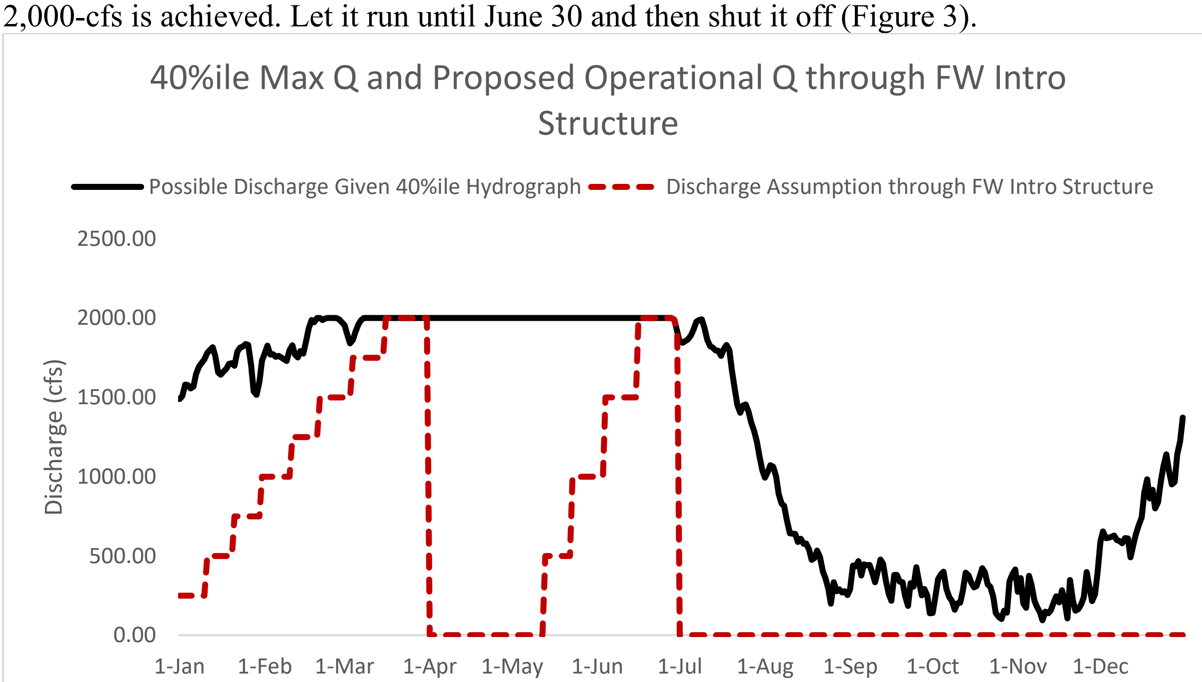


Figure 3. Year 2 operations plotted with the fortieth percentile maximum flow rate hydrograph of the Mississippi River. *

Year 3 – Start operations at 500-cfs on January 1 and increase by 500-cfs every 15 days until 2,000-cfs is achieved. Let it run at 2,000-cfs until April 1 and then shut the diversion off. Restart operations at 500-cfs on May 13 and increase flow by 500-cfs every 10 days until 2,000-cfs or maximum operating capacity based on river conditions is achieved. Let it run until June 30 and then shut it off. (Fig 4)

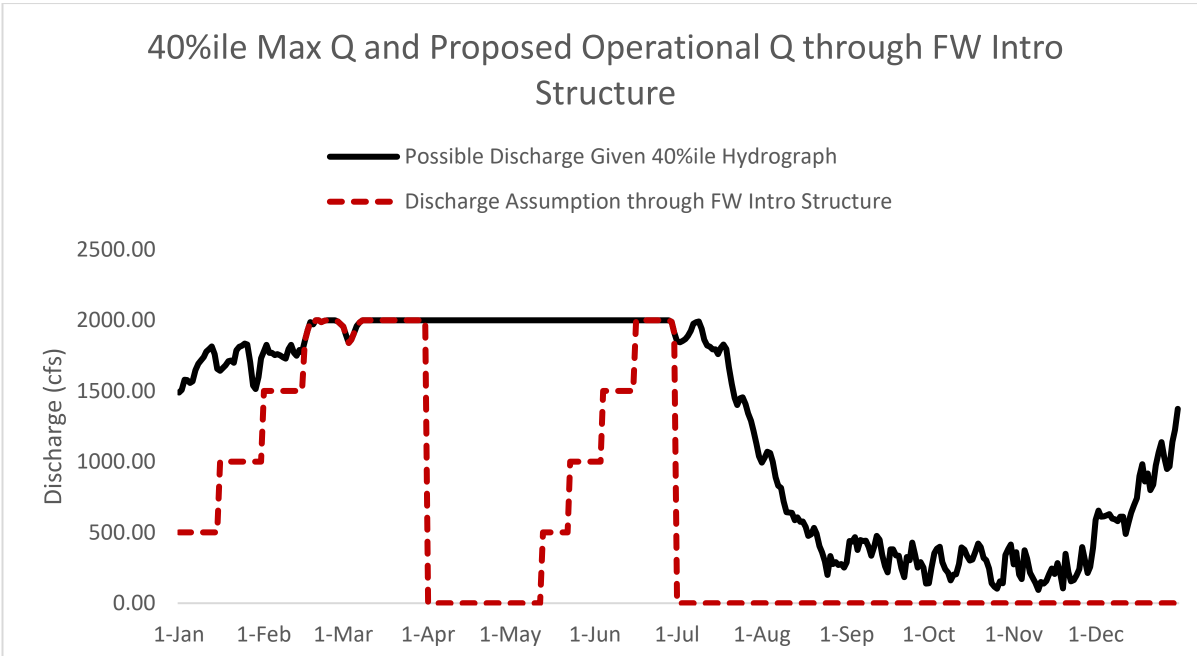


Figure 4. Year 3 operations plotted with the fortieth percentile maximum flow rate hydrograph of the Mississippi River. *

Years 4–50 – Start operations at 2,000-cfs or maximum operating capacity based on river conditions on January 1, let it run until April 1, and then shut it off. Restart operations at 2,000-cfs on May 13, let it run until June 30 and then shut it off. (Fig 5)

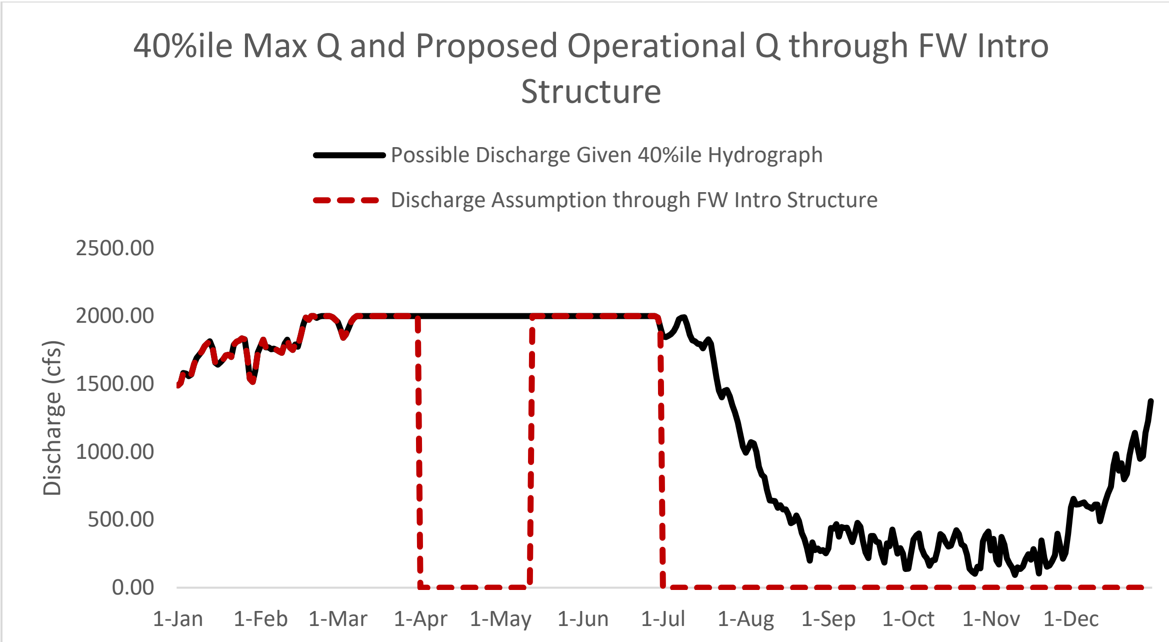


Figure 5. Years 4-50 operations plotted with the fortieth percentile maximum flow rate hydrograph of the Mississippi River. *

Deviations from Operations Plan

The operational assumptions used for the WVA provide seasonal variability of river input in a pulsed manner that coincides with higher river stages and the growing season of the swamp forest. These goals and assumptions serve as an early guide to diversion operations; however, once operations are initiated, knowledge gained through an intensive data collection effort will feed back into and refine the Operations Plan to better meet project needs. The goal of operations is to deliver river water to the swamp each year during the growing season, but the timing and duration of the pulses may be adaptively managed based on river hydrographs and swamp conditions and timing. Project monitoring data, as well as assessments of river stage and discharge, will collectively guide future operations through the project life (Figure 6). This Operations Plan will be a living document and will be adjusted based on site conditions, a review of project monitoring data, and an adaptive management approach.

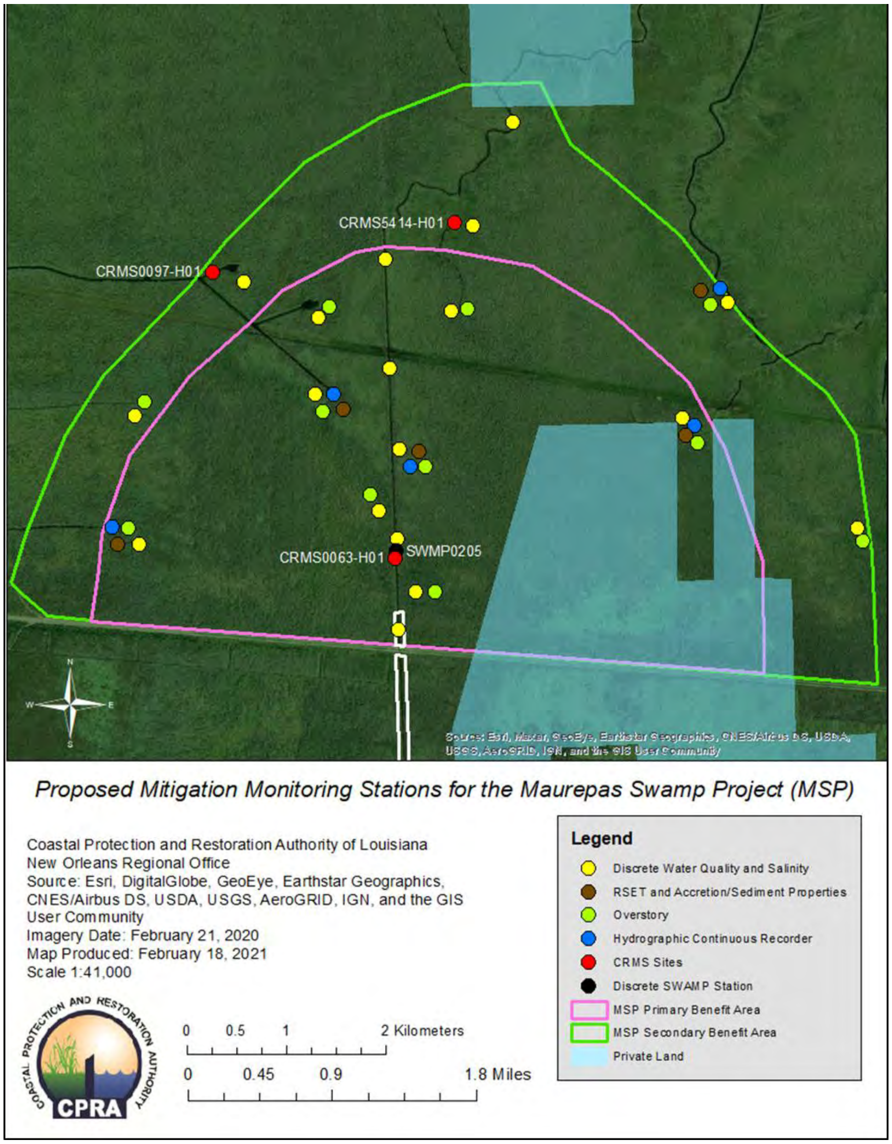


Figure 6. Locations of proposed mitigation monitoring stations for the MSA-2. CRMS sites are represented by the location of each site's continuous hydrographic recorder (H01).

* Discharges may deviate from the Operations Plan as outlined below [the Maurepas Interagency Team (MIT) would be consulted prior to any operational changes]:

- The CPRA will establish a high water elevation to trigger a shutdown of the gated intake structure in the case of basin-wide flooding. The precise water elevation and location of where this elevation will be measured have not yet been determined.

- The MSA-2 gated intake structure will be linked to sensors in the Mississippi River that are established to detect chemical spills from the adjacent Pin Oak oil and gas terminal. These sensors will trigger an alarm which will alert the project operator to immediately close the gated intake structure to prevent chemicals from being drawn into the conveyance channel.

- A supervisory control and data acquisition (SCADA) system is being incorporated into project design to allow for real-time monitoring and management of project operations and rapid intake closure in emergency situations.

- Operations will cease if CPRA is directed by entities in charge of rescue operations in the Mississippi River due to a capsized vessel or other related human life and safety emergency. Operations will resume when CRPA is advised that it is safe to do so.

- Emergency, maintenance, and local parish situations will be evaluated on a case-by-case basis to determine operational needs. All parties shall be notified if operations outside of the plan are required.

- The structure may be operated for public relations and/or educational purposes, though output is not to exceed 500-cfs and the demonstration will not exceed 2 hours.

- Operations of the structure may occur at any time during the year to ameliorate high salinities (≥ 8 ppt) associated with droughts.

- Operations of the structure may occur after tropical storm conditions to expel high salinity water (≥ 8 ppt) from the Maurepas Swamp.

- The option not to operate the structure or to operate at a reduced capacity may occur to coincide with low water Maurepas Swamp conditions conducive to recruitment of swamp tree species.

Decision Making

As part of the adaptive management approach a MIT, comprised of federal, state, and local agencies, will be established to meet periodically (no more than annually) and manage the operation of the diversion. The MIT will provide advice in regard to an operational management plan for the structure, procedures for test operations of the structure, emergency shutdown procedures, and other operational concerns the responsible agency deems appropriate. The responsible agency and the MIT will use the breadth of monitoring data that will be collected to assess the basin-side impacts of the Project, whether it is having the intended effect, and whether the operational regime for the following year(s) should be adjusted to better meet project goals. In advising the responsible agency, the MIT shall take into account the recommendations of the TAG, monitoring data and reports, comments by state and federal agencies, stakeholders, and the public, and any other relevant information. The monitoring and adaptive management plan will be closely linked to the operations decision-making framework detailed herein. The success criteria within the monitoring plan will be carefully considered when making decisions about operation of the diversion. Additionally, given the project must meet its mitigation objectives, it is essential that operational changes be made to achieve mitigation goals and objectives. With respect to emergency operations, the responsible agency anticipates that the MIT will provide comments or suggestions at regularly-scheduled meetings, not for each operational event. Emergency operations are, by nature, time-sensitive and it is unlikely the responsible agency will have time to obtain comments or suggestions prior to closing the structure.

Interaction with other projects

The adaptive management approach outlined above and in the Adaptive Management Plan will allow for managers to operate the Project while also, with input from the MIT, take into account effects such as the extended opening of the Bonnet Carré Spillway (BCS) or other existing or future authorized projects. When open, the discharge from the BCS generally flows east through Lake Pontchartrain towards the Gulf of Mexico and does not significantly increase water levels in Pass Manchac or the Maurepas Swamp, which influence the water levels in Maurepas Swamp (e.g., Georgiou, 2002; McCorquodale & Georgiou, 2004).

The Delft3D hydraulic modeling study by CPRA (FTN, 2020) and the HEC-RAS modeling study by the USACE (Agnew, M., 2019) showed that during the PO-0029 project operation at 2,000 cfs, the increase in water level due to the presence of the West Shore Lake Pontchartrain (WSLP) project is less than 0.2 ft. Therefore, the proposed WSLP project is not expected to affect Project operations.

It is not anticipated that the operations of the Project's gated intake structure will have any significant impact on navigation in the Mississippi River. The FLOW-3D modeling study (Meselhe et al., 2015) commissioned by CPRA showed that under high as well as low river flow conditions, the flow approaches the intake channel entrance along the shoreline of the Mississippi River without significantly affecting flow in the navigation channel. Additionally, it is not anticipated that high water conditions in the Mississippi River will affect the Project structural components. The headworks and rebuilt Mississippi River levee will be constructed to meet the USACE standards for mainline flood protection.

Budget

The CPRA will be responsible for operating the Project based on this Plan at an estimated cost of $105,000 per year. This amount is based on a full time CPRA appropriate level staff annual salary including indirect cost. Because the diversion structure is only expected to operate for six months out of the year, the $105,000 full salary per year cost is a conservative estimate that includes all other incidental, and relatively insignificant, associated costs such as electricity, back-up generator, overhead costs, etc. The 50 year cost, including 2.5% inflation, is $5,381,250.

Citations

Agnew, M. (2019). West Shore Lake Pontchartrain hydraulic design of pump stations and drainage structures. Draft Report. US Army Corps of Engineers. New Orleans, Louisiana.

FTN (2020). Water quality modeling of the proposed river reintroduction into Maurepas swamp (PO-0029). Report submitted by FTN Associates to the Coastal Protection and Restoration Authority, Baton Rouge, Louisiana.

Georgiou, I. Y. (2002). Three-dimensional hydrodynamic modeling of saltwater intrusion and circulation in Lake Pontchartrain. A dissertation for Doctor of Philosophy in Engineering and Applied Science in the Department of Civil and Environmental Engineering, University of New Orleans, New Orleans, LA.

McCorquodale, J. and Georgiou, I. (2004). Modelling Freshwater Inflows in a Shallow Lake. *Archives of Hydro-Engineering and Environmental Mechanics* Vol. 51, No. 1, pp. 75–84.

Meselhe, E., Richardson, J., Lagumbay, R., Allison, M., Jung, H. (2015). Simulation of Flow near Proposed Dock Facility and Freshwater Diversion Reserve, Louisiana at River Mile 144.2. Prepared for and funded by the Coastal Protection and Restoration Authority. Baton Rouge, LA.

Draft MSA-2
Maintenance Plan

CPRA Project Maintenance Plan Summary

CPRA's restoration project, the River Reintroduction into Maurepas Swamp Project (PO-0029), includes all of the maintenance and inspection associated with the head works and all secondary features that are also associated with the Tentatively Selected Alternative (TSA): Maurepas Swamp Alternative 2 – MSA-2 (public lands only). Maintenance features and general description of activities are as follows:

- Head Works: inspect and maintain in operable condition
- Sedimentation Basin: dredging and structural maintenance
- Access Roads: maintain in operable condition
- Outfall Channel: mowing, spraying, erosion control, etc.
- Airline Highway Culverts: maintain in operable condition
- I-10 Check Valves: inspect and maintain in operable condition
- Weirs: inspect and maintain in operable condition
- Railroad Embankment Cuts: inspect and maintain in operable condition

CPRA has planned for a 50-year maintenance schedule for MSA-2. The total cost of the maintenance effort is $353,675,591, with an average annual maintenance cost of $7,073,512 (see **Table 2**).

Additional details on maintenance activities and costs are provided in the appended Maintenance Task Descriptions (see **Appendix A**) and Cost Estimate (see **Appendix B**) for Engineering and Design Feature Maintenance. Maintenance activities and costs described therein do not include "Ancillary Channel Maintenance" as subsequently described.

Ancillary Channel Maintenance Activities

In addition to maintaining project design features, maintenance activities for MSA-2 will be associated with ancillary channel maintenance, including routine inspections and bathymetric surveys every five years, removal of debris and deposited material, and invasive and nuisance species management. Ancillary channels include conveyances within the MSA-2 area that are not associated with the Engineering and Design Features. For these ancillary channel maintenance activities, a summary of costs by activity is provided in **Table 1**. Further description of ancillary channel maintenance activities is provided below.

- Routine inspections will involve visually observing the condition of the ancillary channels. Bathymetric surveying will be conducted periodically (every 5 years). The survey data will be used to evaluate whether deposition or scouring has significantly affected the channel invert elevation or the overall cross-section.
  Estimated Cost: $150,000 per event (uninflated, 10 total events)

- Maintenance will include the removal of debris and deposited material as needed (every 25 years, or based on inspection results).
  Estimated Cost: $500,000 per event (uninflated, 2 planned events plus 1 unplanned event)
- Maintenance will include management of invasive and nuisance species such as Chinese tallow and black willow along levees and spoil banks, and any invasive species that might affect the operation of the diversion. Examples of invasive species that might affect the operation of the diversion are zebra mussels, floating aquatic vegetation, and nutria. Management will primarily consist of mechanical removal.
  Estimated Cost: $3,000 per event (uninflated, 40 events per year)

Table 1. Summary of Ancillary Channel Maintenance Costs (50 years)

Description/ Type of Event	Price per Event (uninflated)	Number of Events	Total	
			Uninflated	Inflated*
Routine inspections and bathymetric surveys every 5 years	$150,000	10 events over 50-year project life	$1,500,000	$1,537,500
Removal of debris and deposited material	$500,000	2 planned events plus 1 unplanned event	$1,500,000	$1,537,500
Invasive and nuisance species management	$3,000	40 events per year for 50 years, total of 2,000 events	$6,000,000	$6,150,000

*Assumes 2.5% inflation factor.

Table 2. Summary of Total Maintenance Cost (50 years).

Description/Type of Event	**50-year Cost***
Routine inspections and bathymetric surveys every 5 years	$1,537,500
Removal of debris and deposited material	$1,537,500
Invasive and nuisance species management	$6,150,000
Engineering and Design Feature Maintenance (From Appendix B)	$344,450,591
Total 50-year Maintenance Cost	**$353,675,591**
Average Annual Maintenance Cost	**$7,073,512**

*Includes inflation factors.

APPENDIX A
MAINTENANCE TASK DESCRIPTIONS

The maintenance tasks of the various features that comprise the Maurepas Diversion and their required frequencies are briefly described below. The features are grouped into the following eight categories: 1) Intake & Levee Crossing, 2) Headworks, 3) Roadway Crossings, 4) Sediment Basin & Conveyance Channel, 5) Railroad Crossings, 6) Check Valves, 7) Flow Distribution Features, and 8) Remote Sensors. The maintenance tasks defined in this document include only the maintenance and inspection duties required to ensure satisfactory operation of the diversion features over a 50-yr project life. The maintenance tasks described herein will be incorporated into the Operations, Maintenance, Monitoring, and Adaptive Management (OMMAM) Plan. The additional monitoring and adaptive management tasks that comprise the complete OMMAM plan are discussed in a separate document; they are not included herein.

1. Intake & Levee Crossing

2. Intake Channel

- An initial inspection, including visual examination and bathymetric surveying, will be conducted upon completion of construction. Subsequent routine annual inspections will involve visually observing the condition of the channel riprap armoring and the revetment along the Mississippi River hurricane levee slope. Bathymetric surveying will be conducted annually for the first two years and, if no significant changes are observed based on comparison of the year-over-year survey data, subsequently every five years thereafter. The survey data will be used to evaluate whether deposition or scouring has significantly affected the channel invert elevation or the overall cross-section. Additional ad-hoc inspections may be conducted, as needed, after extreme events, such as extremely high river levels, the passage of a 2% storm, or other atypical phenomena. Additional inspections due to such incidents are anticipated to be required every ten years.
- Annual maintenance will include the removal of debris, which is anticipated to consist primarily of floating material. The need for removal of deposited sediment will be based on the findings of the bathymetric surveying; this is estimated to be required every five years. The replacement of riprap and the repair of revetment will be also performed based on the bathymetric inspection findings. It is anticipated that riprap replacement will be required every five years and revetment repair every ten years.

3. Concrete Inflow & Outflow U-frames

- An initial detailed inspection, including visual examination and Non-Destructive Testing (NDT), as required, will be conducted upon completion of construction, prior to excavating the last earthen section in the Intake Channel (i.e., prior to flooding the structure). Subsequent routine annual inspections will include visually inspecting the channels for structural integrity as well as for potential erosion or sedimentation. Bathymetric surveying will be conducted concurrent with the Intake Channel survey (annually for the first two years and subsequently every five years thereafter) to detect signs of possible settlement or movement of the monoliths. As with the Intake Channel, bathymetric survey data will be collected for the U-frames after extreme events; this is anticipated every ten years.

- Maintenance tasks will be conducted based on the inspection findings. Floating debris removal will be conducted on an annual basis. Removal of deposited material is anticipated to be required every five years. Structural repairs of damage to the concrete channels are anticipated every twenty-five years.

4. <u>Culverts under Levee & River Rd</u>

- Inspection of the culverts under River Road will be coordinated with LADOTD. An initial detailed inspection, including visual examination and NDT, as required, will be conducted upon completion of construction, prior to flooding the structure. Subsequent inspections will include visual examination via a walk-through of the culverts to assess debris accumulation, sediment build-up, and potential structural distress. Signs of settlement, including movement of the structures, differential settlement from the adjoining U-frames, as well as indications of water leakage will also be investigated. These inspections will require dewatering of the structure using the dewatering sluice gate on the river side of the headworks structure and the bulkhead slot in the last culvert (C-6). The frequency of such inspections will be annually for the first two years and then on a five-year basis.

- Maintenance will be dictated by the inspection findings. The debris and sediment accumulation is anticipated to be minimal since the relatively high velocity through the culverts minimizes the potential for deposition. Since the maintenance activities require dewatering, the removal of any debris which has been caught in the culvert along with any deposited material will follow the same frequency as the detailed inspections. Thus, these maintenance activities will be performed annually for the first two years and thereafter every five years. The culverts have been designed for a fifty-year life, so the need for structural repairs will be infrequent; they are projected to be required every twenty-five years.

5. <u>River Road Crossing</u>

- A visual inspection of the soundness of the roadway over the culverts will be conducted annually to discern if there are any potential problems with the underlying culverts. The travel lanes and shoulders of the roadway will be checked for areas of potential settlement, base failures, potholes, rutting, and other riding surface issues. Those findings will be recorded as part of the Maurepas Diversion OMMAM findings and will be relayed to LADOTD for their roadway performance assessment.

- Maintenance activities that relate to the roadway itself, such as the repair of roadway base failures or driving surface restoration will remain the responsibility of the LADOTD. All roadway repair and maintenance activities will be the responsibility of the LADOTD.

6. <u>Levee at Headworks</u>

- An initial detailed inspection of the levee section adjacent to the Headworks will be conducted per USACE protocol upon completion of construction. This initial inspection will involve close visual examination by Geotechnical, Structural and Civil engineers as well as topographic and bathymetric surveying to ensure that the construction has been performed according to the plans and specifications.

- Two successive inspections will be conducted annually for the first two years, in May, which is representative of site conditions following high river levels. These inspections will be visual examinations by the noted engineering specialties, conducted to verify and rate the levee system operation and maintenance in accordance with the USACE Levee Safety Program.

- Subsequently, a comprehensive periodic inspection of the levee will be conducted by a USACE multidisciplinary team, led by a professional engineer and including the levee sponsor, every five years. It will include: 1) data collection comprised of a review of existing O&M data, previous inspections, emergency action plans and flood fighting records, 2) field inspection, similar to the routine visual inspection, but with additional features, and 3) a report including the data collected, field inspection findings, an evaluation of any changes in design criteria from the time the levee was constructed, and additional recommendations as warranted, such as areas that need further evaluation.

- An elevation survey of the levee crown will be conducted in conjunction with the bathymetric surveying of the Intake Channel - annually for the first two years, then every five years thereafter.

- Grass cutting on the levee surface will be performed every two weeks between mid-March through mid-September and monthly during the remainder of each year.

- A levee lift to maintain the required design protection elevation is anticipated every ten years.

2. Headworks

7. <u>Control Building & Structure</u>

- Annual routine visual inspections will be made of the control building structure and its ancillary on-site facilities. A detailed inspection of the entire concrete structure including the sections supporting the building and those housing the sluice gates will be conducted annually for the first two years and then every five years thereafter. The inspections will consist of both visual examination as well as NDT, as needed. Deficiencies will be noted for repair or replacement.

- Annual routine maintenance will consist of pesticide and herbicide treatment as well as utilities repair, as required. It is anticipated that cleaning and painting of miscellaneous components will be required every five years. Repairs to the building are expected to be needed every ten years. Minor concrete repairs are anticipated to be required every ten years. Major structural repairs to the concrete structure are expected to be required on a twenty-five-year basis.

8. Sluice Gates & Actuators

- Annual inspections will be conducted, including observing the physical condition and functional operability of the gates, hydraulic actuator systems, and ancillary mechanical components. The incoming electrical supply to the overall Headworks and specifically to the gates and actuators will also be inspected yearly. The bulkheads and bulkhead slots will be inspected annually to ensure their capability of achieving a water tight seal when needed for temporary closure to dewater or for emergency operation. The gate hoist mechanism will be checked for bolt loosening, limit switch damage, lubricant leaks, paint damage, and desiccant condition, among other items.

- Annual maintenance activities will include items such as lubrication of the gears, drum, and shaft bearings; replacement of worn components; top-off of hydraulic fluid levels; etc. Additional tasks would include recoating anchor bolts, replacing cracked hoses, tightening leaking fittings, replacing O-rings, etc. The maintenance schedule of moving parts will be guided by the monitoring findings and by the maintenance recommendations of the component manufacturers. Additional maintenance actions will include the repair and replacement of damaged or inoperable hydraulic components, which are expected to be performed every five years. Repair or replacement of the gate seals along with painting of the bulkheads is anticipated every ten years. Major gate rehabilitation is expected to occur every twenty-five years.

9. Stand-By Generator

- To ensure operability, the generator will be automatically operated for ten minutes each week. The generator will be inspected monthly, including checking the fuel, oil, and coolant levels; battery charge; drive belt; exhaust system; fuel storage tank; safety and alarm devices; and radiator hoses, among other items. An operational test will be performed on the generator each month to ensure that it is capable of transferring sufficient power to the designated headworks features; that the output voltage is within range; and that there are no leaks or exhaust system deficiencies.

- Maintenance of the generator will include a tune-up on an annual basis. This will include servicing the lubrication, cooling, and fuel systems as well as testing the starting batteries. Any mechanical problems that can be repaired, such as, replacing fuel lines and hoses, cleaning and tightening the battery connections, replacing engine and exhaust system gaskets, etc. will also be performed. The service life of the generator is expected to be 25 years, at which point the unit will be replaced.

10. SCADA System

- Annual inspection will include visual inspection of the electrical components and instrumentation along with performance testing to verify signaling and control capabilities. Inspections will also include routine testing of the inter-connection of the headworks SCADA system to that of the Marathon Oil terminal emergency leak detection and shutdown system. This will ensure that any potential leaks can be detected and that the system can be shut down quickly to eliminate the transport of any potential spill into the diversion channel.

- Maintenance of the SCADA system will involve the repair and/or replacement of components as indicated by the scheduled annual inspection or the manufacturer's recommendations. Such electrical and instrumentation maintenance is anticipated to be required every five years. The system software will also need to be upgraded to maintain communication with the host network; this is anticipated to be required every five years. Replacement of dysfunctional components is anticipated to be every ten years, as they age and/or technology progresses.

11. Access Roads.

- Inspection of the access roads to the Headworks and Conveyance Channel will occur annually for the first two years and then every two years afterward. Inspection of the access road to the Sedimentation Basin will be conducted annually due to its heavy usage for the semi-annual removal of accumulated sediment. The inspections will consist of visually inspecting the condition of the roads, including their grades and cross-slopes, the stability of both the sub-grade and top aggregate wearing course, as well as their overall condition.

- Maintenance of the access roads will consist of re-grading along with base and surface repairs, as needed, to ensure continuous access to the headworks facilities, sedimentation basin, and conveyance channel. The relatively light usage of the Headworks and Conveyance Channel access roads merits roadway repairs on a five-year interval. The access road to the sedimentation basin will be used every six months by numerous trips of heavy equipment to remove the accumulated sediment; therefore, maintenance activities on this access road are anticipated to be required every two years.

12. Monitoring Equipment.

- Inspection of the various devices will involve their periodic calibration to ensure detection accuracy as well as data polling to insure continued operation. These activities will occur on a basis unique to each component, as specified by the manufacturer. Depending upon the devices, the calibration frequency may be as often as every month, but all instrumentation shall be calibrated at least annually.

- Maintenance of the monitoring equipment will consist of routine replacement of standard component elements that degrade in the normal course of wear and tear. The maintenance of sensing elements will be conducted on at least an annual basis, if not more frequently. Repair and/or replacement of the various instrumentation is estimated to be required every five years, depending upon the type of device and the advances in technology.

3. Roadway Crossings

13. Airline Highway Crossing

- The inspection of the culverts under Airline Highway will be coordinated with the LADOTD. The culvert inlets and outlets will be checked for evidence of erosion, accumulation of sediment and/or debris, and adverse flow phenomena, e.g., scour, eddies or stagnant areas. In addition, visual inspection of the concrete culvert elements will be conducted, via walk-through of the culverts to assess potential structural issues, settlement, sediment build-up, or leakage. The culverts are 9' x 9' boxes, which are large enough to walk in; however, they will almost always be full of water due to their low relative elevation. Sandbags, inflatable dams, or other means will be used to block the upstream and downstream ends of the conveyance channel to allow the culverts to be dewatered. The inspections will be conducted annually for the first two years and then every five years.

- A general examination of the soundness of the roadway over the culverts will also be conducted annually. The travel lanes and shoulders of the roadway will be checked for areas of potential settlement, base failures, potholes, rutting, and other riding surface issues. Those findings will be relayed as a courtesy to LADOTD for their roadway performance assessment.

- The removal of observable debris will be performed annually. Additional maintenance activities will include the removal of sediment accumulation as well as repair of eroded channel materials (riprap), as needed. These activities will occur annually for the first two years and then every five years thereafter. In addition, structural concrete repairs to the culverts will be performed on a ten-year basis. Maintenance activities that relate to the roadway itself, such as the repair of roadway base failures or driving surface reparation will remain the responsibility of the LADOTD.

14. Interstate 10 Crossing

- The crossing under I-10 is an open trapezoidal section with bridge revetment and bridge piers. Visual inspection can be readily performed on the dry sections of revetment. Inspection of the underwater revetment and the areas around the bridge piers will be made by boat via rod probing. Annual inspections will be conducted for the first two years and then at five-year intervals. The inspections will check for erosion and/or sediment build-up in the channel underneath the interstate and around the bridge piers. The condition of the cement bag/concrete revetment system that comprises the channel lining protection underneath the bridge will also be inspected to ensure that the configuration of the channel cross section is stable. The tie-in of the revetment system to the bridge approach slabs will be examined to further document the stability of the bridge\channel crossing. The information collected will be relayed to the LADOTD for their review and documentation. Structural inspection of the bridge sub- and super-structure itself will be conducted by the LADOTD under their periodic bridge inspection program.

- Maintenance dredging and/or filling of scour holes around the bridge piers and throughout the channel cross section will be performed based on the inspection findings. These repairs are expected to be required on a ten-year cycle. The findings will be forwarded to the LADOTD for their use. Repairs to the channel lining revetment, bridge, and\or roadway will be the responsibility of the LDOTD.

4. Sediment Basin & Conveyance Channel

15. <u>Sedimentation Basin</u>

- The condition of the Sedimentation Basin side slopes and bottom will be inspected yearly to ensure that the gross geometric configuration of the basin remains stable. The monitoring and recording of sediment accumulation by manual depth probing will be conducted monthly for the first two years, and thereafter every six months, to assess the need for clean-out. Monthly sampling of the sediment will be performed for the first year to characterize the sediment captured (e.g., specific gravity determination, sieve analysis of grain size distribution, etc.).

- A key maintenance activity will be the excavation, removal, and haul-off of the accumulated sediment. Based on the estimated accumulation rate, it is anticipated that sediment removal will be required every six months. The frequency of the basin clean-out will be adjusted based on the actual sediment accumulation rate as the diversion is operated over time. A sediment removal and disposal plan will be developed during Final Design; the methodology could be suction dredging, clam-shell excavation, front-end loader and dump trucks, or other means. The accumulated material is anticipated to be similar to batture sand and therefore has value as structural fill, offsetting all or part of the removal and disposal costs. Additional maintenance activities will include the repair of any damage to the access roads, side slopes, and bottom, including rehabilitation of the revetment lining, on a ten-year basis. The lining of the basin is to be grouted riprap, which should stand up well to whatever excavation procedure is designated.

16. <u>Conveyance Channel</u>

- Annual visual inspection of the channel side slopes for stability, erosion problems, health of protective turf, animal burrowing damage, and possible leaks will be performed. These inspections will be conducted by walking the levee on the outboard side and from a boat for observation of the channel inside slope. The levee crown roadways will also be inspected annually for potholes, sloughing, loss of surfacing materials, and potential base failures or soft spots that impair surface integrity. A specific protocol will be developed to ensure that maintenance vehicles stay on the levee crown to prevent potential ruts. Every five years, a bathymetric survey of the channel will be conducted. Concurrently, a more detailed five-year periodic inspection of the wetted surface of the inside of the channel will be performed to examine for vegetative growth, observe debris and/or sediment accumulation, and note problematic water flow regime phenomena, e.g., scour, eddies or stagnant areas.

- Grass cutting on the guide levee surface will be performed every two weeks between mid-March through mid-September and monthly during the remainder of each year. Additional maintenance activities will include the repair of the roadway crown stability concerns, channel erosion problems, and leaks in the guide levees every two years. Dredging to restore a smooth internal channel surface, remove debris, repair scour holes, and clear areas of excessive vegetation will be performed on a ten-year cycle to preserve the maximum flow capacity of the diversion. Guide levee lifts will also be required on a ten schedule to maintain the desired elevations.

5. Railroad Crossings

17. <u>CN RR Crossing</u>

- Visual inspection of the culverts via walk-through will be conducted to assess potential structural issues, settlement, sediment build-up, or leakage. Observation of erosion at the culvert inlets and outlets, examination for the accumulation of debris and/or sediment, and surveillance for evidence of potential flow problems, e.g., eddies, stagnant areas, etc. will also be conducted. Sandbags, inflatable dams, or other means will be used to block the upstream and downstream ends of the Conveyance Channel to allow the culverts to be dewatered. The inspections will be conducted annually for the first two years and then every five years.

- Annual maintenance will consist of the removal of observable debris. Removal of sediment accumulation in the culverts, replacement of riprap due to scouring, as well as any other corrective measures required to address flow-related problems will be conducted annually for the first two years and then every five years. Structural repairs to deteriorated sections of the culverts themselves are anticipated to be required every twenty-five years. Maintenance of the RR elements themselves will be the responsibility of CN RR.

- All activities within the RR Right-of-way will be coordinated in advance with CN RR, as required. Observations on the general condition of the RR infrastructure components in relation to the culvert crossing will be submitted as a courtesy to CN RR for their use. The formal inspection of the railroad will be the responsibility of the CN RR per the procedures and schedule dictated in the national AREMA standards as well as their specific requirements.

18. <u>KCS RR Crossing</u>

- The condition of the conveyance channel underneath the RR bridge will be visually examined each year for slope stability, observable debris and/or sediment accumulation around bridge piers, and potentially troublesome flow phenomena, e.g., scour, eddies, stagnant areas, etc. Also annually, the wetted surface of the channel under the bridge will be checked for excessive vegetative growth. In addition, the guide levee side slopes will be examined for stability, leaks, erosion problems, and turf establishment yearly.
- All activities within the RR Right-of-way will be coordinated in advance with KCS RR, as required. Structural inspection of the railroad bridge sub- and super-structure components, the horizontal and vertical stability of the track, the condition of the approach slabs, and the examination of other RR features will be the responsibility of the KCS RR.
- Remedial actions to maintain and/or restore the conveyance channel bank will be prioritized to first maintain the structural integrity of the bridge, then address local repairs needed, and finally, maintain as hydraulically efficient a section as possible. Such repairs are expected to occur every five years. The repair or replacement of any structurally deteriorated elements of the bridge sub- and super-structure, approach slabs, piers, track or ancillary elements will be the responsibility of the KCS RR, as dictated by the AREMA and KCS RR standards.

6. Check Valves

19. Check Valves under I-10

- Annual inspection will include the following items. A visual examination of the connections between the valves and their respective drainage pipes to assess their solidity. The observation of potential debris and/or sediment accumulation in the pipe, valve, or nearby area that could potentially prevent proper valve closure. A check for any erosion or undermining effects that could lead to a pipe failure which could prevent proper function by either closing off the pipe, preventing drainage to the north, or by-passing the valves enabling drainage to the south.
- Annual maintenance activities will include removal of debris and/or sediment accumulation. The replacement of damaged pipe sections or pipe/valve connections is anticipated to be required every ten years. Replacement of the valves is scheduled for a twenty-five-year cycle.

7. Flow Distribution Features

20. Weirs at Bayou Secret & Bourgeois Canal

- Annual inspection activities will consist of observing any settlement of the riprap weirs, accumulation of debris and/or sediment, and any loss of material from the weirs. Water surface elevations on both sides of the weirs will also be observed annually (this would ideally occur when significant flow is being routed from the Maurepas Swamp into Blind River). To enable these measurements, staff gages for both the upstream and downstream sides of the weirs will be designed during Final Design. Particular attention will be paid during inspection as to whether there is a significant volume of flow that by-passes the weirs on either side. Significant flow will be defined as the formation of a flow path, either observed during the flowing condition, or as evidenced by the observable development of channelization around the weirs, that extends 20-ft beyond the termination of the weir cross-section on either side. The water surface elevation data will be recorded for evaluation of the backwater effects created by the weirs and determination of their effectiveness.

- Maintenance activities will include the removal of accumulated debris and/or sediment on a yearly basis. The replacement of riprap lost due to settlement or other reasons is anticipated to be conducted on a five-year basis. Additional material may be added to the weirs, material may be removed from the weirs, or the invert elevations and extents of the weirs may be revised. The frequency of this activity will depend upon the monitoring observations and their assessment, which will be part of the Adaptive Management feature of the OMMAM Plan.

21. Embankment Cuts

- Inspection activities will include observing the stability of the cut sections and noting any sloughing, erosion, or debris and/or sediment accumulation on an annual basis. The movement of water through the embankment cuts will be monitored by visual inspection of flow and measurement of water surface elevations on either side during select periods, when conditions are favorable. Staff gages for both the upstream and downstream sides of the embankment cuts will be designed during Final Design to enable these measurements.

- The removal of accumulated debris and/or sediment will be performed each year. Significant maintenance activities will be performed every ten years, including repairing any embankment areas degraded by sloughing or erosion and reshaping the cut faces to create stable surfaces. Depending upon the observed water movement, the cuts may be widened, deepened, or extended perpendicular to achieve the desired flow.

8. Remote Sensors

- The selection and location of the required monitoring devices to evaluate the performance of the diversion is being conducted by other members of the design team as part of the Monitoring and Adaptive Management portion of the OMMAM Plan. Upon completion of this effort, the operation and maintenance requirements of the remote sensing equipment will be incorporated into the O&M plan.

9. Personnel Salaries

22. Maintenance Personnel Salaries

- Dedicated field personnel will be allocated to the Maurepas Diversion to perform the inspection and maintenance activities described in this document. The following four categories of field personnel are anticipated: Mechanic, Electrician\Instrumentation, Equipment Operator, and Maintenance Worker. While individual personnel may not perform their respective O&M

duties strictly on the subject project, collectively a group of individuals covering the four categories will be required on a part-time basis, averaging 20 hours per week each.

- Office personnel will also be assigned O&M duties for the diversion. The category and man-hour requirements of those personnel will be defined in the finalized version of this plan.

10. Optional Items

23. Airline Highway Sluice Gates

- The installation of sluice gates at Airline Highway is an option that is under consideration by the design team. The purpose of the gates would be to prevent the conveyance of any spill that occurred in the river from reaching the Maurepas Swamp. Operation of the hydraulically actuated sluice gates to block the flow path of any spill in the conveyance channel would be controlled by an automated SCADA system connected to the Marathon Oil spill detection system.

- Routine operation of the gates and hydraulic actuators would be required on a periodic basis to ensure their condition remains fully functional. The SCADA system to be installed will enable the gates to be monitored and controlled remotely by CPRA. Operation of the gates will be performed at least monthly to ensure the functionality of the system. Such operation will require less than an hour of personnel time and the cost of the electricity used will be minimal.

- Annual inspections will be conducted, including observing the physical condition and functional operability of the gates, hydraulic actuator systems, and ancillary mechanical components. The incoming electrical supply to the gates and actuators will also be inspected yearly. The bulkheads and bulkhead slots will be inspected annually to ensure their capability of achieving a water tight seal. The gate hoist mechanism will be checked for bolt loosening, limit switch damage, lubricant leaks, paint damage, and desiccant condition, among other items.

- Annual maintenance activities will include items such as lubrication of the gears, drum, and shaft bearings; replacement of worn components; top-off of hydraulic fluid levels; etc. Additional tasks would include recoating anchor bolts, replacing cracked hoses, tightening leaking fittings, replacing O-rings, etc. The maintenance schedule of moving parts will be guided by the monitoring findings and by the maintenance recommendations of the component manufacturers. Additional maintenance actions will include the repair and replacement of damaged or inoperable hydraulic components, which are expected to be performed every five years. Repair or replacement of the gate seals along with painting of the bulkheads is anticipated every ten years. Major gate rehabilitation is expected to occur every twenty-five years.

- Annual inspection will include visual inspection of the electrical components and instrumentation along with performance testing to verify signaling and control capabilities. Inspections will also include routine testing of the inter-connection of the headworks SCADA system to that of the Marathon Oil terminal emergency leak detection and shutdown system. This will ensure that any potential leaks can be detected and that the system can be shut down quickly to eliminate the transport of any potential spill into the diversion channel.

- Maintenance of the SCADA system will involve the repair and/or replacement of components as indicated by the scheduled annual inspection or the manufacturer's recommendations. Such electrical and instrumentation maintenance is anticipated to be required every five years. The system software will also need to be upgraded to maintain communication with the host network; this is anticipated to be required every five years. Replacement of dysfunctional components is anticipated to be every ten years, as they age and/or technology progresses.

24. <u>Maintenance Building</u>

If the operation and maintenance of the diversion is to be handled in-house, then a building for equipment storage and to serve as a base of operation for maintenance personnel may be constructed. (Such activities could be based from another off-site facility, or they could be contracted out altogether.) If such a building is constructed, then its O&M requirements will be as follows:

- Operation of the building and its utilities will occur as a passive part of the overall operation of the diversion.
- Annual routine visual inspections will be made of the building structure and its facilities. Deficiencies in the structure, the on-site facilities, and the service utilities will be noted for repair or replacement.
- Routine maintenance will consist of pesticide and herbicide treatment as well as utilities repair, as needed. It is anticipated that cleaning, painting and/or minor facility repairs will be required every five years. Structural repairs to the building are expected to be required on a twenty-five-year basis.

APPENDIX B
RIVER REINTRODUCTION INTO MAUREPAS SWAMP
STATE PROJECT NO. PO-0029

Maintenance Cost Estimate
95% Design

No.	Description	Avg. Annual Cost
1	Intake & Levee Crossing	$1,774,381
2	Headworks	$857,205
3	Roadway Crossings[1]	$134,827
4	Sediment Basin & Conveyance Channel	$1,213,640
5	Railroad Crossings[2]	$90,762
6	Check Valves	$41,853
7	Flow Distribution Features	$101,005
8	Remote Sensors[3]	$226,104
9	Personnel Salaries[4]	$859,195
10	Optional Items	$691,473
	Average Annual Maintenance Costs:	$5,990,445
	Contingency (15%):	$898,567
	Average Annual Maintenance Total:	**$6,889,012**

Notes:
1. CPRA is not responsible for roadway repair costs, bridge & revetment inspection costs, or revetment maintenance costs
2. CPRA is not responsible for railroad repair costs or bridge repair costs
3. Annual cost of Remote Sensors assigned $100,000 as a placeholder.
4. Annual cost of CPRA Office Personnel assigned $100,000 as a placeholder.

RIVER REINTRODUCTION INTO MAUREPAS SWAMP
STATE PROJECT No. PO-0029
inflation rate: 2.50%

No.	Description	Average Annual Cost	Subtotal 50- Years	1	2	3	4	5	6	7	8	9	10	11	12	13
				1/1/25	1/1/26	1/1/27	1/1/28	1/1/29	1/1/30	1/1/31	1/1/32	1/1/33	1/1/34	1/1/35	1/1/36	1/1/37
			Inflation Factor:	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.38	1.41	1.45	1.48	1.52	1.56
1	**Intake & Levee Crossing**	**$1,774,381**	**$88,719,035**													
	Intake Channel	$1,267,131	$63,356,564	$14,496	$14,859	$6,092	$6,244	$2,032,134	$6,560	$6,724	$6,893	$7,065	$5,195,770	$7,423	$7,608	$7,798
	Concrete Inflow & Outflow U-Frames	$53,455.04	$2,672,752	$10,437	$10,698	$4,874	$4,995	$43,523	$5,248	$5,380	$5,514	$5,652	$49,242	$5,938	$6,086	$6,239
	Culverts under Levee & River Rd	$418,375	$20,918,732	$597,242	$612,173	$0	$0	$659,244	$0	$0	$0	$0	$745,874	$0	$0	$0
	River Road Crossing	$3,392	$169,578	$1,740	$1,783	$1,828	$1,873	$1,920	$1,968	$2,017	$2,068	$2,119	$2,172	$2,227	$2,282	$2,339
	Levee at Headworks	$32,028	$1,601,409	$28,297	$29,004	$2,924	$2,997	$31,234	$3,149	$3,228	$3,308	$3,391	$122,236	$3,563	$3,652	$3,743
2	**Headworks**	**$857,205**	**$42,860,263**													
	Control Building & Gated Structure	$289,685	$14,484,245	$89,296	$91,529	$32,897	$33,719	$136,969	$35,426	$36,312	$37,220	$38,150	$227,383	$40,082	$41,084	$42,111
	Sluice Gates & Actuators	$391,409	$19,570,452	$9,509	$9,747	$9,991	$10,241	$170,507	$10,759	$11,028	$11,304	$11,586	$808,440	$12,173	$12,477	$12,789
	Stand-By Generator	$14,632	$731,605	$2,899	$2,972	$3,046	$3,122	$3,200	$3,280	$3,362	$3,446	$3,532	$3,621	$3,711	$3,804	$3,899
	SCADA System	$22,450	$1,122,477	$4,639	$4,755	$4,874	$4,995	$14,081	$5,248	$5,380	$5,514	$5,652	$73,863	$5,938	$6,086	$6,239
	Access Roads	$9,246	$462,315	$2,029	$5,646	$914	$5,932	$4,416	$6,232	$1,009	$6,548	$1,060	$10,790	$1,113	$7,228	$1,170
	Monitoring Equipment	$129,783	$6,489,169	$56,825	$58,246	$59,702	$61,194	$113,928	$64,292	$65,900	$67,547	$69,236	$128,899	$72,741	$74,559	$76,423
3	**Roadway Crossings[1]**	**$134,827**	**$6,741,355**													
	Airline Highway Crossing	$95,716	$4,785,814	$91,036	$93,312	$3,046	$3,122	$100,487	$3,280	$3,362	$3,446	$3,532	$403,351	$3,711	$3,804	$3,899
	Interstate 10 Crossing	$39,111	$1,955,541	$2,899	$2,972	$0	$0	$3,200	$0	$0	$0	$0	$220,865	$0	$0	$0
4	**Sediment Basin & Conveyance Channel**	**$1,213,640**	**$60,681,996**													
	Sedimentation Basin	$139,706	$6,985,290	$63,899	$65,497	$67,134	$68,812	$70,533	$72,296	$74,103	$75,956	$77,855	$166,699	$81,796	$83,841	$85,937
	Conveyance Channel	$1,073,934	$53,696,706	$153,080	$156,907	$160,829	$164,850	$424,988	$173,195	$177,525	$181,963	$186,513	$4,391,240	$195,955	$200,854	$205,875
5	**Railroad Crossings[2]**	**$90,762**	**$4,538,111**													
	CN RR Crossing	$75,500	$3,775,019	$91,616	$93,906	$3,046	$3,122	$101,127	$3,280	$3,362	$3,446	$3,532	$114,416	$3,711	$3,804	$3,899
	KCS RR Crossing	$15,262	$763,092	$1,740	$1,783	$1,828	$1,873	$33,922	$1,968	$2,017	$2,068	$2,119	$38,380	$2,227	$2,282	$2,339
6	**Check Valves**	**$41,853**	**$2,092,631**													
	Check Valves under I-10	$41,853	$2,092,631	$8,118	$8,321	$8,529	$8,742	$28,162	$9,185	$9,414	$9,650	$9,891	$140,485	$10,392	$10,651	$10,918
7	**Flow Distribution Features**	**$101,005**	**$5,050,249**													
	Weirs at B. Secret and B. Canal	$57,656	$2,882,808	$17,395	$17,830	$18,276	$18,733	$83,205	$19,681	$20,173	$20,678	$21,195	$94,139	$22,268	$22,824	$23,395
	Embankment Cuts	$43,349	$2,167,441	$20,295	$20,802	$21,322	$21,855	$22,401	$22,962	$23,536	$24,124	$24,727	$47,070	$25,979	$26,628	$27,294
8	**Remote Sensors**	**$226,104**	**$11,305,196**													
	Maintenance	$226,104	$11,305,196	$115,969	$118,869	$121,840	$124,886	$128,008	$131,209	$134,489	$137,851	$141,297	$144,830	$148,451	$152,162	$155,966
9	**Personnel Salaries**	**$859,195**	**$42,959,744**													
	Maintenance Personnel	$633,091	$31,654,548	$324,714	$332,832	$341,153	$349,682	$358,424	$367,384	$376,569	$385,983	$395,633	$405,523	$415,662	$426,053	$436,704
	CPRA Office Personnel	$226,104	$11,305,196	$115,969	$118,869	$121,840	$124,886	$128,008	$131,209	$134,489	$137,851	$141,297	$144,830	$148,451	$152,162	$155,966
10	**Optional Items**	**$691,473**	**$34,573,673**													
	Airline Highway Sluice Gates	$670,452	$33,522,619	$12,989	$13,313	$13,646	$13,987	$475,167	$14,695	$15,063	$15,439	$15,825	$1,493,485	$16,626	$17,042	$17,468
	Maintenance Building	$21,021	$1,051,055	$6,668	$6,835	$7,006	$7,181	$26,562	$7,544	$7,733	$7,926	$8,125	$30,052	$8,536	$8,749	$8,968
	Sub-total Maintenance Costs:	**$5,990,445**	**$299,522,253**	**$1,843,797**	**$1,893,458**	**$1,016,635**	**$1,047,047**	**$5,195,351**	**$1,100,053**	**$1,122,175**	**$1,155,744**	**$1,178,985**	**$15,203,655**	**$1,238,671**	**$1,275,725**	**$1,301,379**
	Contingency (15%) :	**$898,567**	**$44,928,338**	**$276,569**	**$284,019**	**$152,495**	**$157,057**	**$779,303**	**$165,008**	**$168,326**	**$173,362**	**$176,848**	**$2,280,548**	**$185,801**	**$191,359**	**$195,207**
Total Maintenance Costs:		**$6,889,012**	**$344,450,591**	**$2,120,366**	**$2,177,476**	**$1,169,131**	**$1,204,104**	**$5,974,654**	**$1,265,061**	**$1,290,502**	**$1,329,105**	**$1,355,833**	**$17,484,203**	**$1,424,472**	**$1,467,083**	**$1,496,586**

1. CPRA is not responsible for roadway repair costs, bridge & revetment inspection costs, or revetment maintenance costs.
2. CPRA is not responsible for railroad repair costs or bridge repair costs
3. Annual cost of Remote Sensors assigned $100,000 as a placeholder. To be updated.
4. Annual cost of CPRA Office Personnel assigned $100,000 as a placeholder. To be updated.

No.	Description	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
		1/1/38	1/1/39	1/1/40	1/1/41	1/1/42	1/1/43	1/1/44	1/1/45	1/1/46	1/1/47	1/1/48	1/1/49	1/1/50	1/1/51	1/1/52
		1.60	1.64	1.68	1.72	1.76	1.81	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.26
1	**Intake & Levee Crossing**															
	Intake Channel	$7,993	$2,601,304	$8,398	$8,608	$8,823	$9,044	$6,651,024	$9,501	$9,739	$9,982	$10,232	$3,329,889	$10,750	$11,019	$11,294
	Concrete Inflow & Outflow U-Frames	$6,395	$55,713	$6,718	$6,886	$7,058	$7,235	$63,034	$7,601	$7,791	$7,986	$8,186	$595,709	$8,600	$8,815	$9,035
	Culverts under Levee & River Rd	$0	$843,887	$0	$0	$0	$0	$954,781	$0	$0	$0	$0	$3,702,207	$0	$0	$0
	River Road Crossing	$2,398	$2,458	$2,519	$2,582	$2,647	$2,713	$2,781	$2,850	$2,922	$2,995	$3,070	$3,146	$3,225	$3,306	$3,388
	Levee at Headworks	$3,837	$39,982	$4,031	$4,132	$4,235	$4,341	$156,473	$4,561	$4,675	$4,792	$4,911	$51,181	$5,160	$5,289	$5,421
2	**Headworks**															
	Control Building & Gated Structure	$43,164	$175,332	$45,349	$46,482	$47,644	$48,836	$291,069	$51,308	$52,591	$53,905	$55,253	$3,370,791	$58,050	$59,501	$60,989
	Sluice Gates & Actuators	$13,109	$218,264	$13,773	$14,117	$14,470	$14,832	$1,034,872	$15,582	$15,972	$16,371	$16,781	$4,474,531	$17,630	$18,071	$18,523
	Stand-By Generator	$3,997	$4,097	$4,199	$4,304	$4,412	$4,522	$4,635	$4,751	$4,870	$4,991	$5,116	$162,561	$5,375	$5,509	$5,647
	SCADA System	$6,395	$18,025	$6,718	$6,886	$7,058	$7,235	$94,551	$7,601	$7,791	$7,986	$8,186	$23,073	$8,600	$8,815	$9,035
	Access Roads	$7,594	$5,653	$7,978	$1,291	$8,382	$1,357	$13,812	$1,425	$9,252	$1,497	$9,720	$7,237	$10,213	$1,653	$10,730
	Monitoring Equipment	$78,334	$145,837	$82,300	$84,357	$86,466	$88,628	$165,001	$93,114	$95,442	$97,828	$100,274	$186,684	$105,350	$107,984	$110,684
3	**Roadway Crossings**[1]															
	Airline Highway Crossing	$3,997	$128,631	$4,199	$4,304	$4,412	$4,522	$516,323	$4,751	$4,870	$4,991	$5,116	$164,659	$5,375	$5,509	$5,647
	Interstate 10 Crossing	$0	$4,097	$0	$0	$0	$0	$282,726	$0	$0	$0	$0	$5,244	$0	$0	$0
4	**Sediment Basin & Conveyance Channel**															
	Sedimentation Basin	$88,086	$90,288	$92,545	$94,859	$97,230	$99,661	$213,389	$104,706	$107,324	$110,007	$112,757	$115,576	$118,465	$121,427	$124,463
	Conveyance Channel	$211,022	$544,021	$221,705	$227,247	$232,929	$238,752	$5,621,159	$250,839	$257,110	$263,537	$270,126	$696,392	$283,801	$290,896	$298,168
5	**Railroad Crossings**[2]															
	CN RR Crossing	$3,997	$129,451	$4,199	$4,304	$4,412	$4,522	$146,462	$4,751	$4,870	$4,991	$5,116	$690,100	$5,375	$5,509	$5,647
	KCS RR Crossing	$2,398	$43,423	$2,519	$2,582	$2,647	$2,713	$49,130	$2,850	$2,922	$2,995	$3,070	$55,586	$3,225	$3,306	$3,388
6	**Check Valves**															
	Check Valves under I-10	$11,191	$36,050	$11,757	$12,051	$12,352	$12,661	$179,833	$13,302	$13,635	$13,975	$14,325	$46,146	$15,050	$15,426	$15,812
7	**Flow Distribution Features**															
	Weirs at B. Secret and B. Canal	$23,980	$106,510	$25,194	$25,824	$26,469	$27,131	$120,506	$28,504	$29,217	$29,947	$30,696	$136,342	$32,250	$33,056	$33,883
	Embankment Cuts	$27,976	$28,676	$29,393	$30,127	$30,881	$31,653	$60,253	$33,255	$34,087	$34,939	$35,812	$36,707	$37,625	$38,566	$39,530
8	**Remote Sensors**															
	Maintenance	$159,865	$163,862	$167,958	$172,157	$176,461	$180,873	$185,394	$190,029	$194,780	$199,650	$204,641	$209,757	$215,001	$220,376	$225,885
9	**Personnel Salaries**															
	Maintenance Personnel	$447,622	$458,813	$470,283	$482,040	$494,091	$506,443	$519,104	$532,082	$545,384	$559,019	$572,994	$587,319	$602,002	$617,052	$632,478
	CPRA Office Personnel	$159,865	$163,862	$167,958	$172,157	$176,461	$180,873	$185,394	$190,029	$194,780	$199,650	$204,641	$209,757	$215,001	$220,376	$225,885
10	**Optional Items**															
	Airline Highway Sluice Gates	$17,905	$608,254	$18,811	$19,282	$19,764	$20,258	$1,911,787	$21,283	$21,815	$22,361	$22,920	$7,071,320	$24,080	$24,682	$25,299
	Maintenance Building	$9,192	$34,001	$9,658	$9,899	$10,147	$10,400	$38,469	$10,927	$11,200	$11,480	$11,767	$59,256	$12,363	$12,672	$12,988
	Sub-total Maintenance Costs:	**$1,340,308**	**$6,650,489**	**$1,408,161**	**$1,436,479**	**$1,479,450**	**$1,509,201**	**$19,461,964**	**$1,585,604**	**$1,633,036**	**$1,665,875**	**$1,715,708**	**$25,991,170**	**$1,802,566**	**$1,838,815**	**$1,893,821**
	Contingency (15%) :	**$201,046**	**$997,573**	**$211,224**	**$215,472**	**$221,917**	**$226,380**	**$2,919,295**	**$237,841**	**$244,955**	**$249,881**	**$257,356**	**$3,898,675**	**$270,385**	**$275,822**	**$284,073**
Total Maintenance Costs:		**$1,541,355**	**$7,648,062**	**$1,619,386**	**$1,651,951**	**$1,701,367**	**$1,735,581**	**$22,381,258**	**$1,823,445**	**$1,877,991**	**$1,915,757**	**$1,973,064**	**$29,889,845**	**$2,072,951**	**$2,114,637**	**$2,177,894**

No.	Description	29	30	31	32	33	34	35	36	37	38	39	40	41
		1/1/53	1/1/54	1/1/55	1/1/56	1/1/57	1/1/58	1/1/59	1/1/60	1/1/61	1/1/62	1/1/63	1/1/64	1/1/65
		2.32	2.37	2.43	2.49	2.56	2.62	2.69	2.75	2.82	2.89	2.96	3.04	3.11
1	**Intake & Levee Crossing**													
	Intake Channel	$11,577	$8,513,874	$12,163	$12,467	$12,778	$13,098	$4,262,539	$13,761	$14,105	$14,458	$14,819	$10,898,478	$15,569
	Concrete Inflow & Outflow U-Frames	$9,261	$80,689	$9,730	$9,973	$10,223	$10,478	$91,292	$11,009	$11,284	$11,566	$11,855	$103,289	$12,455
	Culverts under Levee & River Rd	$0	$1,222,201	$0	$0	$0	$0	$1,382,808	$0	$0	$0	$0	$1,564,520	$0
	River Road Crossing	$3,473	$3,560	$3,649	$3,740	$3,834	$3,929	$4,028	$4,128	$4,231	$4,337	$4,446	$4,557	$4,671
	Levee at Headworks	$5,557	$200,299	$5,838	$5,984	$6,134	$6,287	$65,516	$6,605	$6,770	$6,940	$7,113	$256,399	$7,473
2	**Headworks**													
	Control Building & Gated Structure	$62,514	$372,593	$65,678	$67,320	$69,003	$70,729	$287,302	$74,309	$76,167	$78,071	$80,023	$476,951	$84,074
	Sluice Gates & Actuators	$18,986	$1,324,723	$19,947	$20,445	$20,957	$21,481	$357,651	$22,568	$23,132	$23,710	$24,303	$1,695,758	$25,534
	Stand-By Generator	$5,788	$5,933	$6,081	$6,233	$6,389	$6,549	$6,713	$6,880	$7,052	$7,229	$7,410	$7,595	$7,785
	SCADA System	$9,261	$121,033	$9,730	$9,973	$10,223	$10,478	$29,536	$11,009	$11,284	$11,566	$11,855	$154,933	$12,455
	Access Roads	$1,736	$17,680	$1,824	$11,843	$1,917	$12,443	$92,635	$13,073	$2,116	$13,735	$2,223	$22,632	$2,335
	Monitoring Equipment	$113,451	$211,215	$119,194	$122,174	$125,228	$128,359	$238,971	$134,857	$138,229	$141,684	$145,227	$270,373	$152,579
3	**Roadway Crossings[1]**													
	Airline Highway Crossing	$5,788	$660,938	$6,081	$6,233	$6,389	$6,549	$210,778	$6,880	$7,052	$7,229	$7,410	$846,056	$7,785
	Interstate 10 Crossing	$0	$361,914	$0	$0	$0	$0	$6,713	$0	$0	$0	$0	$463,280	$0
4	**Sediment Basin & Conveyance Channel**													
	Sedimentation Basin	$127,574	$273,156	$134,033	$137,384	$140,818	$144,339	$147,947	$151,646	$155,437	$159,323	$163,306	$349,663	$171,573
	Conveyance Channel	$305,623	$7,195,558	$321,095	$329,122	$337,350	$345,784	$891,441	$363,289	$372,371	$381,681	$391,223	$9,210,923	$411,028
5	**Railroad Crossings[2]**													
	CN RR Crossing	$5,788	$187,483	$6,081	$6,233	$6,389	$6,549	$212,120	$6,880	$7,052	$7,229	$7,410	$239,994	$7,785
	KCS RR Crossing	$3,473	$62,890	$3,649	$3,740	$3,834	$3,929	$71,154	$4,128	$4,231	$4,337	$4,446	$80,504	$4,671
6	**Check Valves**													
	Check Valves under I-10	$16,207	$230,201	$17,028	$17,453	$17,890	$18,337	$59,071	$19,265	$19,747	$20,241	$20,747	$294,677	$21,797
7	**Flow Distribution Features**													
	Weirs at B. Secret and B. Canal	$34,730	$154,258	$36,488	$37,400	$38,335	$39,294	$174,529	$41,283	$42,315	$43,373	$44,457	$197,464	$46,708
	Embankment Cuts	$40,518	$77,129	$42,569	$43,634	$44,724	$45,843	$46,989	$48,163	$49,367	$50,602	$51,867	$98,732	$54,492
8	**Remote Sensors**													
	Maintenance	$231,532	$237,321	$243,254	$249,335	$255,568	$261,957	$268,506	$275,219	$282,100	$289,152	$296,381	$303,790	$311,385
9	**Personnel Salaries**													
	Maintenance Personnel	$648,290	$664,497	$681,110	$698,138	$715,591	$733,481	$751,818	$770,613	$789,879	$809,626	$829,866	$850,613	$871,878
	CPRA Office Personnel	$231,532	$237,321	$243,254	$249,335	$255,568	$261,957	$268,506	$275,219	$282,100	$289,152	$296,381	$303,790	$311,385
10	**Optional Items**													
	Airline Highway Sluice Gates	$25,932	$2,447,249	$27,244	$27,926	$28,624	$29,339	$996,696	$30,825	$31,595	$32,385	$33,195	$3,132,686	$34,875
	Maintenance Building	$13,313	$49,244	$13,987	$14,337	$14,695	$15,063	$55,715	$15,825	$16,221	$16,626	$17,042	$63,036	$17,905
	Sub-total Maintenance Costs:	**$1,931,905**	**$24,912,959**	**$2,029,707**	**$2,090,424**	**$2,132,461**	**$2,196,251**	**$10,980,971**	**$2,307,436**	**$2,353,838**	**$2,424,250**	**$2,473,001**	**$31,890,693**	**$2,598,197**
	Contingency (15%) :	**$289,786**	**$3,736,944**	**$304,456**	**$313,564**	**$319,869**	**$329,438**	**$1,647,146**	**$346,115**	**$353,076**	**$363,638**	**$370,950**	**$4,783,604**	**$389,730**
Total Maintenance Costs:		**$2,221,691**	**$28,649,903**	**$2,334,164**	**$2,403,987**	**$2,452,331**	**$2,525,689**	**$12,628,117**	**$2,653,552**	**$2,706,914**	**$2,787,888**	**$2,843,952**	**$36,674,297**	**$2,987,927**

RIVER REINTRODUCTION INTO MAUREPAS SWAMP
STATE PROJECT No. PO-0029
inflation rate: 2.50%

MAINTENANCE PLAN
95% DESIGN

No.	Description	42	43	44	45	46	47	48	49	50
		1/1/66	1/1/67	1/1/68	1/1/69	1/1/70	1/1/71	1/1/72	1/1/73	1/1/74
		3.19	3.27	3.35	3.44	3.52	3.61	3.70	3.79	3.89
1	**Intake & Levee Crossing**									
	Intake Channel	$15,958	$16,357	$16,766	$5,456,410	$17,615	$18,056	$18,507	$18,970	$13,950,973
	Concrete Inflow & Outflow U-Frames	$12,767	$13,086	$13,413	$116,862	$14,092	$14,444	$14,806	$15,176	$1,104,412
	Culverts under Levee & River Rd	$0	$0	$0	$1,770,111	$0	$0	$0	$0	$6,863,684
	River Road Crossing	$4,788	$4,907	$5,030	$5,156	$5,285	$5,417	$5,552	$5,691	$5,833
	Levee at Headworks	$7,660	$7,852	$8,048	$83,865	$8,455	$8,667	$8,883	$9,105	$328,212
2	**Headworks**									
	Control Building & Gated Structure	$86,176	$88,330	$90,538	$367,771	$95,122	$97,500	$99,938	$102,436	$6,249,258
	Sluice Gates & Actuators	$26,172	$26,826	$27,497	$457,823	$28,889	$29,611	$30,351	$31,110	$8,295,531
	Stand-By Generator	$7,979	$8,179	$8,383	$8,593	$8,808	$9,028	$9,253	$9,485	$301,380
	SCADA System	$12,767	$13,086	$13,413	$37,808	$14,092	$14,444	$14,806	$15,176	$198,327
	Access Roads	$15,161	$2,454	$15,928	$11,858	$16,734	$2,708	$17,582	$2,845	$28,971
	Monitoring Equipment	$156,393	$160,303	$164,311	$305,903	$172,629	$176,945	$181,368	$185,902	$346,101
3	**Roadway Crossings**[1]									
	Airline Highway Crossing	$7,979	$8,179	$8,383	$269,813	$8,808	$9,028	$9,253	$9,485	$1,083,023
	Interstate 10 Crossing	$0	$0	$0	$8,593	$0	$0	$0	$0	$593,038
4	**Sediment Basin & Conveyance Channel**									
	Sedimentation Basin	$175,863	$180,259	$184,766	$189,385	$194,119	$198,972	$203,947	$209,045	$447,598
	Conveyance Channel	$421,304	$431,837	$442,633	$1,141,120	$465,041	$476,667	$488,584	$500,798	$11,790,760
5	**Railroad Crossings**[2]									
	CN RR Crossing	$7,979	$8,179	$8,383	$271,532	$8,808	$9,028	$9,253	$9,485	$1,279,406
	KCS RR Crossing	$4,788	$4,907	$5,030	$91,083	$5,285	$5,417	$5,552	$5,691	$103,052
6	**Check Valves**									
	Check Valves under I-10	$22,342	$22,900	$23,473	$75,616	$24,661	$25,278	$25,910	$26,557	$377,211
7	**Flow Distribution Features**									
	Weirs at B. Secret and B. Canal	$47,875	$49,072	$50,299	$223,412	$52,846	$54,167	$55,521	$56,909	$252,770
	Embankment Cuts	$55,855	$57,251	$58,682	$60,149	$61,653	$63,194	$64,774	$66,394	$126,385
8	**Remote Sensors**									
	Maintenance	$319,170	$327,149	$335,328	$343,711	$352,304	$361,111	$370,139	$379,392	$388,877
9	**Personnel Salaries**									
	Maintenance Personnel	$893,675	$916,017	$938,918	$962,390	$986,450	$1,011,111	$1,036,389	$1,062,299	$1,088,856
	CPRA Office Personnel	$319,170	$327,149	$335,328	$343,711	$352,304	$361,111	$370,139	$379,392	$388,877
10	**Optional Items**									
	Airline Highway Sluice Gates	$35,747	$36,641	$37,557	$1,275,855	$39,458	$40,444	$41,456	$42,492	$13,109,832
	Maintenance Building	$18,352	$18,811	$19,281	$71,320	$20,257	$20,764	$21,283	$21,815	$109,858
	Sub-total Maintenance Costs:	**$2,675,919**	**$2,729,731**	**$2,811,387**	**$13,949,849**	**$2,953,714**	**$3,013,112**	**$3,103,246**	**$3,165,651**	**$68,812,228**
	Contingency (15%) :	**$401,388**	**$409,460**	**$421,708**	**$2,092,477**	**$443,057**	**$451,967**	**$465,487**	**$474,848**	**$10,321,834**
Total Maintenance Costs:		**$3,077,307**	**$3,139,191**	**$3,233,095**	**$16,042,327**	**$3,396,771**	**$3,465,079**	**$3,568,732**	**$3,640,499**	**$79,134,062**

ATTACHMENT 3

SUCCESS CRITERIA and

ADAPTIVE MANAGEMENT PLAN

These documents are currently under review and subject to minor changes.

Success Criterion	Initial Success	Intermediate and Long-Term Success
Basal Area (BA)	Maintain a stable or increasing mean BA (m^2/ha) relative to baseline (pre-project) BA for *Taxodium distichum* (baldcypress) and *Nyssa aquatica* (water tupelo) trees in the mitigation area.	N/A
Basal Area Increment (BAI)	Maintain stable or increasing BAI (m^2/ha/yr) growth rates relative to baseline (pre-project) growth rates for baldcypress and water tupelo trees in the mitigation area.	Demonstrate a 1.9-2.55x increase in mean BAI (m^2/ha/yr) growth rates relative to mean baseline (pre-project) growth rates at ≥ 75% of monitoring sites in the mitigation area.
Nitrate	Demonstrate a 2x increase in surface water nitrate concentrations relative to baseline concentrations at ≥ 75% of monitoring sites during diversion operation. If baseline concentrations are ≤ 0.1 mg/L nitrate, then ≥ 0.2 mg/L nitrate must be attained for success.	Attain ≥ 0.45 mg/L nitrate concentrations at ≥ 75% of monitoring sites during project operation.
Dissolved Oxygen	Attain ≥ 2 mg/L dissolved oxygen concentrations at ≥ 75% of monitoring sites during project operation.	≥ 4 mg/L dissolved oxygen concentrations at ≥ 75% of monitoring sites during project operation
Inorganic Sediment Retention	**A)** Increased sediment retention within the mitigation project area based on increased TSS concentrations delivered to the project area compared to baseline and decreasing TSS concentrations from the diversion outfall	N/A
	B) Increased inorganic sediment concentrations in surface sediments relative to baseline conditions and those observed in sites outside of the project impact area.	
Soil Surface Elevation Change	N/A	Attain an additional 5.0 ± 1 mm/yr increase in wetland soil surface elevation rates at ≥ 75% of monitoring sites.

Salinity Maintenance	Maintain a salinity of ≤0.8 ppt at ≥ 75% of monitoring sites

Draft Adaptive Management Plan
Maurepas Swamp Project for WSLP Mitigation

1. Overview

The Louisiana Coastal Protection and Restoration Authority (CPRA) developed this Adaptive Management Plan (AMP) for the Maurepas Swamp Project (MSP), in coordination with the U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District and Habitat Evaluation Team (HET) members, including U.S. Fish and Wildlife Service, Louisiana Department of Wildlife and Fisheries (LDWF), and the Louisiana Department of Natural Resources (LDNR). This plan focuses on adaptive management of Maurepas Swamp Alternative 2 (MSA-2), for purposes of describing the decision-making framework that will be used to assess and determine project success and identify potential needs to implement adaptive management actions to ensure mitigation success criteria are achieved.

This plan is a living document that will be updated as needed to reflect site and other environmental changes, monitoring procedures (including data sampling, analysis, storage, and reporting), adaptive management actions, and updates to the decision making-framework. This plan will be executed and maintained by the Environmental Planning Branch of Regional Planning & Environment Division, South (RPEDS) until the project meets initial success criteria targets, which must occur within ten years after the start of project operations. If initial success criteria are achieved prior to year 10, then the non-federal sponsor (CPRA) will assume responsibility for executing and maintaining the AMP requirements once project success has been achieved.

2. Project Background and History

2.1 Project Description

The Maurepas Swamp Project, hereafter referred to as MSP, was considered by the United States Army Corps of Engineers (USACE) for swamp habitat compensatory mitigation through enhancemnt for construction impacts by the West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction (WSLP) project. The MSP was converted into several viable compensatory mitigation alternatives, the Tentatively Selected Plan was Maurepas Swamp Alternative – 2 (MSA-2: Public Lands only). The MSA 2 is a 2,000 cubic foot per second (cfs) freshwater diversion that would be operated to optimize benefits to swamp habitats within for a 8,838-acre mitigation Area. The MSA-2 project is a subset of the larger approximately 45,155-acre Mississippi River Reintroduction to Maurepas Swamp Project (CPRA Project PO-0029). The diversion will reconnect the Mississippi River to the Maurepas Swamp, strategically delivering fresh, nutrient-laden river water to enhance and/or improve the health of the dying baldcypress-water tupelo swamp. and includes the following primary project features:

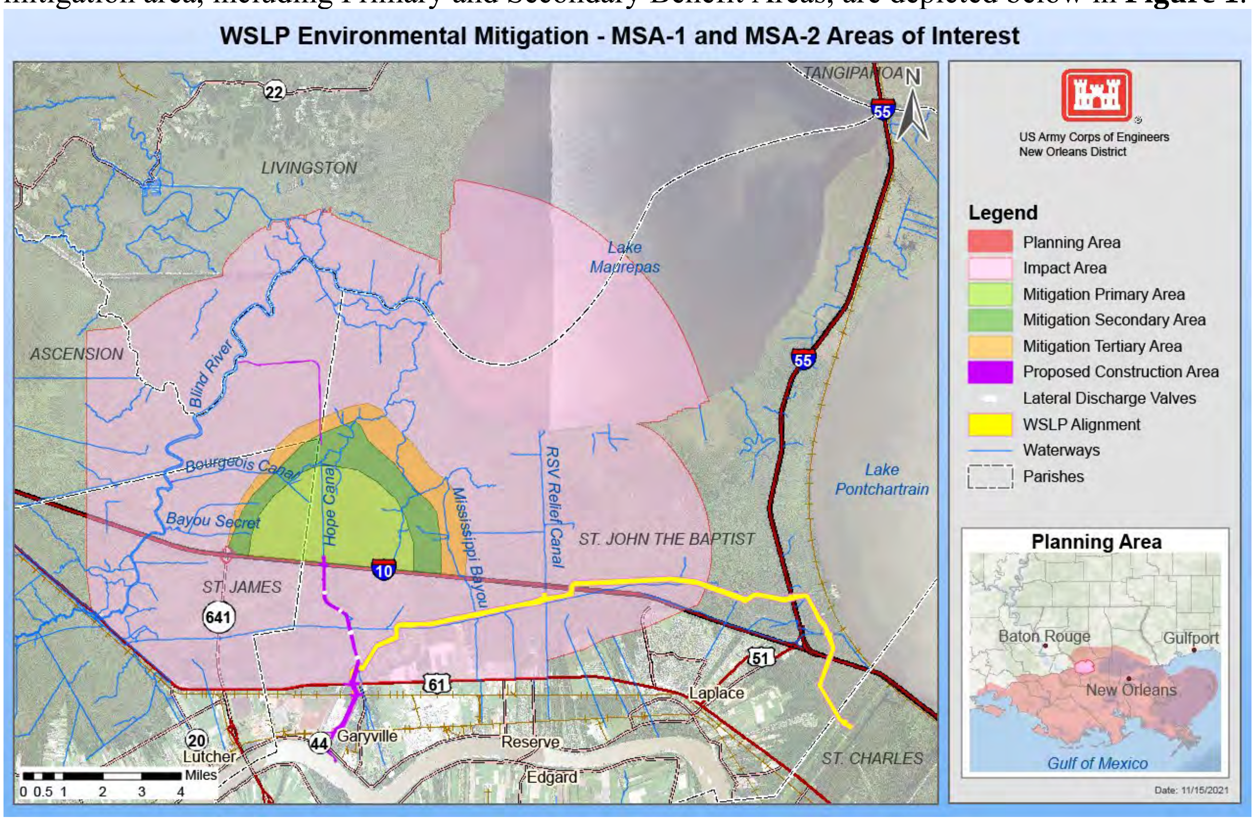
- an intake channel in the batture of the Mississippi River;
- an automated gate structure in the Mississippi River levee;
- a sedimentation basin;
- a 5.5-mile-long open conveyance channel;
- box culverts under River Road, Canadian National Railroad (CN), and Airline Highway;
- a bridge over the channel at Kansas City Southern Railroad (KCS);

- up to approximately 32 lateral discharge valves between Airline Highway and I-10 to carry flow from the conveyance channel to areas east and west of the channel;
- check valving on culverts underneath I-10 to reduce or eliminate southward backflow;
- reshaping the geometry of the existing Hope Canal channel under I-10
- embankment cuts in the existing ridge of an old railroad embankment located in St. John the Baptist and Ascension Parishes;

submerged rock rip-rap weirs in Bayou Secret and Bourgeois Canal located in St. James Parish;

2.2 Project Location

The boundaries of MSA-2 are areas of the Maurepas Swamp north of Interstate 10, east of Blind River, south of Lake Maurepas, and west of Reserve Relief Canal. Establishment of the mitigation area boundaries for MSA-2 was completed as part of the U.S. Fish and Wildlife Service (USFWS) benefit wetland value assessment. The geographic boundaries of the MSP mitigation area, including Primary and Secondary Benefit Areas, are depicted below in **Figure 1**.



The intake structure will be located on the east bank of the Mississippi River in St. John the Baptist Parish, immediately west of Garyville, Louisiana, at River Mile 144 above Head of Passes. The conveyance channel traverses between the Marathon Petroleum Terminal upriver and the Ernest Amann residential subdivision downriver and extends northward for 5.5 miles, terminating approximately 1,000-ft north of Interstate 10 (I-10). The primary features are located in St. John the Baptist Parish.

2.3. Project Objectives and Goals

The goal of the MSA-2 is to provide 1,000 Average Annual Habitat Units (AAHUs) of swamp habitat as compensatory mitigation for the construction of the WSLP risk reduction project through enhancement of approximately 8,838 acres of swamp habitat. The goal of is to convey Mississippi River water into the Maurepas Swamp to improve the structure, function, and resilience of the coastal forest habitat through reintroduction of fresh oxygenated water, nutrients, and sediment. MSA-2 can generate approximately 1,210 AAUHs in all three of the benefit areas (primary, secondary, and tertiary) combined (this meets the mitigation need of the WSLP project).

3. Data Collection, Management, Analysis and Reporting

3.1 Data Collection and Management

Data collection and management, associated methods, station locations, and monitoring frequency for the MSP are detailed in the MSP Mitigation Monitoring Plan (Appendix H). CPRA has a well-established system for data collection, processing, and quality assurance/quality control (QA/QC) that is explained in the Coastwide Referencing Monitoring System (CRMS)/System-Wide Assessment and Monitoring Program (SWAMP) standard operation procedures manual (Folse et al. 2020). Once all QA/QC measures have been completed, CPRA accepts and posts the data to the public Coastal Information Management System (CIMS) database (CIMS, https://cims.coastal.louisiana.gov). The CIMS database framework is currently established to store, display, and facilitate download of all data that will be collected for mitigation monitoring, except for radioisotope data. If radioisotope data are collected as part of this monitoring plan, the data may be provided to the public through an alternate format, such as a report or data release. Data will be made available to the USACE for internal use and public posting. Data analysis, assessment, report and the subsequent decision making process on the collected data is described in the subsequent sections.

3.2 Data Analysis and Assessment

The specifics regarding data analysis for each mitigation success criterion have yet to be finalized and require further Project Delivery Team (PDT) discussion. Once these details have been resolved, the MSP Monitoring and Adaptive Management plans will be updated with clear guidance regarding the determination of each metric's success. Success criteria are defined and explained in section 5.1 and Attachment A of this document.

3.3 Reporting

Reporting will involve the Interagency Environmental Team (IET). The IET is a commonly utilized team for USACE mitigation projects that is primarily comprised of federal and state agency practitioners and scientists. Team members review monitoring data and analyses, procedures, and reports, determine whether success criteria have been met, and propose appropriate actions when one or more success criteria have not been attained. The team is involved in specific scientific details of the project and may make scientifically-based operational and adaptive management recommendations. Assembling the MSP IET will be the responsibility of the USACE and CPRA, who will make membership recommendations and outline roles and responsibilities.

The USACE will develop and submit a draft baseline mitigation monitoring report to the IET by August 31 of the first year of project operations. The report will contain a summary and analysis of all mitigation monitoring data collected prior to the start of project operations. The report will also include the baseline conditions that will be used to inform mitigation success criteria. All reviews by the IET and a final submittal of the baseline report must be completed by December 31 of the same year.

Initial, intermediate and long-term success criteria mitigation monitoring reports will be written in the year following the completion of data collection for the respective success criteria assessment. As with the baseline report, the draft monitoring report must be submitted to the IET for review by August 31 of that year, with all reviews and a final submittal of the report completed by December 31 of the same year. All reports will be made available to all members of the IET, USACE, CPRA and the Maurepas Interagency Team (MIT).

4. AMP Development and Purpose

4.1 AMP Development

The Louisiana CPRA developed the initial version of the MSP AMP for review and comment by the USACE MVN and HET members, including U.S. Fish and Wildlife Service, LDWF, and LDNR. The plan has been heavily influenced and assisted by PDT discussion, HET meetings, and input both from USACE Engineer Research and Development Center (ERDC) and the Maurepas Technical Advisory Group (TAG) that consists of Dr. Ken Krauss, Dr. Richard Keim, Dr. Gary Shaffer, and Dr. Jim Chambers. The plan was revised after the selection of MSA-2 as the Tentatively Selected alternative by the USACE.

4.2 AMP Purpose

The purpose of this AMP is to assess the risks associated with achieving (or not achieving) the projected benefits of the MSP and address what actions may be necessary to ensure the mitigation requirements are achieved if these risks become reality. This AMP will address unforeseen changes in site conditions that may adversely affect the MSP and/or inhibit achieving success criteria.

This AMP will guide decisions for revising compensatory mitigation work plans and the implementation of measures to address both foreseeable and unforeseeable circumstances that may adversely affect project success. The AMP is heavily reliant on ecosystem monitoring, as detailed in the MSP Monitoring Plan, and actions associated with the operation and maintenance of the project, as described in the MSP Operations and Maintenance plans (Appendix N). Additionally, adaptive management will include management of targeted invasive species that threaten the functionality and integrity of project infrastructure, inhibit water flow, impact water quality or negatively impact baldcypress-water tupelo swamp habitat.

5. Adaptive Management

The MSP has been in development for decades and, at the programmatic level, knowledge gained through various studies and designs and from lessons learned from other constructed freshwater diversions (e.g., Davis Pond, Caernarvon, etc.) in Louisiana have been applied to the development of the MSA-2. The use of adaptive management approaches during project planning informed selection of design and operation elements to meet project objectives and mitigation requirements. This AMP defines and justifies whether adaptive management is needed during construction and/or the operations phase in relation to mitigation success criteria. A primary component of adaptive management for the MSA-2 is the project-specific mitigation monitoring plan (see MSP Monitoring Plan), which contains monitoring targets to gauge project success.

Adaptive management is a process that allows for decisions to be made in the face of uncertainty to increase the likelihood that project goals and objectives are met. The MSP will be adaptively managed to assist in achieving the desired project outcomes and mitigation objective while reducing undesirable impacts. The expected project outcome is to provide at least 1,000 AAHUs of swamp habitat through enhancement for compensatory mitigation of the WSLP project impacts.

5.1 Success Criteria

The success criteria that were drafted by ERDC, reviewed and modified by the PDT, HET, and the TAG and ultimately agreed upon by the PDT on February 18, 2021 are listed in Attachment A. Not all criteria have to be met to claim project success. Success criteria may need to be modified in the adaptive management process based on monitoring data or site conditions.

Project success will be determined by collecting and analyzing monitoring data in accordance with established protocols appropriate for each parameter. Monitoring assessments after the start of project implementation will determine how the ecosystem is responding to the project through a comparison to baseline data and success criteria targets. Because of the current variation in forest health in the project area, the project will not have consistent effects in all locations. In addition, project effects will vary with respect to space and time; therefore, monitored parameters will be collected at locations and time intervals reflective of the ability to detect changes of each parameter, especially in their influence on the target habitat. The project has initial, intermediate and long-term success criteria to capture this spatial and temporal variability. If project outcomes do not meet the desired expectations, adaptive management actions will be considered and selected remedies implemented.

5.2 Decision-Making Framework

Until initial success criteria have been met, adaptive management measures will be the responsibility of the USACE. Once initial success has been achieved, the State of Louisiana acting through the CPRA, will be responsible for adaptive management measures through project year 50.

As described in the MSP Operations Plan, USACE and CPRA will establish, assemble, and utilize the MIT comprised of federal, state, and local agencies, tto manage the operation and adaptive management of the project. . This could include decisions on the operational management plan for the structure, procedures for test operations of the structure, emergency shutdown procedures, and such other operational concerns deemed appropriate. The MIT will consider the recommendations of the Maurepas Technical Advisory Group, comments by state and federal agencies, stakeholders, and the public, and rely on project monitoring data and other relevant information, as appropriate. The MIT will consist of members with varied backgrounds and interests with respect to the diversion structure operations. The committee will be led by USACE and CPRA, who will determine committee membership to potentially include but not be limited to federal, state and local agencies and officials, landowners, not-for-profits, non-governmental agencies, and resource users.

Varying levels of approval may be required to implement any adaptive management actions. Specific governance with respect to adaptive management of this project will be affected by the source of project construction, operations, monitoring, and adaptive management funds. At this time, known entities that will be involved in governance are CPRA, USACE, Pontchartrain Levee District, LDWF, private landowners and parish representatives.

5.3 Potential Triggers for Adaptive Management Action

The need for adaptive management actions will be identified based on monitoring data and associated assessments. Many circumstances may trigger the need for adaptive management action(s), primarily associated with not attaining one or more success criteria. While attaining all success criteria is the goal of this mitigation project, the benefit of meeting one success criterion will always be assessed in relation to meeting other success criteria. Improving the health of the Maurepas Swamp and meeting required mitigation success criteria, as well as maintaining the health of the surrounding environment, will always be of primary importance and will guide diversion operations. Some of the triggers for adaptive management may include, but not be limited to:

1. One or more monitoring success criteria metrics are not attained
2. Hydrologic connectivity between the river and swamp is not adequately achieved
3. Conveyance channel is eroding or clogging
4. Hydrology is altered in the project area due to siltation, erosion, or invasive species
5. Project area, project infrastructure and/or project operations are impacted by severe weather events (flooding, structural damage from wind, etc.)
6. Diversion operations result in water level exceeding expectations
7. Excess nitrate from the diversion is causing eutrophication
8. Salinity increases above 0.8 ppt outside of the planned operations schedule
9. Mortality increases and/or growth is reduced for non-target woody species
10. Monitoring plan does not effectively assess the success criteria (station number and locations are sufficient, analyses are inappropriate, monitoring frequency is not adequate)
11. Invasive species increase or are introduced in the project area
12. Future climate change trajectories or projections affect swamp conditions (e.g., subsidence, sea level rise, flood events, drought, growing season lengths, etc.)
13. River conditions change
14. River hydrographs and swamp conditions impact timing and duration of operation during the growing season
15. Pollution or oil/contaminant spills in the river or vicinity of project area
16. Existing or future projects cause unexpected interactions with the MSP
17. Landowner exhibits concerns
18. Diversion infrastructure is damaged or inefficient
19. Challenges are identified with wildlife species (e.g., impingement, entrainment, entrapment, etc.)

5.4 Potential Adaptive Management Actions

If the project is not meeting all of the defined success criteria targets, specific adaptive management actions, as detailed below, may be identified, recommended, and implemented. These recommendations could be made by state and federal agencies or variety of entities including but not limited to local entities, landowners, non-governmental organizations, not-for-profit organizations, and others. Should the proposed adaptive management actions have ground disturbing or ground clearance components, these actions will be evaluated for their potential to affect historic properties, following the provisions of the executed BBA 18 Mitigation PA (see section 5.6 for more discussion).

The primary means of adaptively managing this project will involve adjustments to the operation of the diversion structure, as outlined in the MSP Operations Plan. This Operations Plan will be strengthened by the Adaptive Management plan to address situations that may adversely affect compensatory mitigation. Operational adjustments may be needed due to a variety of factors, including Mississippi River conditions, seasonal environmental trends, and weather patterns. In addition, operations will need to be flexible to meet the needs of the project area, including the potential for low water periods to promote seedling establishment and maximize nutrient uptake. Operational changes may be made to the timing, flow rate, duration, and frequency of operations.

In addition to changing operational regimes, the most inexpensive, expeditious, and least complicated adaptive management action is to expand the original mitigation project footprint. As described in the project description and objectives of the MSP Mitigation Plan, the mitigation project area is currently limited to the size required to provide the WSLP project with 1,000 AAHUs of forested swamp habitat enhancement. However, the projected benefit area extends beyond the mitigation footprint into a much larger area of the Maurepas Swamp; therefore, the potential exists to expand the original mitigation footprint to capture additional AAHUs, if needed. Figure 2, taken from FTN and Associates modeling report (2021), clearly shows the large extent of the area that is projected to be reached by river water. Figure 3, taken from FTN and Associates modeling report (2021), shows the large extent that has increased levels of Total Nitrogen (TN) and Total Phosphorus (TP). Expanding the MSP project area could be a component of a larger adaptive management response should a portion of the original mitigation footprint not meet defined success criteria. If the footprint is expanded additional monitoring and associated costs would need to be incorporated.

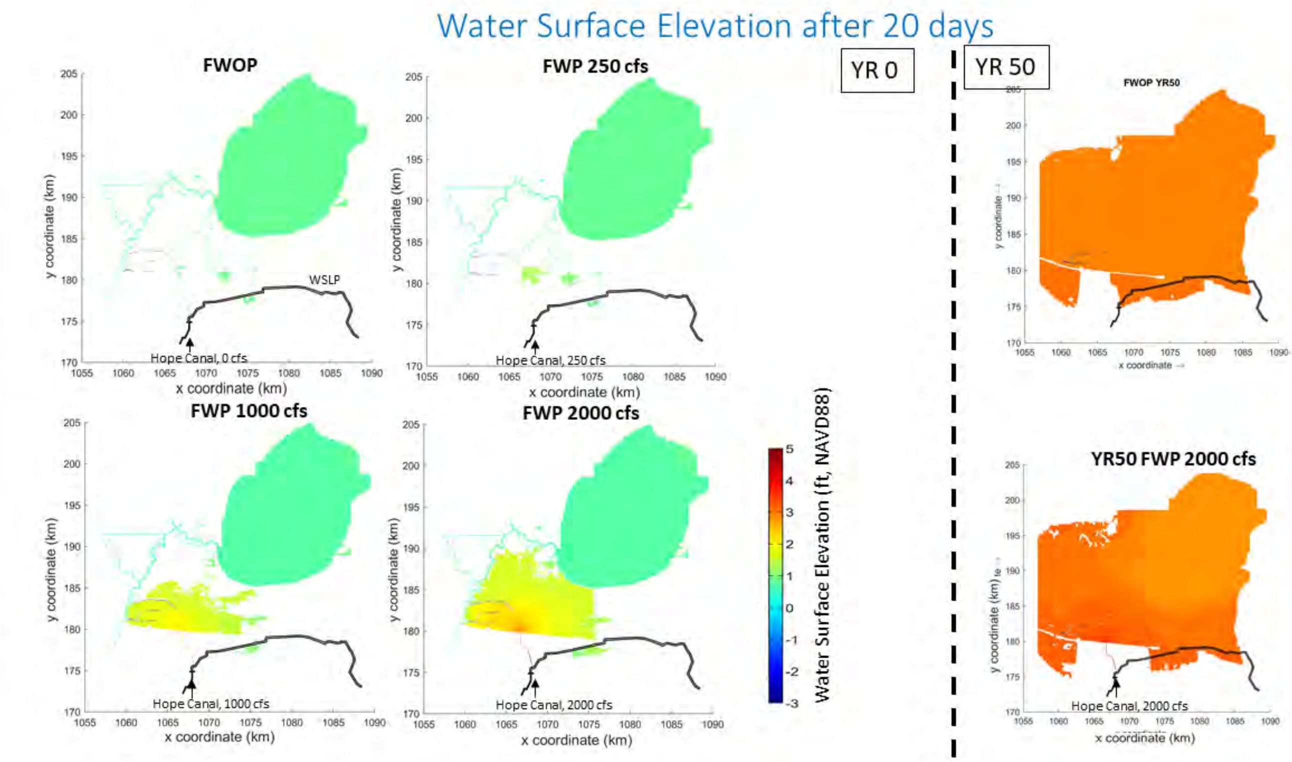


Figure 2. Predicted water surface elevation contours at the end 20 days under operational regimes ranging from 250–2000 cfs *(taken from FTN and Associates, LTD Hydraulic and Water Quality Modeling of Proposed River Reintroduction into Maurepas Swamp (PO-0029) report, Figure C-5, 2021.*)

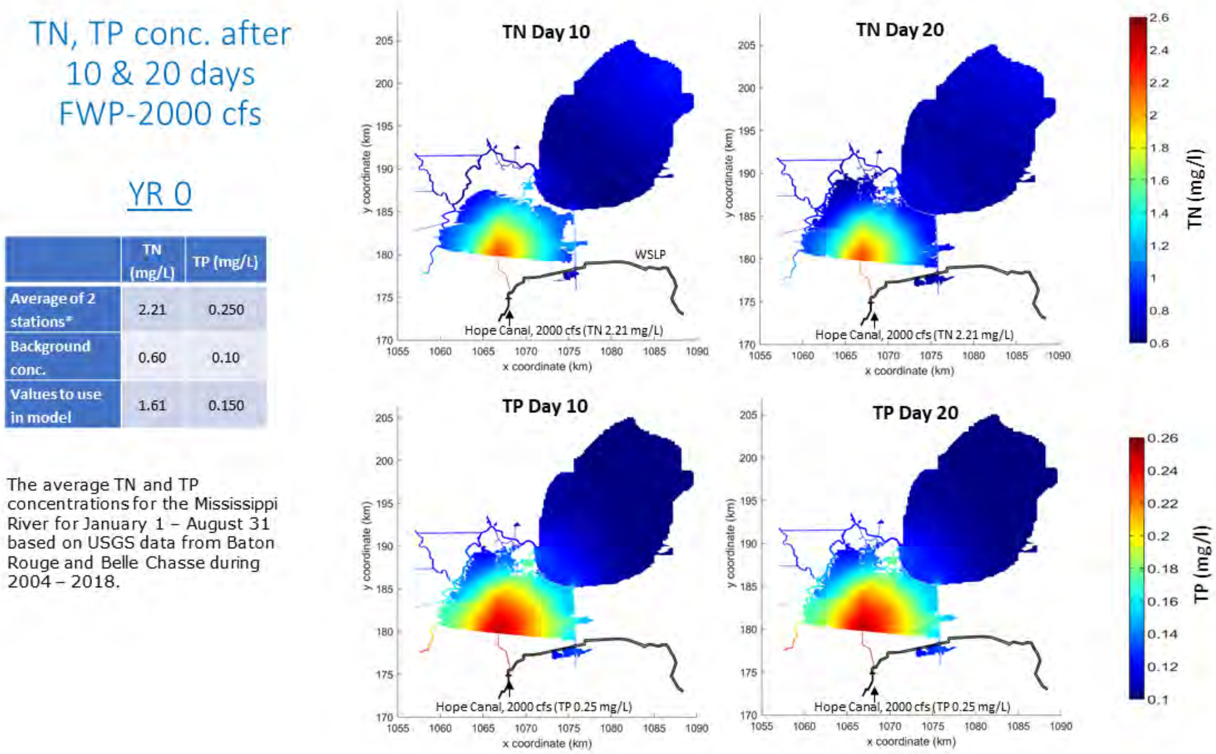


Figure 3. Predicted TN and TP concentrations at the end of 10 and 20 days of 2000 cfs operations *(taken from FTN and Associates, LTD Hydraulic and Water Quality Modeling of Proposed River Reintroduction into Maurepas Swamp (PO-0029) report, Figure C-10, 2021.*)

Another adaptive management action that could be implemented is purchasing swamp habitat mitigation credits. Success criteria are more likely to be met in the primary benefit area, as define by the project WVA. The secondary benefit area is 2836 acres and 401.14 AAHUs. Should criteria not be met in the secondary benefit area, an adaptive management option that could be implemented is the purchase of swamp credits. Based on a cost of $54,000 per acre of swamp habitat and 0.46 AAHU per acre, purchasing credits for the entire secondary benefit area would cost approximately $47,073,913. Based on modeling results and monitoring data, it is highly unlikely that no benefits will be realized in the secondary benefit area. Therefore, it is assumed that credits may need to be purchased for 50% of the secondary benefit area, which would cost approximately $23,536,957.

In addition to changing operational regimes, other potential adaptive management measures may be needed. These features could include additional spoil bank gapping, water control structures (i.e. weirs), or cuts in railroad embankments to assist with establishing the desired hydrology and meeting the success criteria targets. The purpose of the weirs is to increase retention time of the diverted fresh water within the swamp. It is possible that after operation of the diversion, additional weirs may be needed to optimize diversion operations and hydrology within the swamp. Embankment cuts in prominent high elevation man-made features, in particular abandoned railroad embankments and canal spoil banks, are a component of the project. It is possible that after operation of the diversion reveals where water flow through the swamp is impeded, additional embankment cuts may be needed to optimize diversion operations and improve hydrologic efficiency within the swamp.

Should more benefits be needed, the preferred adaptive management actions are modifying operations, expanding the project area, or purchasing mitigation credits. However, another action could potentially include location-targeted vegetative plantings to assist with the development of the desired vegetative community. However, this method is not preferred for several reasons: (1) Site hydrologic conditions would need to be monitored post operations to assess the best location for plantings to maximize survivability, and (2~~3~~) the number, density, species, and size of trees potentially planted would be highly dependent on site conditions. For these reasons, plantings are included as a potential adaptive management action, but no costs are estimated.

Throughout the project life, extreme weather events such as storms and droughts, external environmental contamination, and acute biologic hazards (*eg* fish kills, algal blooms, invasive species, etc.) may require additional monitoring beyond the routinely scheduled monitoring to meet success criteria. In addition, if increasing the mitigation project area is implemented as an adaptive management action, additional monitoring will be needed in this area. For these reasons, CRASH (Contingent, Rapid Assessment of Status of Habitat) monitoring is budgeted throughout the project life.

Should aquatic invasive plant species density or location cause significant impacts to outfall flows reaching the target areas or prove to be detrimental to achieving success as indicated by success criteria metrics (such as DO), management actions may be considered. These could include biological control (such as salvinia weevils), chemical control (spraying with herbicides), mechanical control (physical removal by cutting or raking), or potentially using pulses of flow to flush the channels. Apple snail populations could potentially be managed by targeted flooding of the egg masses. Should nutria damage to levee or channel embankments threaten the integrity of the infrastructure, additional targeted control measures (exclusion, trapping, or shooting) could be considered. Also, a reassessment of the suitability of the success criteria and monitoring plan may be warranted.

5.5 Invasive Species

Invasive species of greatest concern to the project were determined through an initial review and evaluation of the many studies on the status of invasive species in the Maurepas Swamp and throughout coastal Louisiana, which was followed by project-specific evaluations and discussions among stakeholders, including CPRA, USFWS, LDWF, and USACE. The invasive species of greatest concern to the MSP are floating aquatic plants (water hyacinth (*Eichhornia crassipes*), common salvinia (*Salvinia minima*), alligatorweed (*Alternanthera philoxeroides*), and crested floating heart (*Nymphoides cristata*)) that may negatively impact the MSP's success by affecting water quality parameters (such as dissolved oxygen) or functionality by impeding the flow of introduced river water. While not tied directly to Project success criteria, these invasive species may also outcompete or adversely affect native species, thereby degrading the swamp ecosystem that the Project intends to benefit.

It is possible that introduction of nutrient-rich river water may increase the growth rate of floating aquatic plants, but the swamp forest is expected to uptake a substantial percentage of available nutrients prior to reaching the main waterways. Most of these plants tend to be more problematic in stagnant water, as indicated by their current distributions.

In addition to the aquatic invasive plants identified above, apple snails (*Pomacea maculata*) have been identified as a nearly ubiquitous invasive species in the Maurepas swamp. Apple snails have been noted to consume large quantities of aquatic vegetation, both native and invasive, but the impact of the diversion on their growth and spread is unknown. Potentially, if the diversion raises water levels enough to flood their egg masses laid above the water line, it is possible that the diversion-related water level increases could retard snail reproduction (Ronny Paille, personal communication). Fluctuating water levels through regular and/or seasonal diversion operations could increase the likelihood that the MSP would provide benefits related to apple snail control. There is no known effective eradication method for apple snails other than killing the egg masses.

As previously mentioned, nutria (*Myocastor coypus*) could damage the guide levees or other Project structure embankments by burrowing into them, potentially causing erosion. If conditions allow for germination of baldcypress or water tupelo seedlings, they would be vulnerable to nutria herbivory, preventing regeneration.

Additionally, terrestrial invasive plant species (e.g., Chinese tallow (*Triadica sebifera*), Chinese privet *(Ligustrum sinense*), etc.) could colonize these Project features; however, routine maintenance would likely prevent their establishment. The spoil banks and abandoned railroad embankments in the Project area are already dominated by Chinese tallow and other terrestrial invasive plants which are not expected to establish in the swamp or impact the forest's integrity.

Zebra mussels (*Dreissena polymorpha*) are present in the Mississippi River and could be introduced into the Project area by the MSP. The main concern would be their ability to attach to and impact the structural components of the Project. However, the species is not considered a primary threat to ecosystem function compared to other invasive species discussed above.

Due to numerous portals and pathways of potential introduction of new invasive species to the project area, there is potential for additional, new invasive species to impact the project effectiveness. Early detection through existing monitoring efforts (project-specific and existing LDWF program) could trigger adaptive management actions, if warranted.

It is generally acknowledged that the eradication of any of these invasive species already widely distributed within the Project area is not realistic. Constraints to eradication include the following: how well established they already are in the Project area and throughout Louisiana; the unlikelihood that eradication is feasible given the costs required and past effectiveness of such efforts; and how easily these invasive species could be reintroduced from other areas. However, the MSP is committed to managing invasive species as threats to Project facilities and benefits arise.

There are no monitoring success criteria proposed specifically for invasive species management because no planting component is included in the mitigation plan, and invasive species control is not a feature of the Project. However, any potential impacts by invasive aquatic plants to dissolved oxygen—one of the key water quality metrics that will be monitored for the Project—would be addressed should that water quality metric's target not be met.

Overstory surveys to assess the forest integrity success criteria include a documentation of all overstory species at sites, including any invasive species. Additionally, annual herbaceous surveys conducted at CRMS sites in the project area, and herbaceous surveys conducted at a lesser frequency at a subset of project-specific sites for PO-0029 monitoring, will document the presence of invasive species present in those layers. Contractors will frequently be in the MSP area to collect data, as will agency representatives for site inspections and to assist with monitoring. During these monitoring and operations field trips, a qualitative assessment of invasive species can be documented, which can be followed by a site visit to specifically assess their presence, extent, and need for adaptive management.

After monitoring data are collected/managed, assessments will determine ecosystem responses to the Project and will determine if there is a need for any adaptive management actions to manage invasive species. Monitoring for structural integrity and function of the Project will be conducted. If USACE or CPRA, in coordination with the LDWF, determine any such species are hindering the attainment of mitigation success and/or causing negative impacts within the project area that did not exist prior to, or have been greatly exacerbated since, the start of project operations, then appropriate measures to control invasive and/or nuisance species will be initiated.

Managing invasive species is usually conducted through chemical, physical, or biological methods. Potential adaptive management actions to control invasive aquatic floating plant species include herbicide spraying and mechanical removal. Herbicide spraying would likely be contracted to Louisiana Department of Wildlife and Fisheries (LDWF) since they are the primary landowner and currently spray in the area.

Because common salvinia is thriving in the Maurepas Swamp year round, salvinia weevils could be a valuable biological tool for control. If successful, the weevils would not only benefit Blind River, but also recreational activities on Maurepas Swamp. Attempts could be made to transplant weevil-infested common salvinia from the Blind River site to appropriate sites in Maurepas Swamp.

If nutria are noted to cause excessive damage to the project area, USACE and CPRA could work with LDWF and their Coast-wide Nutria Control Program to potentially increase bounties or implement other options.

5.6 Cultural Resources

Identified resources of concern. Cultural Resources of greatest concern to the MSP were determined through an initial evaluation of the many studies conducted in the MSP project area and impact area documenting the location and National Register of Historic Places status of recorded cultural resources including archaeological sites, cemeteries, and historic standing structures, and discussed in this SEIS. These data were shared with consulting parties, including the Alabama Coushatta Tribe of Texas, Chitimacha Tribe of Louisiana, Choctaw Nation of Oklahoma, Coushatta Tribe of Louisiana, Jena Band of Choctaw Indians, Mississippi Band of Choctaw Indians, Muscogee (Creek) Nation, Seminole Nation of Oklahoma, Tunica-Biloxi Tribe of Louisiana, Louisiana State Historic Preservation Office (SHPO), and the Advisory Council of Historic Places (ACHP). Additional identification strategies are planned to document unrecorded properties within the MSP project and impact areas, which will also be coordinated and consulted upon with the same parties. Currently, cultural resources of concern within the MSP impact area are: four (4) prehistoric shell middens (16AN8, 16LV73, 16LV24, 16SJB4), 2 possible watercrafts/shipwrecks (16LV74, 16SJ72), one (1) railroad bridge (16SJ72), and the Amite River Diversion Canal (16LV103); two (2) cemeteries, 16SJ58 and 16SJ61, both dating back to the Civil War.

Adaptive Management Actions of potential impact. While most actions proposed to respond to the triggers for Adaptive Management Action, would not have the potential to affect historic properties, a few, such as additional spoil bank gapping, water control structures (ie weirs), or cuts in railroad embankments to assist with establishing the desired hydrology, and targeted vegetative plantings, which may require access routes and ground work, have the potential to affect archeological deposits in the action areas.

Actions to assure that cultural resources are taken into account. To address these potential impacts, the provisions of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA) shall be implemented. The most relevant provision would be, Stipulation III A. Changes to an Approved Scope of Work, which outlines project review steps to be taken when project actions change following survey and determinations of effect.

6. Long-term Protection and Maintenance

Long-term management of the MSA-2 will be the responsibility of CPRA through the project's 50-year post-construction life. As stated in the Maintenance Plan, an MIT will be established prior to the end of project construction for decision-making for diversion structure operation and adaptive management actions. Per the PO-0029 Operations, Maintenance, Monitoring, and Adaptive Management (OMMAM) Plan (Buras et al 2018) delivered to the USACE in October 2018, costs for operations, maintenance, monitoring, and adaptive management have been estimated for the life of the project. Cost estimates will likely increase from 2018 levels and due to additional monitoring required for the MSP. CPRA has planned and budgeted for these long-term management needs for the project based on the agency's future budget projections.

7. Funding

Funding is an important component of the planning and potential implementation of adaptive management. Over the 50 year project life, it is possible that implementing adaptive management measures could cost a total of approximately $40,535,852.63 (**see Table 2**). Costs are included for construction of a total of three additional weirs, to be constructed and budgeted at years 5, 15, and 35 at a total cost of $832,881.61. Costs are included for additional embankment cuts at years 2, 4, 10, 20, 30, and 40 at a total cost of approximately $1,888,956.94. Costs for adaptive management construction features (weirs, gapping) were estimated by taking the Engineer's Opinion of Probable Construction Cost and projecting into the future using an annual inflation rate.

Purchasing swamp mitigation credits for 50% of the secondary benefit area costs approximately $23,536,957, based on a cost of $54,000 per acre of swamp habitat and 0.46 AAHU per acre (costs provided by USACE MVN). CPRA is also budgeting $30,000 per year for invasive species management (estimated as $3,000 per day for 10 events) for a total estimated cost of $1,500,000. CRASH (Contingent, Rapid Assessment of Status of Habitat) monitoring is budgeted at years 5, 10, 20, 30, 40, and 50 for a total cost of approximately $ 12,777,057.56. The State, led by CPRA, has planned for this level of future funding for MSP adaptive management actions, as well as for continued operations, maintenance, and monitoring, to provide assurances that the project and its benefits are protected in perpetuity.

REFERENCES *(currently incomplete. CPRA will complete week of 2/22/21)*

OMMAM Report

Attachment A

Summary Table of Mitigation Monitoring Success Criteria (from Hurst and Berkowitz, 2021).

Mitigation Monitoring Success Criteria	Performance Metric	Initial Success Criteria Monitoring Targets (USACE)	Intermediate a Criteria Moni
Enhance Forest Integrity	Basal Area Increment (m^2/ha/yr)	Maintain or increase the mean growth rate of baldcypress and water tupelo in the project area, as compared to the mean baseline growth rate for the same species in the project area prior to the start of diversion operations.	Achieve a 1.9–2.55 growth rate of bald ≥ 75% of monitorin area, as compared t rate for the same sp prior to the start of
	Basal Area (m^2/ha)	Maintain or increase the mean basal area of baldcypress and water tupelo in the project area, as compared to the basal area for the same species in the year prior to the start of diversion operations.	None
Improve Water Quality	Nitrate (mg/L)	Attain a 2x increase in nitrate relative to baseline concentration at ≥ 75% of stations during diversion operations. If baseline concentration is ≤ 0.1 mg/L nitrate, the success criteria limit is ≥ 0.2 mg/L nitrate.	Attain ≥ 0.45 mg/L in the project area c
	Dissolved Oxygen (mg/L)	Attain ≥ 2 mg/L DO at ≥ 75% of stations in the project area during diversion operations.	Attain ≥ 4 mg/L DC project area during
Increase Sediment Accumulation and Soil Surface Elevation	Sediment Delivery and Retention	Demonstrate that diversion operations have increased sediment delivery and retention in the project area. Demonstrate that sediment deposition during diversion operations has increased the inorganic content of surface sediment in the project area as compared to baseline conditions.	None
	Wetland Soil Surface Elevation Change	None	Demonstrate an adc increase in the rate change at ≥ 75% of
Maintain Salinity	Surface Water Salinity (ppt)	Maintain surface water salinity at ≤ 0.8 ppt during diversion operati monitoring stations in the project area.	

ATTACHMENT 4

PHYSIOLOGIC AND BIOLOGIC COMPONENTS OF AQUATIC HABITAT

Maurepas Diversion Biological Assessment Aquatic Features

	Body of Water	Source Organization	Site Name	Coordinates	Reference site	Depth (ft)	# of Data Points, Date Range, Collection Length	Current ft^3/s	# of Data Points, Date Range, Collection Length	Turbidity (FNU)	# of Data Points, Date Range, Collection Length	pH	# of Data Points, Date Range, Collection Length	Temp (C)	# of Data Points, Date Range, Collection Length	Dissolved Oxygen (mg/L)	# of Data Points, Date Range, Collection Length	Specific Conductance (uS/cm)	Points, Date Range, Collection	Salinity ppt	# of Data Points, Date Range, Collection Length
1	Maurepas Swamp	No Data Found				x		x		x		x		x		x		x		x	
2	MSR	USGS	USGS 07374000 Mississippi River at Baton Rouge, LA	(-91.191389, 30.44556)	https://waterdata.usgs.gov/nwis/inventory?site_no=07374000	20.27	5 annual averages, JAN10-DEC14, 5 years	700,360	5 annual averages, JAN16-DEC20, 5 years	x	2 annual averages, 18, 19, ~2 years	x		18.17	4 annual averages, 11, 13, 18, 19, ~4 years	8.33	3 annual averages, 13, 18, 19, ~3 years	368.8	3 annual averages, 13, 18, 19, ~3	0.2	2 annual averages, 18, 19, ~2 years
3	Bayou Secret	No Data Found				x		x		x		x		x		x		x		x	
4	Bourgeois Canal	LDEQ	3947 - Bourgeois Canal north of Gramercy	(-90.677219, 30.153098)	https://waterdata.deq.louisiana.gov/Sites/3947	9.84	5, JAN10-MAY10, ~0.5 years	x		6.38	5, JAN10-MAY10, ~0.5 years	6.66	1, MAY10	27.35	1, MAY10	2.95	1, MAY10	365.4	1, MAY10	0.18	1, MAY10
5	Hope Canal (1)	USGS	Crms5373-H01-Rt	(-90.630833, 30.100556)	https://dashboard.waterdata.usgs.gov/api/gwis/2.0/service/site?agencyCode=USGS&siteNumber=300602090375100&	1.811	5 annual averages, JAN16-DEC20, 5 years	x		x		x		20.6	5 annual averages, JAN13-DEC17, 5 years	x		291	5 annual averages, JAN16-DEC20,	0.148	5 annual averages, JAN16-DEC20, 5 years
	Hope Canal (2)	CPRA	SWMP0205	(-90.641134, 30.128742)	Excel SWAMP Station 201-205	5.85	24, NOV17-OCT19, 2 years	x		4.87	121, NOV17-OCT19, 2 years	x		20.25	121, NOV17-OCT19, 2 years	2.76	121, NOV17-OCT19, 2 years	241.65	121, NOV17-OCT19, 2 years	0.114	121, NOV17-OCT19, 2 years
6	Blind River (1)	LDEQ	1102 - Blind River (at Lake Maurepas) Southeast of French Settlement,	(-90.597996, 30.20706)	https://waterdata.deq.louisiana.gov/Collection_Data/WQ1958001/1102	x		x		21.07	23, OCT13-SEP18, ~5 years	7.01	24, OCT13-SEP18, ~5 years	21.76	24, OCT13-SEP18, ~5 years	5.82	24, OCT13-SEP18, ~5 years	226.39	24, OCT13-SEP18, ~5 years	0.11	24, OCT13-SEP18, ~5 years
	Blind River (2)	CPRA	SWMP0202	(-90.674780, 30.212295)	Excel SWAMP Station 201-205	20.86	24, NOV17-OCT19, 2 years	x		9.98	261, NOV17-OCT19, 2 years	x		22.07	261, NOV17-OCT19, 2 years	4.22	261, NOV17-OCT19, 2 years	180.05	261, NOV17-OCT19, 2 years	0.084	261, NOV17-OCT19, 2 years
7	Lake Maurepas	LDEQ	4471 - Lake Maurepas Southeast of Maurepas, Louisiana	(-90.558067, 30.203133)	https://waterdata.deq.louisiana.gov/Collection_Data/WQ1958001/4471	x		x		21.87	24, OCT13-SEP18, 5 years	7.22	24, OCT13-SEP18, 5 years	21.7	24, OCT13-SEP18, 5 years	6.62	24, OCT13-SEP18, 5 years	367.65	24, OCT13-SEP18, 5 years	0.18	24, OCT13-SEP18, 5 years

Nutrient data were not available at the sample locations

ATTACHMENT 5

SUPPORTING DOCUMENTS

US ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT

Biological Assessment
Bonnet Carré Spillway
2019 Emergency Operation

September 2020

Lead Contact: **Howard Ladner**
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Table of Contents

1.0 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended, requires that *"Each Federal agency shall, in consultation with and with the assistance of the secretary, insure that any action authorized, funded, or carried out by such agency….Is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species…"*

This Biological Assessment (BA) provides the information required pursuant to the ESA and implementing regulations 50 Code of Federal Regulations (CFR) 402.05 (Emergencies) and 50 CFR 402.14 (Formal Consultation), to comply with the ESA. Additional legal authorities include the National Environmental Policy Act (NEPA) of 1969, 42 United States Code (USC) section 4321, *et seq.;* the Fish and Wildlife Conservation Act of 1958 (PL 85-624; 16 USC 661 *et seq*.); the Marine Mammal Protection Act of 1972; and the Migratory Bird Treaty Act of 1918. This BA is submitted to the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) by the U.S. Army Corps of Engineers, New Orleans District (CEMVN) to initiate formal consultation regarding impacts to threatened and endangered species from the 2019 emergency operation of the Bonnet Carré Spillway (BCS). This BA is promulgated in accordance with Section 7 (Interagency Consultation) of the ESA.

2.0 THREATENED AND ENDANGERED SPECIES

There are 12 animal species, under the jurisdiction of the USFWS and/or the NMFS, presently classified as threatened or endangered that may be found within the action area (Table 1), as discussed in Section 6.0. The USFWS and NMFS share jurisdictional responsibility for sea turtles and the Gulf sturgeon.

2.1 "No Effect" on Listed Species:

1. The piping plover (*Charadrius melodus*) and red knot (*Calidris canutus rufa*) occupy non-vegetated intertidal habitat typical of coastal shores and barrier islands and can be found within the action area. The inland location of the BCS results in slightly reduced salinities and increased turbidity in portions of the Lake Pontchartrain basin where piping plover and red knot habitat may be found. These temporary reductions in salinity levels and increased turbidity levels would have "*no effect*" on the piping plover and red knot or their prey species.

2. The giant manta ray (*Manta birostris*) is the world's largest ray with a wingspan of up to 29 feet. They are filter feeders and eat large quantities of zooplankton. Giant manta rays are slow-growing, migratory animals with small, highly fragmented populations that are sparsely distributed across the world. The main threat to the giant manta ray is commercial fishing, with the species both targeted and caught as bycatch in a number of global fisheries throughout its range. The action area considered for this assessment, as discussed in Section 6.0, is not preferred habitat for giant manta ray. They are migratory filter feeders and will generally go where their food is plentiful. The proposed action would have "*no effect*" to this species.

3. No documented effects to sea turtles from previous BCS events or openings exist. Sea turtles can tolerate short term decreases in salinity and are highly mobile. In the past, CEMVN has appropriately determined that previous BCS operations had "*no effect*" on sea turtles or their critical habitat. However, the 2019 operation was the longest on record and extended well into the summer months. As a result, CEMVN can only assert the 2019 operation had "*no effect*" on the hawksbill and leatherback sea turtles.

a. The hawksbill (*Eretmochelys imbricata*) is a small sea turtle, generally spending most of its life in tropical waters such as the warmer portions of the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. Hawksbills frequent rocky areas, coral reefs, shallow coastal areas, lagoons, narrow creeks, and passes. Nesting may occur on almost any undisturbed deep-sand beach in the tropics—in North America, the Caribbean coast of Mexico is a major nesting area. In the continental United States, nesting sites are restricted to Florida where nesting is sporadic at best. Further, the action area is not preferred foraging habitat for this species. It is unlikely that the hawksbill frequents the action area considered for the 2019 BCS operation. Mississippi Sea Turtle Stranding data did not identify any mortalities for this species during the 2019 BCS operational period. Therefore, "*no effect*" to hawksbill occurred from the 2019 operation.

b. The leatherback sea turtle (*Dermochelys coriacea*) is the largest, deepest diving, and most migratory and wide ranging of all the sea turtles. Leatherbacks are mainly pelagic, inhabiting the open ocean and seldom entering coastal waters except for nesting purposes. Nesting in the United States is mainly confined to the Florida coast. Further, the action area is not preferred foraging habitat for this species. It is unlikely that the leatherback frequents the action area considered for the 2019 BCS operation. Mississippi Sea Turtle Stranding data did not identify any mortalities for this species during the 2019 BCS operational period. Therefore, "*no effect*" to leatherback occurred from the 2019 operation.

c. Potential effects to other sea turtles will be discussed in detail below.

4. Due to the "*no effect*" determination, no additional evaluation of these species will be presented in this BA.

2.2 Direct Effects to Listed Species:

The species directly affected during the 2019 operation of the BCS were the pallid sturgeon (*Scaphirhynchus albus*), shovelnose sturgeon (*Scaphirhynchus platorynchus*), and Atlantic (Gulf) sturgeon (*Acipenser oxyrinchus desotoi*). Therefore, a determination of "*may affect, likely to adversely affect*" was made for those three species of sturgeon. Sections 8 and 9 below provide greater detail about these species and the effects of the BCS operation on these species. Based in part on a 2009 Benthic Report (Ray, 2009), CEMVN has made a no adverse modification determination for Gulf sturgeon critical habitat within the action area considered for this assessment.

2.3 Indirect Effects to Listed Species:

Indirect effects to listed species were considered for: West Indian manatee (*Trichechus manatus*); green sea turtle (*Chelonia mydas*); Kemp's Ridley sea turtle (*Lepidochelys kempii*); and loggerhead sea turtle (*Caretta caretta*). CEMVN made a determination that the 2019 BCS operation "*may effect, but not likely to adversely affect*" these species. Sections 8 and 9 below provide greater detail about these species and the effects of the BCS operation on these species.

With the submittal of this BA, CEMVN wishes to finalize formal consultation with the USFWS and NMFS on the 2019 emergency operation on the species specific effect determinations found in Table 1 below. All other species managed by NMFS were determined to be located outside the action area considered for the 2019 BCS operation.

Table 1. Threatened (T) and Endangered (E) Species potentially in the action area.

Common Name	Scientific name	Federal Status	State Status	Effect Determination	Managed By: USFWS or NMFS Within Action Area
Gulf Sturgeon	*Acipenser oxyrinchus desotoi*	T; Critical Habitat	T	May Affect, not likely to adversely affect	Both
Pallid Sturgeon	*Scaphirhynchus albus*	E		May Affect likely to adversely affect	USFWS
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*	T; SOA		May Affect	USFWS
Green sea turtle	*Chelonia mydas*	T	T	May Affect, not likely to adversely affect	NMFS
Hawksbill sea turtle	*Eretmochelys imbricata*	E	E	No Effect	NMFS
Kemp's ridley sea turtle	*Lepidochelys kempii*	E	E	May Affect, not likely to adversely affect	NMFS
Leatherback sea turtle	*Dermochelys coriacea*	E	E	No Effect	NMFS
Loggerhead sea turtle	*Caretta*	T	T	May Affect, not likely to adversely affect	NMFS
Piping plover	*Charadrius melodus*	T; Critical Habitat	T	No Effect	USFWS
Red Knot	*Calidris canutus rufa*	T; Critical Habitat	T	No Effect	USFWS
West Indian manatee	*Trichechus manatus*	T	T	May Affect, not likely to adversely affect	USFWS
Eastern black rail	Laterallus jamaicensis ssp.	T (Proposed)		No Effect	USFWS
Giant manta ray	Manta birostris	T		No Effect	NMFS
Source: United States Fish and Wildlife Service (USFWS; July 2020). (P = protected; T = Threatened; E = Endangered) NMFS (July 2020)					

3.0 CANDIDATE SPECIES

The eastern black rail (*Laterallus jamaicensis ssp.*) is a wetland dependent bird requiring dense emergent cover and extremely shallow water depths (< 6 cm) over a portion of the wetland-upland interface to support its resource needs. Birds are found in a variety of salt, brackish, and freshwater marsh habitats that can be tidally or non-tidally influenced. In Louisiana, occurrences have been documented in high brackish marsh and presence is highly correlated with gulf cordgrass (*Spartina spartinae*) and often interspersed with shrubs such as marsh elder (*Iva frutescens*) or saltbush (*Baccharis hamilifolia*). The high marsh is only inundated during extreme high tide events. The inland location of the BCS restricts impacts to eastern black rail habitat to slightly reduced salinities and increased turbidity in portions of the Lake Pontchartrain basin. These temporary reductions in salinity levels and increased turbidity levels would have "*no effect*" on the eastern black rail or their prey species. No other candidate species are listed in the area.

4.0 CRITICAL HABITAT

Critical habitat for the Gulf sturgeon, the piping plover, and the red knot has been designated within the vicinity of the action area. Gulf sturgeon critical habitat (Unit 8) has been designated in Lake Pontchartrain, Lake St. Catherine, The Rigolets, Little Lake, Lake Borgne, and the Mississippi Sound. Piping plover and red knot critical habitat unit (LA-7) has been designated in the Breton Islands and Chandeleur Island chain (outside of the action area considered for this assessment). No adverse impacts to critical habitat occurred during the 2019 operation of the BCS.

5.0 PREVIOUS CONSULTATION

A 1991 consultation on the operation and maintenance activities within the CEMVN's portion of the Mississippi River did not include the effects of opening the BCS on pallid sturgeon. In 1997, the BCS was opened for 31 days. At the time of the previous consultation and opening of the BCS, pallid sturgeon were thought to be rare to infrequently found in lower reaches of the river where the spillway is located. Additionally, pallid sturgeon were believed to be confined to the main channel and side slopes, and not normally found in the flooded riverbanks during high water periods. Previous consultations on the effects of operating the BCS have not included the pallid sturgeon.

Subsequent to the 1991 consultation and 1997 operation of the BCS, additional information has become available that indicates pallid sturgeon are more abundant in the lower reaches of the lower Mississippi River than previously believed. Four days prior to the 2008 operation of the BCS, Louisiana Department of Wildlife and Fisheries (LDWF) personnel captured at least one pallid sturgeon in the flooded bank of the river adjacent the BCS structure during one of their fisheries monitoring trips. This capture prompted the CEMVN to enter into emergency consultation with the USFWS. On April 10, 2008, CEMVN notified the USFWS Lafayette, Louisiana office via telephone that the BCS would be partially opened the following day. The telephone conversation was followed-up with a letter from CEMVN to USFWS documenting the phone call. Pursuant to emergency procedures, the USFWS and CEMVN entered into informal consultation; and the USFWS provided CEMVN with conservation recommendations via FAX letter on April 11, 2008. Once water velocities within the BCS became manageable, CEMVN tasked the Engineering Research and Development Center (ERDC) Fish Ecology Team with conducting pallid sturgeon rescue and recovery efforts. Over the course of four weeks of collecting, the ERDC team captured 14 pallid sturgeon and 41 shovelnose sturgeon within the outfall of the BCS. CEMVN prepared a BA for the incidental take of the 14 pallid sturgeon and formal consultation with the USFWS Lafayette office was completed on August 14, 2009.

At the time of the 2008 event, use of the flooded river batture by sturgeon had received little study. Following the 2008 flood event, the CEMVN initiated a study aimed at filling in data gaps that exist regarding sturgeon distribution and abundance in the lower Mississippi River. The CEMVN and the Mississippi Valley Division funded ERDC to monitor potential entrainment of pallid sturgeon in existing diversions and provide information to evaluate the risk of future entrainment. Objectives were to:

- Document and quantify sturgeon entrainment in existing diversions compared to adjacent river reaches.
- Estimate population size of pallid sturgeon in river reaches associated with diversions.
- Develop population viability models of pallid sturgeon to analyze impacts of entrainment-based "take" by water diversions (ERDC-EL, 2013).

The ERDC estimated the spatial distribution and relative abundance of sturgeon in the lower 320 miles (mi) (515 kilometers [km]) of the Mississippi River. An age-based population viability model of pallid sturgeon was developed from the field data. The ERDC determined that entrainment during episodic diversions characteristic of the BCS reduced median local population size by 0-20% in 60 years (ERDC-EL, 2013). ERDC continues to be at the forefront for expanding the biological understanding of the habitat preferences and population size of sturgeon within the Mississippi River. In November 2016, ERDC collected two young-of-year *Scaphirhynchus* sturgeon with a trawl in the lower Mississippi River, River Mile 33 in about 110 feet (ft) (33.5 meters [m]) of water. This extends the occurrence of *Scaphirhynchus* from River Mile 85 (Caernarvon) downstream 50 mi (80 km).

Since a known entrainment risk existed for the BCS in 2011, when flood fight monitoring indicated the need to operate the BCS, CEMVN immediately initiated informal consultation with the USFWS Lafayette office. On April 27, 2011, CEMVN contacted the USFWS via telephone, to discuss the implications of a 2011 BCS opening on the pallid sturgeon and recently listed shovelnose sturgeon. During this conversation CEMVN expressed its continued commitment to conducting retrieval efforts for sturgeon entrained through the BCS. The CEMVN tasked ERDC with preparing a scope of work (SOW) for their retrieval efforts, and to determine specific actions that will reduce or eliminate incidental take during future operations of the spillway. The following five tasks were identified for this study.

Task 1: Recover pallid sturgeon entrained through the BCS.
Task 2: Evaluate movement of sturgeon in the spillway and into Lake Pontchartrain using sonic telemetry.
Task 3: Assess fish community composition.
Task 4: Determine salinity tolerance of shovelnose sturgeon.
Task 5: Prepare report.

On May 5, 2011, it was determined that the operation of the BCS was necessary to prevent the loss of life and property within the greater New Orleans area. The CEMVN sent a letter requesting the initiation of emergency consultation for potential impacts to pallid sturgeon and the shovelnose sturgeon. Enclosed within this letter was a copy of the SOW for ERDC efforts. The USFWS responded via letter on May 6, 2011 containing four conservation recommendations for the operation of the BCS. The conservation recommendations were a rendition of the tasks identified during the April 27, 2011 conversation. The conservation recommendations provided by the USFWS were:

1. Recover pallid sturgeon entrained through the BCS and return them to the river.
2. Tag and track (either actively and/or passively) shovelnose sturgeon (as a surrogate species for the pallid sturgeon) with sonic transmitters to determine movement within and out of the spillway and, if possible, relate those movements to environmental conditions.
3. Determine salinity tolerance of shovelnose as a means of possibly determining dispersal of pallid sturgeon during spillway operation.
4. Provide a report documenting completion of the above recommendations.

On May 27, 2011 the USFWS provided their comments on the ERDC SOW provided on May 6, 2011. The ERDC SOW was revised to incorporate the USFWS's revisions. When the spillway became accessible by the ERDC Fish Ecology Team, rescue and recovery operations were initiated.

On December 30, 2015, CEMVN requested the initiation of emergency consultation with the USFWS via telephone regarding the potential for entrainment of sturgeon through the BCS.

On January 5, 2016, CEMVN initiated, via letter dated January 4, 2016, emergency consultation, under Section 7 of the ESA of 1973, as amended for the Federally listed endangered pallid sturgeon and the threatened, under the similarity of appearance provision, shovelnose sturgeon.

The USFWS responded on January 6, 2016, and provided six conservation recommendations for sturgeon that CEMVN could undertake to minimize the potential take of the species during the structures operation.

The USACE initiated, via letter dated December 12, 2017, formal consultation with the Service on the BCS 2011 and 2016 emergency operations including a Final BA for the emergency operations.

The Service provided the Biological Opinion (BO) on the 2011 and 2016 operations to USACE on June 18, 2018.

On March 2, 2018, USACE requested the initiation of emergency consultation, under Section 7 of the ESA for the 2018 BCS Operation. On March 2, 2020, the USFWS received the USACE's February 27, 2020, BA regarding the emergency operation of the BCS in 2018 and its effects to federally listed species and their critical habitats. On April 6, 2020, the Service provided confirmation to the USACE that all information had been received and that the biological opinion would be issued no later than July 15, 2020. USFWS later requested a time extension which was granted by USACE. The signed USFWS 2018 BO was received by USACE on August 26, 2020.

On February 25, 2019 CEMVN provided the USFWS notification of emergency action for Section 7 ESA consultation for the 2019 BCS operation. On February 26, 2019 the USFWS informed us to proceed with the emergency work described in the notice. On May 7, 2019, the USFWS was also notified of the second opening.

On February 25, 2019 CEMVN provided the NMFS notification of emergency action for Section 7 ESA consultation for the 2019 BCS operation. On February 26, 2019, the NMFS informed us to proceed with the emergency work described in the notice. On May 7, 2019, the NMFS was also notified of the second opening. Previous consultation with NMFS has been limited as prior operations had "*no effect*" on NMFS managed species. The 2019 operation was longer and extended further into the calendar year than has typically occurred.

6.0 LOCATION OF THE ACTION AREA

The BCS is located in St. Charles Parish, Louisiana, and protects New Orleans and other downstream communities during major floods on the lower Mississippi River (Figures 1). For purposes of consultation under ESA §7, the action area is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR § 402.02). The areas to be affected directly or indirectly will vary based on the duration and flow associated with a particular spillway opening. There are other sources of freshwater in the Lake Borgne/Mississippi Sound area, particularly during major flood events, making it difficult to estimate the exact limits of any potential effects from operating the BCS. To ensure this analysis captures all areas which could potentially be affected, the action area includes the BCS, Lake Pontchartrain, Lake Borgne, portions of the Biloxi Marsh, and the Western Mississippi Sound (West of the Gulfport Ship Channel). This determination was based on a combination of Hydrocoast maps (Lake Pontchartrain Basin Foundation) showing salinity gradients during and shortly after operation of the BCS in conjunction with USACE water quality monitoring.

7.0 DESCRIPTION OF THE ACTION

The BCS is located approximately 30 miles above New Orleans in St. Charles Parish, Louisiana. Completed in 1936, the primary purpose of the project is to reduce the risk of floods to New Orleans and other downstream communities from the Mississippi River by discharging excess floodwaters into Lake Pontchartrain which has a hydrologic connection to the Mississippi Sound. After heavy rains in early 2019 increased

Mississippi River stages, the U.S. Army Corps of Engineers determined operating BCS was required to reduce the potential for loss of life and property from floodwaters on the lower Mississippi River. The BCS was opened on February 27, 2019 with a peak discharge of 213,000 cfs (Table 2) in order to keep the volume of the Mississippi River flows at New Orleans from exceeding 1.25 million cubic feet per second (cfs). The 1.25 million cfs flow continues down river until reaching the Gulf of Mexico. It is dispersed through various channels, diversions and bayous into the local ecosystem. That volume of water is roughly five times that released through the BCS in a maximum flow event (250,000 cfs). In the 2019 flood event, the river stages remained high following the April 11, 2019 closure of the BCS until heavy rains across the valley prompted a second opening of the BCS on May 10, 2019 with a peak discharge of 161,000 cfs (Table 3). The BCS remained open until July 27, 2019. This was the first time in the project's history that the BCS was opened twice within a calendar year. This BA reviews the potential effects resulting from the 2019 operation to species managed under the ESA.

Table 2: Spillway Opening Pace: 2019 First Opening

Day	Date	Bays Opened	Total Opened	Discharge
1	Feb. 27	28	28	23,000 cfs
2	Feb. 28	20	48	37,000 cfs
3	Mar. 1	40	88	74,000 cfs
4	Mar. 2	20	108	91,000 cfs
5	Mar. 3	0	108	94,000 cfs
6	Mar. 4	40	148	138,000 cfs
7	Mar. 5	0	148	148,000 cfs
8	Mar. 6	0	148	148,000 cfs
9	Mar. 7	20	168	169,000 cfs
10	Mar. 8	20	188	187,000 cfs
11	Mar. 9	0	188	176,000 cfs
12	Mar. 10	10	198	197,000 cfs
13	Mar. 11	8	206	198,000 cfs
14	Mar. 12	0	206	196,000 cfs
15	Mar. 13	0	206	202,000 cfs
16	Mar. 14	0	206	207,000 cfs
17	Mar. 15	-10	196	207,000 cfs
18	Mar. 16	0	196	207,000 cfs
19	Mar. 17	0	196	199,000 cfs
20	Mar. 18	0	196	207,000 cfs
21	Mar. 19	0	196	213,000 cfs
22	Mar. 20	0	196	210,000 cfs
23	Mar. 21	0	196	196,000 cfs
24	Mar. 22	0	196	194,000 cfs
25	Mar. 23	0	196	184,000 cfs
26	Mar. 24	0	196	179,000 cfs
27	Mar. 25	0	196	177,000 cfs
28	Mar. 26	-20	176	158,000 cfs
29	Mar. 27	-24	152	135,000 cfs

30	Mar. 28	-17	135	131,000 cfs
31	Mar. 29	0	135	131,000 cfs
32	Mar. 30	0	135	135,000 cfs
33	Mar. 31	0	135	133,000 cfs
34	Arp. 1	0	135	135,000 cfs
35	Arp. 2	0	135	126,000 cfs
36	Apr. 3	0	135	114,000 cfs
37	Apr. 4	0	135	107,000 cfs
38	Apr. 5	0	135	105,000 cfs
39	Apr. 6	0	135	96,000 cfs
40	Apr. 7	0	135	85,000 cfs
41	Apr. 8	-36	99	66,000 cfs
42	Apr. 9	-47	52	38,000 cfs
43	Apr. 10	-34	18	11,000 cfs
44	Apr. 11	-18	0	0 cfs

Table 3: Spillway Opening Pace: 2019 Second Opening

Day	Date	Bays Opened	Total Opened	Discharge
1	May 10	60	60	79,000 cfs
2	May 11	10	70	83,000 cfs
3	May 12	0	70	86,000 cfs
4	May 13	58	128	116,000 cfs
5	May 14	10	138	127,000 cfs
6	May 15	0	138	128,000 cfs
7	May 16	0	138	122,000 cfs
8	May 17	0	138	124,000 cfs
9	May 18	0	138	127,000 cfs
10	May 19	10	148	142,000 cfs
11	May 20	0	148	148,000 cfs
12	May 21	20	168	161,000 cfs
13	May 22	0	168	161,000 cfs
14	May 23	0	168	158,000 cfs
15	May 24	0	168	155,000 cfs
16	May 25	0	168	158,000 cfs
17	May 26	0	168	159,000 cfs
18	May 27	0	168	158,000 cfs
19	May 28	0	168	157,000 cfs
20	May 29	0	168	149,000 cfs
21	May 30	0	168	145,000 cfs

22	May 31	0	168	141,000 cfs
23	June 1	0	168	143,000 cfs
24	June 2	0	168	135,000 cfs
25	June 3	0	168	140,000 cfs
26	June 4	0	168	138,000 cfs
27	June 5	0	168	136,000 cfs
28	June 6	0	168	138,000 cfs
29	June 7	0	168	138,000 cfs
30	June 8	0	168	144,000 cfs
31	June 9	0	168	146,000 cfs
32	June 10	0	168	146,000 cfs
33	June 11	0	168	147,000 cfs
34	June 12	0	168	147,000 cfs
35	June 13	0	168	144,000 cfs
36	June 14	0	168	147,000 cfs
37	June 15	0	168	150,000 cfs
38	June 16	0	168	146,000 cfs
39	June 17	0	168	147,000 cfs
40	June 18	0	168	142,000 cfs
41	June 19	0	168	137,000 cfs
42	June 20	0	168	131,000 cfs
43	June 21	0	168	130,000 cfs
44	June 22	0	168	124,000 cfs
45	June 23	0	168	115,000 cfs
46	June 24	0	168	116,000 cfs
47	June 25	0	168	110,000 cfs
48	June 26	0	168	108,000 cfs
49	June 27	0	168	108,000 cfs
50	June 28	0	168	104,000 cfs
51	June 29	0	168	105,000 cfs
52	June 30	0	168	99,000 cfs
53	July 1	0	168	110,000 cfs
54	July 2	0	168	108,000 cfs
55	July 3	0	168	104,000 cfs
56	July 4	0	168	103,000 cfs
57	July 5	0	168	102,000 cfs
58	July 6	0	168	106,000 cfs
59	July 7	0	168	109,000 cfs
60	July 8	0	168	112,000 cfs
61	July 9	0	168	108,000 cfs
62	July 10	0	168	110,000 cfs
63	July 11	0	168	117,000 cfs
64	July 12	0	168	131,000 cfs

65	July 13	0	168	133,000 cfs
66	July 14	0	168	117,000 cfs
67	July 15	0	168	111,000 cfs
68	July 16	0	168	106,000 cfs
69	July 17	0	168	103,000 cfs
70	July 18	0	168	103,000 cfs
71	July 19	0	168	96,000 cfs
72	July 20	0	168	90,000 cfs
73	July 21	0	168	84,000 cfs
74	July 22	-10	158	72,000 cfs
75	July 23	-22	136	57,000 cfs
76	July 24	-42	94	40,000 cfs
77	July 25	-30	64	25,000 cfs
78	July 26	-38	26	11,000 cfs
79	July 27	-26	0	0 cfs

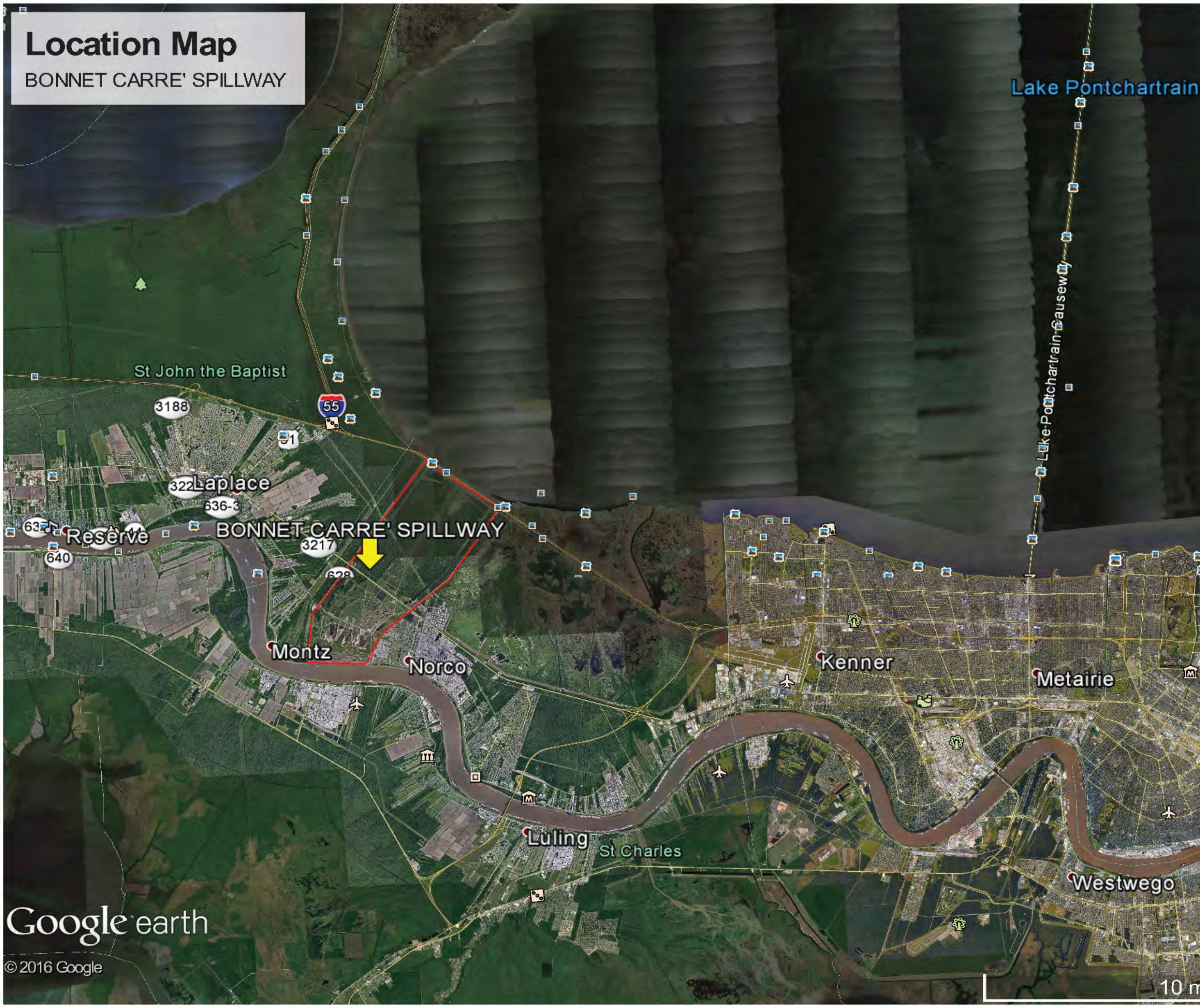

Figure 1. Location Map.

8.0 SPECIES ACCOUNTS

8.1 Description of Pallid Sturgeon and Shovelnose Sturgeon (*Scaphirhynchus albus* and *Scaphirhynchus platorynchus)*

The pallid sturgeon is a bottom oriented, large river obligate inhabiting the Missouri, Mississippi, and Atchafalaya Rivers from Montana to Louisiana. The pallid sturgeon is adapted to the predevelopment habitat conditions that historically existed in these large rivers. Those conditions can generally be described as large, free-flowing, warm water, turbid habitats with a diverse assemblage of physical attributes that were in a constant state of change. Floodplains, backwaters, chutes, sloughs, islands, sandbars and main channel waters formed the large-river ecosystem that provided macrohabitat requirements for all life stages of pallid sturgeon and other large river fish. Within this range, pallid sturgeon tend to select main channel habitats in the Mississippi River and main channel areas with islands or sand bars in the upper Missouri River (USFWS, 2009a and USFWS, 2009b).

The pallid sturgeon has a robust body tapering posteriorly into a long and narrow caudal peduncle. The snout is broad, flat and spatulate in shape. Viewed dorsally, the pallid sturgeon's rostrum is more elongated than that of other species of *Scaphirhynchus*. The inner barbels are situated slightly anterior to the outer barbels and are heavily fimbriated. The pallid sturgeon's mouth is transverse with four papillose lobes on the continuous lower lip. The pectoral fins are large and rounded. Most specimens, especially adults, lack retrose spines on the tip of the snout, parietal spines and pre-orbital spines typical of Alabama sturgeon (*Scaphirhynchus suttkusi*) and shovelnose sturgeon. The frontal spines are always absent. The squamation on the ventral surface is weak and reduced (Mayden and Kuhajda, 1997). Similar to other shovelnose sturgeons, the spiracle is absent in *S. albus*. The anterior edge of the clavicle keel is smooth. The flattened caudal peduncle is entirely covered with scutes and the upper lobe of the caudal fin has a distinct filament, but absent in large individuals. The post anal plates range in number from 7-8. There are 9 post dorsal plates. Both of these counts overlap meristically with Alabama sturgeon and shovelnose sturgeon. The average size of adult pallid sturgeon is 18 – 33 pounds (lb) (8 – 15 kilogram [kg]) with a historic maximum size of 88 lb (40 kg) being noted in the literature (Vecsei and Peterson, 2004).

The coloration of pallid sturgeon is lighter than other species of *Scaphirhynchus*, with the entire fish having an overall grayish-white appearance. The principal rows of scutes are slightly darker than the surrounding body. The transition from the pale dorsum coloration to the white ventrum is subtle compared to other shovelnose sturgeon (Vecsei and Peterson, 2004).

The shovelnose sturgeon has an elongated, tapering body. The caudal peduncle is narrow and long. The upper lobe of the caudal fin extends into a long filament. The body is more flattened in cross-section than *Acipenser* or *Huso*. The rostrum is wide, flat and shovel shaped. The lower lips have four papillose lobes. The eyes are tiny and spiracles are absent. The 5 rows of scutes remain prominent throughout the individual's life. All scutes have a prominent retrose hood appendage. The narrow, elongated caudal peduncle is entirely covered with scutes and plates. The filament of the upper lobe of the heterocercal tail is present only in small, immature individuals. Adult shovelnose sturgeon are usually 3.3 – 9 lb (1.5 – 4 kg). Carlander (1969) reported a maximum weight of 9.9 lb (4.5 kg) with most individuals weighing less than 5.5 lb (2.5 kg). However, Keenlyne (1997) reported individuals of over 15 lb (7 kg) in the upper Missouri River. Keenlyne (1997) suggests that the larger shovelnose sturgeon of the upper Missouri represent a different strain or "stock" from those lower downstream (Vecsei and Peterson, 2004). Shovelnose sturgeon coloration is consistent throughout this species' range. The dorsum is dark brown, becoming progressively lighter on the lateroventral surface. The principal rows of scutes are slightly darker than the surrounding body. The ventral surface of the head and body is white or cream colored. The fins are pigmented and similar in color to the body region of origin (Vecsei and Peterson, 2004).

Pflieger (1975) reported the principal features distinguishing pallid sturgeon from shovelnose sturgeon as the paucity of dermal ossifications on the belly, 24 or more anal fin rays, and 37 or more dorsal fin rays. Forbes and Richardson (1905) noted that pallid sturgeon contain 20 to 22 ribs while the shovelnose sturgeon has only 10 to 11 ribs. The air bladder was also noted as being relatively smaller in the pallid sturgeon. Those authors recorded differences between the pallid and shovelnose sturgeon in the number of ventral radials, relative depth of lateral scutes, orbital space size, proportional lengths of inner and outer barbels, mouth width, proportion of head width to head length, and proportion of head length to body length.

Genetic testing can be another tool to further identify individuals though this technology needs further development. Geneticists and ichthyologists have worked to refine testing procedures and develop the materials to definitively distinguish and identify these two fish species. More information is needed on the evolutionary dynamics of intermediate forms between pallid and shovelnose sturgeon to understand the role and effects of hybridization on the status of pallid sturgeon.

Historically the Missouri and Mississippi River were characterized by a shifting braided channel with abundant sandbars and accumulations of large woody debris. The shifting channel contained a wide variety of hydraulic environments that provided diverse habitat for many benthic fish species. In the 1800s, training into a fast, deep, and single-thread channel to support navigation was begun. Wing dikes concentrated flow, and revetments and levees kept the channels in place and disconnected it from the flood plains. Reservoir regulation substantially changed the annual hydrograph, sediment load, and temperature regime of the Missouri and Mississippi Rivers. As in other large flood-plain rivers, agricultural pesticides, nutrient runoff, and increasing discharge of domestic and industrial effluents affect the aquatic biota and the ecological health of the Missouri River Basin. Proliferation of introduced and non-indigenous species has further threatened to diminish the ecological integrity of the river ecosystem. Together these changes in flow, channel morphology, water quality, and biota have been implicated as causative agents in the dramatic declines in native river fishes and their resource base in general, and with the decline of pallid sturgeon in particular (Wildhaber et al., 2007).

The pallid sturgeon is endemic to the turbid waters of the Missouri River and the Lower Mississippi River (Wildhaber et al., 2007). Extensive sampling in the lower Mississippi River was undertaken by the ERDC so that a better understanding of population size, population density, habitat preference, extent of range in lower Mississippi River, and impacts from entrainment. After accounting for survival, movement, and habitat use, ERDC estimated that the total abundance of age-3+ pallid sturgeon in the Lower and Middle Mississippi River is at least 3,400-4,100 with probability 0.99; 5,900-7,000 with probability 0.95; and 17,000-20,000 with probability 0.75 (ERDC-EL, 2013).

On April 4, 2008, one week prior to the 2008 opening of the BCS, personnel of the LDWF captured at least one pallid sturgeon among willow trees along the flooded bank of the river adjacent the BCS structure. Although no diagnostic measurements were taken of the sturgeon, experts who have reviewed the photographic evidence have all concluded that the fish was a pallid sturgeon. This capture represented a very rare capture of a pallid sturgeon from the flooded riverbank of the river. Prior to this capture, pallid sturgeon were generally believed to inhabit only the main river channel and side slopes, not overbank areas during high-water events. It is not known if pallid sturgeon might also be found in grassy or revetted areas. To date the use of the flooded river batture by sturgeon has received little study. Following this flood event, the CEMVN initiated a study aimed at filling in data gaps that exist regarding sturgeon distribution and abundance in the lower Mississippi River. Dr. Jack Killgore, who is in charge of this sampling effort, believes that pallid sturgeon could be found over nearly any flooded habitat, if enough sampling effort was expended, but they are more likely to be found in open water than in flooded willows.

The ERDC conducted multiple studies and compiled the studies into one main report dated November 15, 2013, titled “Entrainment Studies of Pallid Sturgeon Associated with Water Diversions in the Lower Mississippi River.” ERDC increased their understanding of the habitat preferences and population size of sturgeon within the Lower Mississippi River in a study titled “Water Diversions and Pallid Sturgeon Population Viability in the Lower Mississippi River: Uncertainties and Priorities for Ecological Risk Assessment.” The report indicated that entrainment during episodic diversions characteristic of the BCS reduced median local population size by 0-20% in 60 years (ERDC-EL, 2013).

Genetic and morphological data have been used to differentiate pallid sturgeon into three groupings, an upper Missouri River group and two less differentiated groups in the lower Missouri/middle Mississippi and Atchafalaya River (USFWS, 2007). These data suggest that the genetic structuring within the pallid sturgeon’s range represents two distinct groups at the extremes of the species range with a middle intermediate group representing the lower Missouri and middle Mississippi Rivers. This pattern is suggestive of a pattern of isolation by distance, with gene flow more likely to occur between adjacent groups than among geographically distant groups, and thus, genetic differences increase with geographical distance.

The shovelnose sturgeon historically was more common and widespread than the pallid sturgeon. Before anthropogenic disturbances, distribution of the species included the Mississippi, Missouri, Ohio, and Rio Grande Rivers and their tributaries. Of the 24 states that comprise the historical range of the shovelnose sturgeon, five list the species as extirpated, and eight list the species as either imperiled or vulnerable. The World Conservation Union listed the species as “vulnerable”. The “vulnerable” assessment reflects a past reduction in species range of 30 percent, and anticipates a further 30 percent reduction in population within the next 10 years, or three generations (Wildhaber et al., 2007). Current ERDC sturgeon sampling efforts in the Lower Mississippi River initiated in 2008, have been collecting shovelnose sturgeon distribution and abundance data. Over the course of this study the shovelnose sturgeon has been found to be more abundant than the pallid sturgeon. The persistence and resiliency of the shovelnose sturgeon in comparison to the pallid sturgeon may be partly because of its earlier maturity, lower trophic status, and adaptability to a broader range of environmental conditions. The shovelnose sturgeon matures earlier and attains a smaller maximum size than the pallid sturgeon. The smaller shovelnose sturgeon primarily subsists on invertebrates, whereas the larger pallid sturgeon becomes piscivorous relatively early in life. Pallid sturgeon, also are highly adapted to large, turbid, riverine environments, and are believed to not use tributaries or clear-water riverine habitats that are frequented by shovelnose sturgeon (Wildhaber et al., 2007).

Pallid sturgeon exhibit seasonal variation in movement patterns based upon temperature and discharge. The timing of pallid sturgeon movements and migration in the Lower Mississippi

River may differ from that of other rivers (i.e. the Missouri River) and other portions of the Mississippi River. Migrations and movement in the Atchafalaya River was associated with water temperatures between 57° and 70° Fahrenheit (F) (14° and 21° Celsius [C]) and spring and early summer season. Movement patterns also vary between spawning versus non-spawning years. Pallid sturgeon have been reported as having an average home range of 48.8 mi (78.5 km) in the Yellowstone and upper Missouri Rivers while only having a home range of 21.2 mi (34.1 km) in the middle Mississippi River. It has been speculated that because habitat in the Mississippi River is relatively uniform, large movements and home ranges may not be as beneficial in the Mississippi River as in the Yellowstone and Upper Missouri Rivers area, because study fish are not likely to encounter new habitats and thus have a smaller home range.

As large river fish, pallid sturgeon are capable of moving long distances in search of favorable habitat or during spawning runs. Bramblett (1996) noted a maximum home range as large as 205 mi (330 km), with pallid sturgeon moving up to 13 mi/day (21 km/day) and shovelnose sturgeon moving up to 9 mi/day (15 km/day). Hoover et al. (2007) hypothesized that long-range movements during the spring may not just be associated with spawning but could also be associated with feeding.

Although shovelnose sturgeon are capable of migrating long distances telemetry data suggests they are predominately a sedentary species. Shovelnose sturgeon in the Mississippi and Missouri Rivers typically exhibit limited movement. However, migrations upstream by shovelnose sturgeon are made for the purposes of spawning. Seasonal migrations in the Missouri River have been extensive, with total movements cited to be in excess of 298 mi (480 km) from the tagging site (Wison and Mckinley, 2004). Following the 2011 opening, ERDC used acoustic telemetry to monitor movement of entrained shovelnose sturgeon in the BCS. No mortalities were reported and initially all individuals moved extensively near their original release point (ERDC-EL, 2013).

Hoover, et al. (2005) examined swimming performance of juvenile pallid sturgeon (maximum size 6.3 inches [in]; 16 centimeters [cm]) at different velocities to determine possible entrainment by dredges. Minimum escape speeds for pallid sturgeon ranged from 1.6 to 1.7 feet per second (ft/s) (49 to 52 centimeters per second [cm/s]) and burst speeds were determined to range from 1.7 to 2.95 ft/s (52 to 89.9 cm/s). Because they frequently failed to exhibit rheotaxis or orientation to the direction of flow (greater than 25 percent were non-swimmers); their ability to avoid entrainment based on swimming performance was determined to be relatively low. Hoover et al. (2011) examined swimming performance of adult shovelnose sturgeon in rectilinear and boundary layer flow. Mean critical swim speed in rectilinear flow was documented as 3.35 ft/s (102 cm/s) and boundary layer flow was documented as 5.25 ft/s (160 cm/s). Swim speeds were reduced in rectilinear flow because shovelnose sturgeon were unable to seek velocity refugia by skimming above the ground.

Adams (1999) also studied swim performance in juvenile pallid sturgeon. It was found that maximum sustained swimming speed was 0.328 and 0.82 ft/s (9.99 and 25 cm/s) for their two groups of fish. The fish were found to transition to burst swimming speeds at 1.31 and 1.9 ft/s (39.9 and 58 cm/s). White and Mefford (2002) examined swimming behavior and performance of shovelnose sturgeon ranging from 25.2 to 31.5 in (64.0 to 80.0 cm) in length to aid in the design of a fish passage on the Yellowstone River. The ability of shovelnose sturgeon to navigate the length of the test flume was best (60 to 90 percent) over a smooth bottom followed by coarse sand, gravel and then cobble, but the small sample size and large variability precluded this from being a definitive conclusion. The greatest success at negotiating the flume was determined to occur between the range of 2 and 4 ft/s (61 to 122 cm/s). Failure to exhibit rheotaxis was also observed at velocities below 1.6 ft/s (49 cm/s). Conversely, Adams et al. (1997) found all adult shovelnose to be positively rheotatic. Pallid sturgeon are believed to avoid areas that have no water velocity (Constant et al., 1997). It's important to note that swim studies are often performed on hatchery fish or fish kept in tanks with low water velocity.

Carlson et al. (1985) determined composition of food categories, by volume and frequency of occurrence, in the diet of shovelnose sturgeon (n=234), pallid sturgeon (n=9), and hybrids (n=9). Although benthic macro invertebrates characteristic of river habitats are important dietary components (Modde and Schmulbach, 1977 and Carlson et al., 1985), the occurrence of lake and terrestrial invertebrates in sturgeon stomachs suggest that drifting invertebrates may also be important forage organisms (Modde and Schmulbach, 1977 and Constant et al., 1997). Aquatic invertebrates (principally the immature stages of insects) compose most of the diet of shovelnose sturgeon, while adult pallid sturgeon and purported hybrids consume a greater proportion of fishes (mostly cyprinids) (Hoover et al., 2007). Grohs et al. (2009) reported that pallid sturgeon in the Missouri River downstream of Fort Randall Dam, had high percent occurrences' of Diptera, Emphemeroptera and fish and that percent composition of fishes increased with pallid sturgeon body size. It was noted that between ages four and five in their study, pallid sturgeon shifted from predominately invertebrates to fishes. Most piscivorous Missouri River species eat large quantities of aquatic insect larvae in early life and even as adults (Modde and Schmulbach, 1977).

Pallid and shovelnose sturgeon are generally found to utilize the similar habitat types in the lower Mississippi River. Forbes and Richardson (1905), Kallemeyn (1983), and Gilbraith et al. (1988) describe pallid sturgeon as being a fish well-adapted to life on the bottom in swift water of large, turbid, free-flowing rivers. Mayden and Kuhajda (1997) describe the natural habitats to which pallid sturgeon are adapted as: braided channels, irregular flow patterns, flooding of terrestrial habitats, extensive microhabitat diversity and turbid waters. The historic floodplain habitat of the Missouri and Mississippi Rivers provided important functions for the native large-river fish. Floodplains were the major sources of organic matter, sediments, and woody debris for the main stem rivers when flood flows crested their banks. The transition zone between the vegetated floodplain and the main channel included habitats with varied depths described as chutes, sloughs, or side channels. The chutes or sloughs between the islands and shore were shallower and had less current than the main channel. These areas provided valuable diversity to the fish habitat, and probably served as nursery and feeding areas for many aquatic species (Funk and Rovinson, 1974). The still waters in this transition zone allow organic matter accumulations; important to macroinvertebrate production. Both shovelnose and pallid sturgeon have a high incidence of aquatic invertebrates in their diet (Carlson et al. 1985; Gardner and Stewart, 1987). Flood flows connected those important habitats and allowed fish from the main channel to utilize those habitat areas and to exploit available food sources.

The pallid sturgeon was listed as endangered throughout its range on October 9, 1990. The reasons for listing were habitat modification, apparent lack of natural reproduction, commercial harvest, and hybridization in parts of its range. To date critical habitat has not been proposed nor designated for this species.

The pallid sturgeon was listed due to the apparent lack of recruitment for over 15 years, and the habitat threats existing at the time of listing. Destruction and alteration of habitats by human modification of the river system is believed to be the primary cause of decline in reproduction, growth, and survival of the pallid sturgeon. The curtailment of range and habitat destruction/modification were primarily attributed to the construction and operation of dams on the upper Missouri River and modification of riverine habitat by channelization of the lower main stem Missouri River and Mississippi Rivers. Dams substantially fragmented pallid sturgeon range in the upper Missouri River. However, free-flowing riverine conditions currently exist throughout the lower 2,000 mi (3218 km) (60%) of the pallid sturgeon's historical range (USFWS, 2009a and USFWS, 2009b). Until this past decade, they were considered a rare occurrence in the Lower Mississippi. New information from recent collection efforts indicates that the Mississippi River currently supports substantial numbers of wild fish. Since 1997, more than 200 pallid have been collected at more than 60 locations in the Mississippi River between the confluence of the Missouri River and New Orleans, Louisiana (Bettoli, 2006).

Aquatic habitats in the Mississippi River have been modified though the construction of flood control levees and channel modification through time, and some changes resulting from those modifications have likely been detrimental to pallid sturgeon (USFWS 2007). Although the river flows unobstructed for about 2,000 river mi (3,219 km) from Gavins Point Dam in the middle Missouri River to the Gulf of Mexico, tributary impoundments, bendway cutoffs, and dike and levee construction have each changed localized patterns of channel erosion and deposition in the Mississippi River; collectively they resulted in a degradation trend throughout the system. Effects of these changes on pallid sturgeon are unknown, because there is no historical data for comparison. In 1981, the USACE established the Lower Mississippi River Environmental Program, with a goal of protecting fisheries and other natural resources in the lower Mississippi River (USFWS, 2007). Input from the Lower Mississippi River Environmental Program resulted in experimentations with dike placement and notches as measures to protect secondary channels and maintain shallow water and fisheries habitats.

The Pallid Sturgeon Lower Basin Recovery Workgroup has identified information gaps essential to the consultation and recovery processes in the Lower Mississippi River Basin. These include: relative abundance of pallid sturgeon, demographics, feeding habits, habitat use, hybridization ratios, presence of fish diseases in the wild, population anomalies, and reliable separation and identification of pallid sturgeon, shovelnose sturgeon, and hybrids. While recent publications have contributed to filling some of these data gaps (e.g., Killgore et al., 2007a; Killgore et al., 2007b; and ERDC-EL, 2013) incomplete knowledge of some areas remains.

The shovelnose sturgeon and the pallid sturgeon are difficult to differentiate in the wild and inhabit overlapping portions of the Missouri and Mississippi River basins. Commercial harvest of shovelnose sturgeon has resulted in the documented take of pallid sturgeon where the two species coexist and is a threat to the pallid sturgeon (75 FR 53598-53606).

Other factors which threaten the species include: poaching (commercial take of any species of sturgeon was prohibited by Mississippi and Louisiana during the early 1990s to avoid incidental take of pallid sturgeon), predation, disease, contaminants, tug boat propeller entrainment, and hybridization. The cumulative impacts to the species currently are not quantifiable.

8.2 Description of the Atlantic (Gulf) sturgeon (*Scaphirhynchus platorynchus*)

NOAA Fisheries and the USFWS listed the Atlantic sturgeon, also known as the Gulf sturgeon, as a threatened species on September 30, 1991 (56 CFR 49653). The present range of the Gulf sturgeon extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida. Historically, the Gulf sturgeon has not been affected by the operation of the Spillway. However, the 2019 operation was longer in duration than previous events. In this particular event a Gulf sturgeon was relocated during rescue operations of other sturgeon.

The Gulf sturgeon is an anadromous fish; adults spawn in freshwater then migrate to feed and grow in estuarine and marine habitats. After spawning in the upper river reaches, both adult and subadult Gulf sturgeon migrate from the estuaries, bays, and the Gulf of Mexico to the coastal rivers in early spring (i.e., March through May) when river water temperatures range from 16 to 23°C. Fall downstream migration from the river into the estuary/Gulf of Mexico begins in September (at water temperatures around 23°C) and continues through November.

Most subadult and adult Gulf sturgeon spend cool months (October or November through March or April) in estuarine areas, bays, or in the Gulf of Mexico. Research indicates that in the estuary/marine environment both subadult and adult Gulf sturgeon show a preference for sandy shoreline habitats with water depths less than 3.5 m and salinity less than 6.1 parts per thousand. The predominantly sandy areas support a variety of potential prey items including marine crustaceans, small bivalve mollusks, ghost shrimp, small crabs, various polychaete worms, and lancelets. Once subadult and adult Gulf sturgeon migrate from the river to the estuarine/marine environment, having spent at least 6 months in the river fasting, it is presumed that they immediately begin foraging. Upon exiting the rivers, Gulf sturgeon are found in high concentrations near their natural river mouths; these lakes and bays at the mouth of the river are important because they offer the first opportunity for Gulf sturgeon to forage. Spawning occurs in the upper river reaches in the spring when water temperature is around 15° to 20°C.

Genetic studies conclude that Gulf sturgeon exhibit river-specific fidelity. Five regional or river-specific stocks (from west to east) have been identified: (I) Lake Pontchartrain and Pearl River, (2) Pascagoula River, (3) Escambia and Yellow Rivers, (4) Choctawhatchee River, and (5) Apalachicola, Ochlockonee, and Suwannee Rivers.

8.3 Description of the Kemp's Ridley Sea Turtle (*Lepidochelys kempi*)

Kemp’s Ridley turtles occur mainly in bays and coastal waters of the Atlantic Ocean and Gulf of Mexico. Nesting occurs on the northeastern coast of Mexico and occasionally on Texas Gulf Coast beaches from April to July. Along the Louisiana coast, turtles are generally found in shallow nearshore and inshore areas, and especially in salt marsh habitats, from May through October. The Kemp's ridley sea turtle is the smallest and most endangered of all sea turtles. Adults do not exceed 30 inches in shell length and range in weight from about 80 to 100 pounds. The broadly oval-shaped shell is usually olive grey, but the young are black. Most Kemp's ridley nesting occurs near Rancho Nuevo, Mexico about 30 kilometers south of the Rio Grande. In recent years Kemp's ridley nests have been documented on Padre Island, Texas, as well as in Florida and South Carolina. This nesting occurs from mid-April through August (Rabalais and Rabalais 1980). On one day in 1947 approximately 40,000 female Kemp's ridleys nested at Rancho Nuevo. A large scale nesting event such as this is called an arribada. Anthropogenic activities, such as the collection of eggs, fishing for juveniles and adults, killing adults for meat and other products, and direct take for indigenous use, are thought to be the primarily reason for the decline of this species. In addition to those sources of mortality, Kemp's ridleys have been subject to high levels of incidental take by shrimp trawling which is believed to have hurt their recovery.

Major foraging grounds include the Campeche-Tabasco region while some feed in coastal waters and bays of the Atlantic Ocean and the northern Gulf of Mexico (Chavez 1969). These sea turtles are usually found in water with low salinity, high turbidity, high organic content, and where shrimp are abundant. The continual influx of freshwater and high organic content associated with the northern Gulf of Mexico provides ideal foraging habitat for this species. Stomach content from Kemp’s ridleys collected in shrimp trawls had crabs (Callinectes), gastropods (Nassarius), and clams (Nuculana, Corbula, and probably Mulinia), as well as mud balls, indicating feeding near a mud bottom in an estuarine or bay area. These benthic feeders are known to also feed upon jellyfish (Fritts et al. 1983). Presence of fish such as croaker and spotted seatrout in the gut of stranded individuals in Texas may suggest that turtles feed on the bycatch of shrimp trawlers (Landry 1986).

The total number of Kemp’s ridleys occurring in the Gulf of Mexico is unknown. Collecting data to assess population trends for the Kemp’s ridley presents scientists with many challenges. Scientists monitor trends of their most accessible life stages on the nesting beaches. Population trends are identified through directly monitoring their hatchling production and the status of adult females. Population declines of the Kemp’s ridley sea turtles have been attributed to egg stealing on the localized nesting beach, capture of diurnal nesting females, and fishing and accidental capture in shrimp trawls.

The nearshore areas of the Gulf of Mexico appear to be important habitats for the Kemp's ridley. Primary habitat for subadult ridleys includes Port Aransas, Texas continuing east to Cedar Key, Florida. These turtles are characteristically found in waters of low salinity, high turbidity, high organic content, and where shrimp are abundant (Zwinenberg 1977, Hughes 1972). Preliminary analysis of data collected by Texas A&M University suggests that subadult Kemp’s ridleys stay in shallow, warm, nearshore waters in the northern Gulf of Mexico until cooling waters force them offshore or south along the Florida coast. Juvenile ridleys are usually found in waters of 24 feet or less, and all ridleys are generally found in water depths less than 54 feet (Renaud, draft in-house report transmitted December 8, 1994).

Kemp's ridley sea turtles are the most abundant sea turtles noted near the action area. The highly productive shrimping areas offshore of Louisiana and Mississippi are thought to be the major feeding grounds for subadult and adult ridleys. The current patterns in the Gulf of Mexico could aid in transporting individuals, where small turtles would enter the major clockwise loop current of the western Gulf of Mexico, carrying individuals north and east along Texas, Louisiana, and other northern Gulf areas (Pritchard and Marquez 1973; Hildebrand 1981).

Ridleys are commonly captured by shrimpers off the Texas coast and in heavily trawled areas of the Louisiana coast (Pritchard and Marquez 1973; Carr 1980). The cause of most of the strandings traditionally are the simultaneous occurrence of an intensive pulse of shrimping in an area of high Kemp's ridley abundance. Stomach content analyses on sea turtles stranded in Texas suggest that, in all years, most mortalities occur in nearshore waters. Stomach contents of Kemp's ridleys along the lower Texas coast also showed a predominance of nearshore crabs and mollusks, as well as fish, shrimp and other foods considered to be shrimp fishery discards (Shaver 1991).

8.4 Description of the Loggerhead Sea Turtle (*Caretta caretta*)

The loggerhead sea turtle is a medium to large turtle. Adults are reddish-brown in color and generally 31 to 45 inches in shell length with the record set at more than 48 inches. Loggerheads weigh between 170 and 350 pounds with the record set at greater than 500 pounds. Young loggerhead sea turtles are brown above and whitish, yellowish, or tan beneath, with three keels on their back and two on their underside.

Loggerhead sea turtles occur throughout the temperate and tropical regions of the Atlantic, Gulf of Mexico, Pacific, and Indian Oceans. This species may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, and the mouths of large rivers. In shallow Florida lagoons, loggerheads were found during the morning and evening, leaving the area during mid-day when temperatures reached 87° F. At dusk, turtles moved to a sleeping site and remained there until morning, possibly in response to changes in light or water temperature (Nelson 1986).

Loggerhead turtles are essentially carnivores, feeding primarily on sea urchins, sponges, squid, basket stars, crabs, horseshoe crabs, shrimp, and a variety of mollusks. Their strong beak-like jaws are adapted for crushing thick-shelled mollusks. Although loggerhead sea turtles are primarily bottom feeders, they also eat jellyfish and mangrove leaves obtained while swimming and resting near the sea surface. Presence of fish species such as croaker in stomachs of stranded individuals may indicate feeding on the by-catch of shrimp trawling (Landry 1986). Caldwell et al. (1955) suggest that the willingness of the loggerhead to consume any type of invertebrate food permits its range to be limited only by the presence of cold water.

As loggerheads mature, they travel and forage through near shore waters until their breeding season, when they return to the nesting beach areas. The majority of mature loggerheads appear to nest on a two or three year cycle. Major nesting beaches for loggerheads include the Sultanate of Oman, southeastern United States, and eastern Australia. From a global perspective, the southeastern U.S. nesting aggregation is of paramount importance to the survival of the species and is second in size only to the nesting aggregation on Masirah Island, Oman. This species nests within the U.S. from Texas to Virginia, although the major nesting concentrations are found along the Atlantic coast of Florida, Georgia, South Carolina, and North Carolina. About 80 percent of all loggerhead nesting in the southeastern U.S. occurs in six Florida counties (Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward Counties). Total estimated nesting in the U.S. is approximately 50,000 to 70,000 nests per year. Nesting in the northern Gulf outside of Florida occurs primarily on the Chandeleur Islands in Louisiana and to a lesser extent on adjacent Ship, Horn, and Petit Bois Islands in Mississippi (Ogren 1977). Ogren (1977) reported a historical reproductive assemblage of sea turtles, which nested seasonally on remote barrier beaches of eastern Louisiana, Mississippi, and Alabama. In Louisiana, loggerhead sea turtles are known to nest on the Chandeleur Island. Nesting and hatching for loggerheads in the Gulf of Mexico occur from May through November.

Loss or degradation of suitable nesting habitat may be the most important factor affecting the nesting population in northern Gulf of Mexico (Ogren 1977). Overall the loss of nesting beaches, hatchling disorientation from artificial light, drowning in fishing and shrimping trawls, marine pollution, and plastics and Styrofoam have led to the decline of loggerheads.

Loggerhead sea turtles are considered turtles of shallow water. Juvenile loggerheads are thought to utilize bays and estuaries for feeding, while adults prefer waters less than 165 feet deep (Nelson 1986). Aerial surveys suggests that loggerheads (benthic immatures and adults) in U.S. waters are distributed in the following proportions: 54% in the southeast U.S. Atlantic, 29% in the northeast U.S. Atlantic, 12% in the eastern Gulf of Mexico, and 5% in the western Gulf of Mexico. During aerial surveys of the Gulf of Mexico, the majority (97 percent) of loggerheads were seen off the east and west coasts of Florida (Fritts 1983). Most were observed around mid-day near the surface, possibly related to surface basking behavior (Nelson 1986). Although loggerheads were seen off the coast of Alabama, Mississippi, and Louisiana, they were 50 times more abundant in Florida than in the western Gulf. The majority of the sightings were in the summer (Fritts et al. 1983).

8.5 Description of the Green Sea Turtle (*Chelonia mydas*)

The green sea turtle is mottled brown in color. The name is derived from the greenish fat of the body. The carapace is light or dark brown. It is sometimes shaded with olive, often with radiating mottled or wavy dark markings or large dark brown blotches. This species is considered medium to large in size for sea turtles with an average length of 36 to 48 inches. The record was set at about 60 inches in length. Its weight ranges from about 250 to 450 pounds with the record at more than 650 pounds. The upper surfaces of young green turtles are dark brown, while the undersides are white. Although green sea turtles are found worldwide, this species is concentrated primarily between the 35° North and 35° South latitudes. Green sea turtles tend to occur in waters that remain warmer than 68 °F.

This species migrates often over long distances between feeding and nesting areas (Carr and Hirth 1962). During their first year of life, green sea turtles are thought to feed mainly on jellyfish and other invertebrates. Adult green sea turtles prefer an herbivorous diet frequenting shallow water flats for feeding (Fritts et al. 1983). Adult turtles feed primarily on seagrasses, such as *Thalassia testudinum*. This vegetation provides the turtles with a high fiber content and low forage quality (Bjorndal 1981a). Caribbean green sea turtles are considered by Bjorndal (l981b) to be nutrient-limited, resulting in low growth rate, delayed sexual maturity, and low annual reproductive effort. This low reproductive effort makes recovery of the species slow once the adult population numbers have been severely reduced (Bjorndal 1981). In the Gulf of Mexico, principal foraging areas are located in the upper west coast of Florida (Hirth 1971). Nocturnal resting sites may be a considerable distance from feeding areas, and distribution of the species is generally correlated with grassbed distribution, location of resting beaches, and possibly ocean currents (Hirth 1971).

Major nesting areas for green sea turtles in the Atlantic include Surinam, Guyana, French Guyana, Costa Rica, the Leeward Islands, and Ascension Island in the mid-Atlantic. Historically in the U. S., green turtles have been known to nest in the Florida Keys and Dry Tortugas. Yet, these turtles primarily nest on selected beaches along the coast of eastern Florida, predominantly Brevard through Broward Counties. However, they probably nested along the Gulf Coast before their decline. In the southeastern U.S., nesting season is roughly June through September. Nesting occurs nocturnally at 2, 3, or 4-year intervals. Only occasionally do females produce clutches in successive years. Estimates of age at sexual maturity range from 20 to 50 years (Balazs 1982; Frazer and Ehrhart 1985) and they may live over 100 years Zug et al. (1986). Immediately after hatching, green turtles swim past the surf and other shoreline obstructions, primarily at depths of about 8 inches or less below the water surface, and are dispersed both by vigorous swimming and surface currents (Frick 1976; Balzas 1980). The whereabouts of hatchlings to juvenile size is uncertain. Most green turtle populations have been depleted or endangered because of direct exploitation or incidental drowning in trawl nets (King 1981). A major factor contributing to the green turtle's decline worldwide is commercial harvest for eggs and meat. In Florida, the nesting population was nearly extirpated within 100 years of the initiation of commercial exploitation (King 1981). Fibropapillomatosis, a disease of sea turtles characterized by the development of multiple tumors on the skin and internal organs, is also a mortality factor and has seriously impacted green turtle populations in Florida, Hawaii, and other parts of the world. These tumors interfere with swimming, eating, breathing, vision, and reproduction, and turtles with heavy tumor burdens become severely debilitated and die. Other threats include loss or degradation of nesting habitat from coastal development and beach armoring; disorientation of hatchlings by beachfront lighting; excessive nest predation by native and non-native predators; degradation of foraging habitat; marine pollution and debris; watercraft strikes; and incidental take from commercial fishing operations.

8.6 Description of the West Indian Manatee (*Trichechus manatus)*

The West Indian manatee (*Trichechus manatus*) is an infrequent summer visitor to Lakes Pontchartrain and Borgne. West Indian manatee live in marine, brackish, and freshwater systems in coastal and riverine areas throughout their range. Preferred habitats include areas near the shore featuring underwater vegetation like seagrass and eelgrass. They feed along grass bed margins with access to deep water channels. However, they cannot tolerate temperatures below 68 °F for extended periods of time. The West Indian manatee is a slow-moving mammal with a small head, rounded body, and gray to brown skin with fine sparse hair. It has a square snout with a deeply split upper lip, valvular nostrils, small eyes, flexible flippers, and a large rounded horizontally flattened tail. Adults usually are 300-400 cm in total length and 200-500 kg (Nowak 1991). The species occurs in coastal areas from the southeastern U.S. to northeastern South America. It is found in rivers, estuaries, and coastal areas of subtropical and tropical areas of northern South America, West Indies/Caribbean region, Gulf of Mexico (now mainly western and southwestern portions) and southeastern North America. Present range limits are similar to those known historically, but the distribution is fragmented due to areas of local extirpation. U.S. populations occur primarily in Florida where they are effectively isolated from other populations by the cooler waters of the northern Gulf of Mexico and the deeper waters of the Straits of Florida. Occasionally manatees are found in summer from Texas to North Carolina. The species occur along most of the Gulf coast of Florida, but infrequently occurs north of the Suwannee River and between the Chassahowitzka River and Tampa Bay. They occur all along the Atlantic coast of Florida, from the Georgia coast to Biscayne Bay and the Florida Keys, including the St. Johns River, the Indian River lagoon system, and various other waterways.

Populations are threatened by high mortality often associated with human activity (especially collisions with boats in Florida), low reproductive rates, and habitat loss. The species is primarily dependent upon submergent, emergent, and floating vegetation.

9.0 EFFECTS OF THE ACTION

BCS was opened twice in 2019, first from February 27 through April 11 and again from May 10 to July 27. Openings lasted 123 days combined with a total of 206 open bays at a peak discharge of 196,000 cfs during the second opening. The BCS was opened for the 13 and 14th time in the structure's 87-year history, with six openings occurring over the past 11 years.

9.1 Sturgeon Effects/Recovery Operations.

Recovery of potentially entrained pallid sturgeon after closure was conducted by Bonnet Carré project staff, LDWF, and ERDC for the fifth time that includes openings in 2008, 2011, 2016, 2018, and 2019. Pallid sturgeon is a federally endangered species and it is the responsibility of USACE to facilitate recovery efforts after the structure is closed.

All sampling occurred after the second closure over a 10-day period in August beginning immediately after high bays ceased flowing allowing vehicular and boat access to the canals and Stilling Basin. Sampling stopped several days after the last sturgeon was collected. The BCS was sampled at seven locations using electroshocking, gillnets, gillnet-seines, cast nets, and visual sightings with dipnets. The primary sampling location was in Barbar's Canal and the Stilling Basin. A trammel net was set downstream in Barbar's prior to electroshocking and periodically checked for fish. The Stilling Basin was sampled using three different methods:

1) Gillnet-seines were pulled through the Stilling Basin towards a block net set 20-30 bays away, and repositioned as the crew continued sampling the entire length of the basin.

2) A crew rode the tram on top of the structure, and when a sturgeon was visually located, a ground crew was notified, waded into the Stilling Basin with a dip net, and retrieved the sturgeon.
3) A ground crew rode along the downstream edge of the Stilling Basin and visually located sturgeon. Fish were retrieved with a dip net or cast net.

In addition, two ditches (Ditches 2 and 4) captured substantial flow from the leaking pins and were sampled with electroshocking and gillnet-seines. Two lakes (Memphis and Phylway) were sampled by deploying gillnets followed by electroshocking. Memphis Lake was divided into two sections due to a sand berm that had formed during openings. In two cases, recreational fisherman caught a shovelnose sturgeon with a cast net and notified the Bonnet Carre' Park Rangers. One shovelnose sturgeon jumped into the electroshocking boat.

Electroshocking was conducted periodically from August 5-15 with a total effort of 335 minutes or 5.6 hours. The block net at the lower end of Barbar's Canal during electroshocking was deployed for approximately 5 hours. A total of 10 hauls were made with the gillnet-seine in Ditch 4. Four gillnets were deployed in Memphis Lake (1 and 2) for a total of 2.7 hours. One Paddlefish net was deployed in Phylway Lake for a total of 25 minutes. The Stilling Basin was sampled 12 times between August 6 – 21 for a total effort of 24.7 hours. Initially, the gillnet-seine was used by a larger crew (6-8 individuals) followed by visual sightings with a smaller crew (2-3 individuals).

Water quality measurements were taken on 12 occasions excluding the Stilling Basin. Average temperature was warm ranging from 29 – 32 °C. Dissolved oxygen in surface waters was above 6.0 mg/l at all ditch and canal locations. Low dissolved oxygen less than 3 mg/l were observed along the bottom in Memphis and Phylway Lakes. Turbidity in the lakes was also higher in bottom waters (12.6 – 26.9 NTU) compared to the surface (2.0 – 9.2 NTU). Average pH ranged from 7-8 and conductivity averaged 400 to near 500 µs/cm. Water quality parameters within the Stilling Basin varied during the monitoring period. Observed conditions during the recovery period illustrate the change in water quality conditions following the decline of water leaking through the bays and the sensitive nature of expedited recovery efforts before dissolved oxygen levels become critical.

Overall, a total of 46 species of fishes were collected in the BCS after the 2019 opening. Notable species included one Gulf sturgeon collected in the Stilling Basin and released by LDWF into the Suction Canals draining into Lake Pontchartrain, a sheepshead never collected before, and five black carp. Tissue and bony structures were extracted from the black carp for subsequent genetic and age analysis, respectively. Four paddlefish and 7 freshwater eels were also tagged and released into the Mississippi River. A total of 86 silver carp, 1 bighead carp, and 2 grass carp were tagged and released back into the floodway. Large schools of striped mullet, gizzard shad, and silver carp were observed in the Stilling Basin throughout the sampling period. Seven reptiles were caught and released. Notable sightings were the American alligator consuming dead fishes and the first documented collection of Graham's crayfish snake.

A total of 19 pallid and 239 shovelnose sturgeon were collected in the BCS in 2019. One hundred and sixty (160) sturgeon were observed within the Stilling Basin with locations (bay number) noted for 146 individuals. Forty two percent (67) were characterized as live, 92 individuals were dead and 1 individual was reported as unknown. Of the processed individuals, 7 were pallid sturgeon (1 dead) and 153 shovelnose (91 dead). Sturgeon recovery occurred throughout the entire Stilling Basin but the largest proportion of recovered individuals (73%) were observed in the middle section between bays 120 and 300. The incidence of mortality within the Stilling Basin began to increase after August 10 when leakage through the low bays began to be reduced. The largest number of dead sturgeon recovered was on August 19 after dissolved oxygen levels within the Stilling Basin had been at low levels for an extended period. All live individuals were released back into in the Mississippi River.

All fishes captured were identified to species (Table 4), enumerated, and total length measured except for sturgeon (fork length) and paddlefish (eye-to-fork length). Weight was recorded for pallid sturgeon and a subset of shovelnose sturgeon, paddlefish, and Asian carp. A numbered floy tag with a toll-free ERDC phone number was inserted externally behind the dorsal fin for sturgeon, paddlefish, and Asian carp. Additional morphometric measurements and meristic counts were taken on pallid sturgeon to verify species designation. A tissue sample was collected for future genetic analysis and archived at ERDC. Pallid sturgeon were scanned for the presence of a Coded Wire Tag to determine if individuals were of hatchery origin from the Missouri River basin and a Passive Integrated Transponder (PIT) tag indicating recapture. If no tags were detected, a non-encrypted PIT tag was inserted at the base of the dorsal fin sturgeon and Paddlefish were transported in an aerated live well and released back into the Mississippi River. All other fish species collected were released back into the floodway at the original capture location. Water quality measurements were taken in the BCS (Table 5) and within the stilling basin (Table 6) to document conditions at the time of sampling/relocation.

The Gulf sturgeon (Figure 3) was captured in a seine on August 8, 2019 from the stilling basin and relocated to the Suction Canal by LDWF personnel. The sturgeon was in good condition, and was collected before water conditions begin to deteriorate in the Stilling Basin. Tissue and pectoral spine samples were collected from the fish which was 865 mm in length (FL) and 4.65 kg in weight. The sturgeon was tagged prior to release (WES Tag: WES12058; PIT Tag: 152276457A).

Figure 2. Three primary areas where sturgeon were collected in 2019: Stilling Basin, Canals (Barbar's and Y), and Lakes.

Figure 3. Gulf sturgeon (*A. oxyrinchus desotoi*)

Table 4. List of fish species collected in the Bonnet Carré Spillway in 2008, 2011, 2016, 2018, and 2019. Relative abundance is categorized as rare (<10 individuals), common (10-100 individuals) and abundant (>100 individuals). Species marked with a dagger (†) are euryhaline marine species. Species are listed in systematic order.

Species	**Common Name**	**2008**	**2011**	**2016**	**2018**	**2019**
Acipenser oxyrhynchus desotoi	Gulf Sturgeon					R
Scaphirhynchus albus	Pallid Sturgeon	C	C		R	C
Scaphirhynchus platorynchus	Shovelnose Sturgeon	C	C		R	A
Polyodon spathula	Paddlefish	R	C		R	R
Atractosteus spatula	Alligator Gar	R			C	R
Lepisosteus platostomus	Shortnose Gar	C	C		R	C
Lepisosteus oculatus	Spotted Gar	C		R	R	C
Lepisosteus osseus	Longnose Gar	R	R	R	R	C
Amia calva	Bowfin	R		R	R	R
Hiodon alosoides	Goldeye		R	R		R
Anguilla rostrata	American Eel	A	R		R	C

Anchoa mitchilli†	Bay Anchovy	R				
Alosa chrysochloris†	Skipjack Herring	A	C	R		R
Brevoortia patronus†	Gulf Menhaden	C				
Dorosoma cepedianum	Gizzard Shad	A	A	A	A	A
Dorosoma petenense	Threadfin Shad	C		R	A	A
Ctenopharyngodon idella	Grass Carp			R	A	R
Cyprinella venusta	Blacktail Shiner		R			
Hybognathus nuchalis	Mississippi Silvery Minnow					
Cyprinus carpio	Common Carp	R	R	C	R	C
Hypophthalmichthys molitrix	Silver Carp	R	C	A	A	A
Hypophthalmichthys nobilis	Bighead Carp	R	R	R	R	R
Mylopharyngodon piceus	Black Carp					
Macrhybopsis hyostoma	Shoal Chub	R	R	C		C
Macrhybopsis storeriana	Silver Chub	R		R	C	
Notropis atherinoides	Emerald Shiner	R		R	R	R
Notropis longirostris	Longnose Shiner		R			
Notropis shumardi	Silverband Shiner	R				
Notropis wickliffi	Channel Shiner	R		R		R
Opsopoeodus emiliae	Pugnose Minnow			R		
Pimephales vigilax	Bullhead Minnow			R	C	
Cycleptus elongatus	Blue Sucker	R				
Carpiodes carpio	River Carpsucker	R	R	C	C	R
Carpoides velifer	Highfin Carpsucker					R
Ictiobus bubalus	Smallmouth Buffalo	C	C	A	C	C
Ictiobus cyprinellus	Bigmouth Buffalo		R	A	R	R
Ictiobus niger	Black Buffalo	R		R		R
Ictalurus furcatus	Blue Catfish	A	A	C	A	A
Ictalurus punctatus	Channel Catfish	C	R	R	C	C
Pylodictis olivaris	Flathead Catfish	A	A	R	C	C
Mugil cephalus†	Striped Mullet	C		R	R	A
Menidia beryllina	Inland Silverside	R	R	C	C	
Strongylura marina†	Atlantic Needlefish	R			R	R
Fundulus grandis†	Gulf Killifish	R				
Morone chrysops	White Bass	R		R	R	C
Morone mississippiensis	Yellow Bass	R		R		R
Morone saxatilis	Striped Bass	R			R	R
Elassoma zonatum	Bantam Pygmy Sunfish				R	
Chaenobryttus gulosus	Warmouth Sunfish	R		R	R	R
Lepomis humilis	Orangespotted Sunfish	R		C	A	C
Lepomis macrochirus	Bluegill Sunfish	C	R	C	C	C
Lepomis megalotis	Longear Sunfish	R	R	C	C	C
Lepomis microlophus	Redear Sunfish		R	C	R	R
Lepomis miniatus	Redspotted Sunfish	A		C		R

Lepomis symmetricus	Bantam Sunfish				R	
Micropterus salmoides	Largemouth Bass	R		C		C
Pomoxis annularis	White Crappie	R	R	R	R	C
Pomoxis nigromaculatus	Black Crappie	R		R	R	C
Percina suttkusi	Gulf Logperch		R			
Sander canadensis	Sauger			R		
Aplodinotus grunniens	Freshwater Drum	C	R	R	A	A
Archosargus probatocephalus	Sheepshead					R
Ctenogobius shufeldti	Freshwater Goby	R	R		C	
Herichthys cyanoguttatus	Rio Grande Cichlid	R				
Trinectes maculatus†	Hogchoker	R	R	R		R
Total species	**65**	**48**	**30**	**40**	**40**	**46**

Table 5: Surface water quality measurements in the Bonnet Carré Spillway excluding the Stilling Basin, August 7-17, 2019.

Location	N	Variable	Mean	Std Dev	Minimum	Maximum
Barbar's Canal	3	Conductivity, µs/cm	455.3	43.8	405	485
		Dissolved Oxygen, mg/l	7.3	1.5	5.5	8.14
		Water Temperature, °C	30.9	0.3	30.7	31.2
		Turbidity, NTU	18.8	4.8	15.6	24.4
		pH	7.2	1.0	6.12	7.8
Ditch 2	2	Conductivity, µs/cm	482.0	1.4	481	483
		Dissolved Oxygen, mg/l	7.2	1.0	6.46	7.87
		Water Temperature, °C	30.1	1.2	29.2	30.9
		Turbidity, NTU	13.6	0.9	12.9	14.2
		pH	7.4	0.1	7.38	7.5
Ditch 4	2	Conductivity, µs/cm	455.0	41.0	426	484
		Dissolved Oxygen, mg/l	7.1	0.3	6.94	7.32
		Water Temperature, °C	29.2	0.5	28.8	29.5
		Turbidity, NTU	14.3	0.5	13.9	14.6
		pH	7.3	0.0	7.29	7.31
Memphis Lake	2	Conductivity, µs/cm	437.5	3.6	435	440
		Dissolved Oxygen, mg/l	7.6	2.3	5.9	9.2
		Water Temperature, °C	31.7	0.7	31.2	32.2
		Turbidity, NTU	9.2	0.6	8.8	9.6
		pH	7.7	0.3	7.5	7.8
Phylway Lake	2	Conductivity, µs/cm	409.5	4.9	406	413
		Dissolved Oxygen, mg/l	9.0	2.4	7.3	10.7
		Water Temperature, °C	31.8	0.3	31.6	32.0
		Turbidity, NTU	2.0	2.6	0.2	3.9
		pH	8.4		8.4	8.4

Y Canal	2	Conductivity, µs/cm	487.5	6.4	483	492
		Dissolved Oxygen, mg/l	6.0	2.7	4.1	7.87
		Water Temperature, °C	31.0	0.1	30.9	31.1
		Turbidity, NTU	21.0	9.5	14.2	27.7
		pH	7.5	0.0	7.5	7.52

Table 6: Water quality measurements in the Stilling Basin.

	Water quality parameters		
	Water temperature (C)	Dissolved oxygen (mg/L)	Turbidity (NTU)
August 6, 2019			
Minimum	30.74	6.08	2.26
Maximum	33.97	22.08	168
Mean (± 95% CI)	32.08 (± 0.027)	12.08 (± 0.027)	15.96 (± 0.34)
December 4, 2019			
Minimum	11.49	6.93	1.02
Maximum	13.45	12.66	68.3
Mean (± 95% CI)	12.55 (± 0.014)	11.09 (± 0.032)	3.41 (± 0.13)

9.2 Potential Effects to Sea Turtles

Kemp's ridley, loggerhead, and green sea turtles are the primary species found along the Mississippi coast. Sea turtle mortalities are rarely documented in Louisiana within the action area. There are no apparent links between releases of freshwater into the Gulf of Mexico and the current sea turtle strandings, however, environmental changes that reduce sea turtle prey or alter their preferred habitats can result in indirect effects (https://www.fisheries.noaa.gov/southeast/marine-life-distress/frequent-questions-northern-gulf-mexico-sea-turtle-strandings). The Sea Turtle Stranding and Salvage Network (STSSN) monitors and investigates all strandings and incidental captures that are reported by the public and member participants in Mississippi. That Mississippi STSSN data was utilized to make some general assumptions about potential effects the 2019 operation of the BCS may have had upon sea turtles. Additional mortalities in Louisiana were possible, but data collection in that area appears less consistent likely due to the remoteness of the area. The Mississippi data is not intended to say how many mortalities occurred. The intention is to show mortalities relative to the 10 year average. It is also important to note that the BCS was only one of many sources of freshwater in the area monitored by the STSSN during the spring of 2019.

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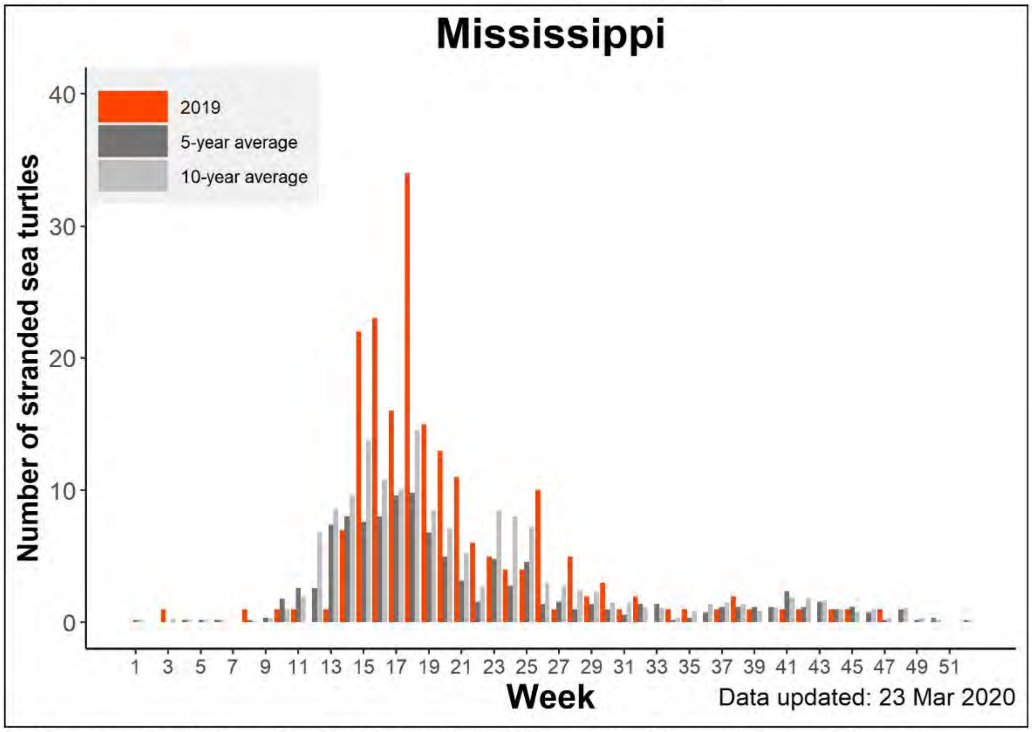

Weekly numbers of stranded sea turtles within Mississippi during 2019 (ongoing) and the previous 5-year and 10-year averages.

Figure 4. Mississippi STSSN Data (Provided by NMFS)

The STSSN data (Figure 4) indicates an increase in sea turtle strandings (injury/mortality) over the 10-year average during the period of BCS operation (Weeks 9 thru 30). Data indicted a 2019 cumulative yearly stranding of 186 sea turtles ending on July 29, 2019, with the 10-year average being 138 sea turtles for that date. As a reminder, BCS operations ceased on July 27, 2019, and Hurricane Barry made landfall in in Louisiana on July 13, 2019. The STSSN data suggest that some factor contributed to an increase in effects to sea turtles during spring and summer of 2019. A review of the salinity data indicates that salinities in the Western Mississippi Sound were extremely low during most of that period (Figure 5). Freshwater is not known to directly affect sea turtles like it does marine mammals. However, the freshwater (from all sources) could have indirectly affected sea turtles by reducing or relocating in some cases potential food sources. The freshwater could also have caused the turtles to relocate due to other water quality factors associated with freshwater (temperature, turbidity, etc.). That relocation could have concentrated turtles in certain geographic areas increasing the probabilities of encountering other hazards (such as shrimp trawls, boats, etc.). It is difficult to quantify these indirect effects to sea turtles much less identify the underlying cause. Assuming that reduced salinity contributes to indirect effects on sea turtles, reduction in salinity cannot be traced back to a single freshwater source. A review of local freshwater sources (Figure 6) indicates that multiple sources of freshwater flow into the Western Mississippi Sound. Limited Oxygen Isotope Analysis (Figure 7) indicates that at times approximately half of the freshwater present in the review area was from the Mississippi River. It is difficult to determine the exact source of the freshwater because testing cannot differentiate the water from the BCS from that coming from the numerous passes at the mouth of the Mississippi River. Assuming some of this freshwater entered the action area through the BCS, it is possible that the BCS had potential for indirect effects on Kemp's ridley, loggerhead and green sea turtles during and shortly after operation of the BCS. However, the potential for effects was essentially terminated by the arrival of Hurricane Barry. Review of post-Barry Oxygen Isotope Analysis (Figure 8) indicates very little remaining Mississippi River water within the review area.

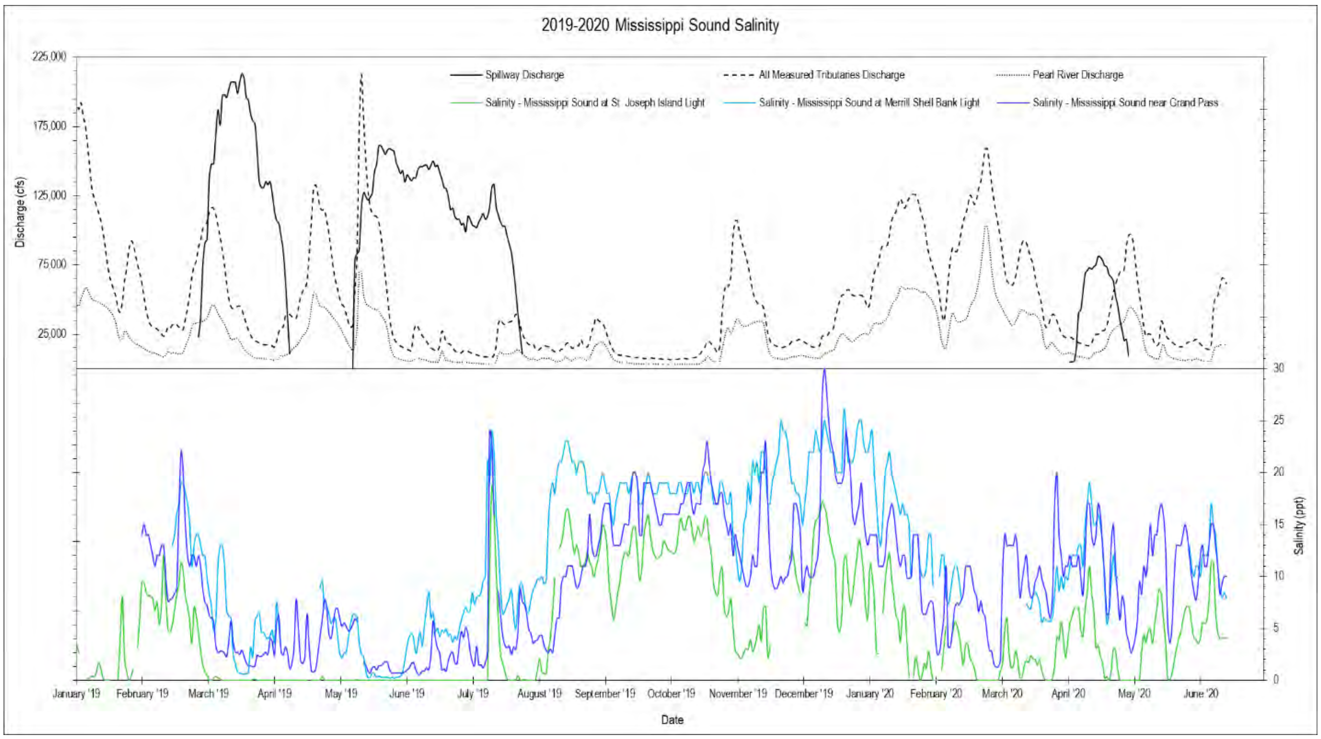

Figure 5. Salinity/Discharge

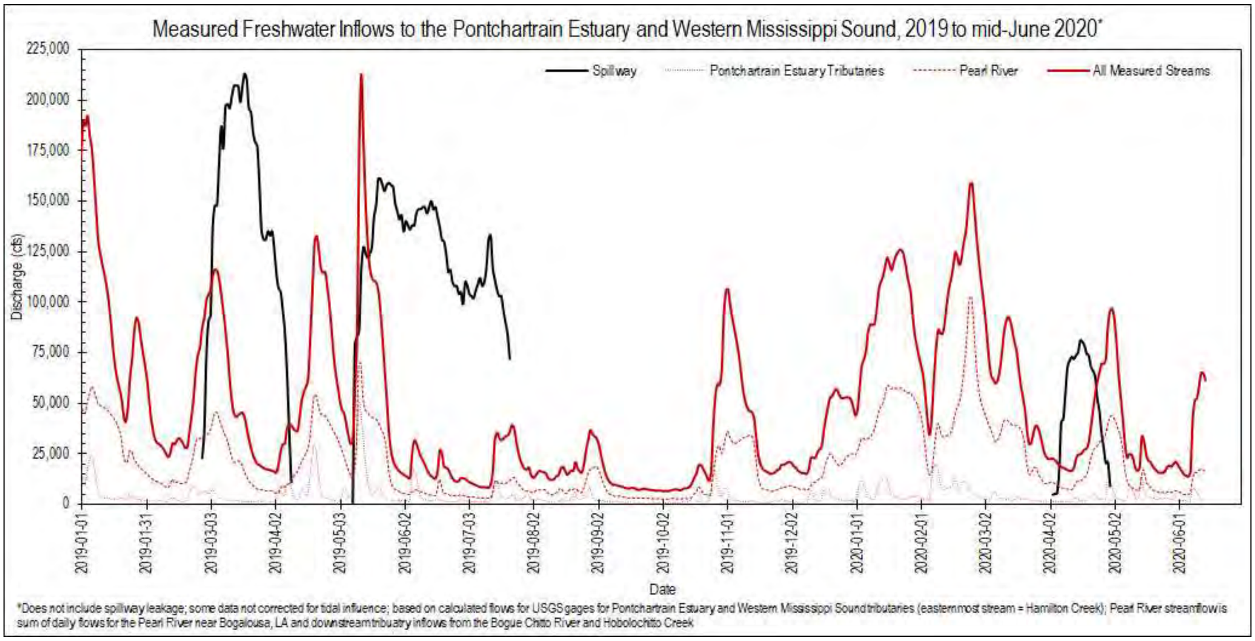

Figure 6. – Other contributors of Freshwater

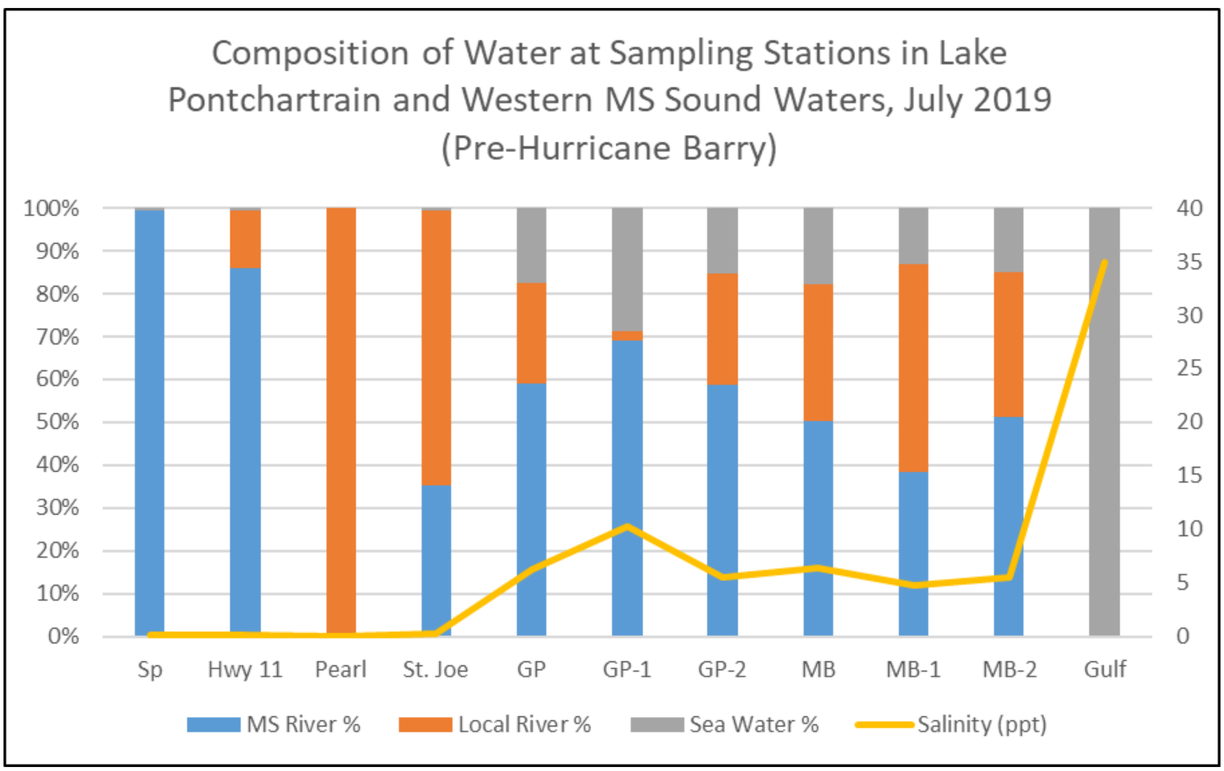

Figure 7. Oxygen Isotope Analysis (Pre-Hurricane Barry)

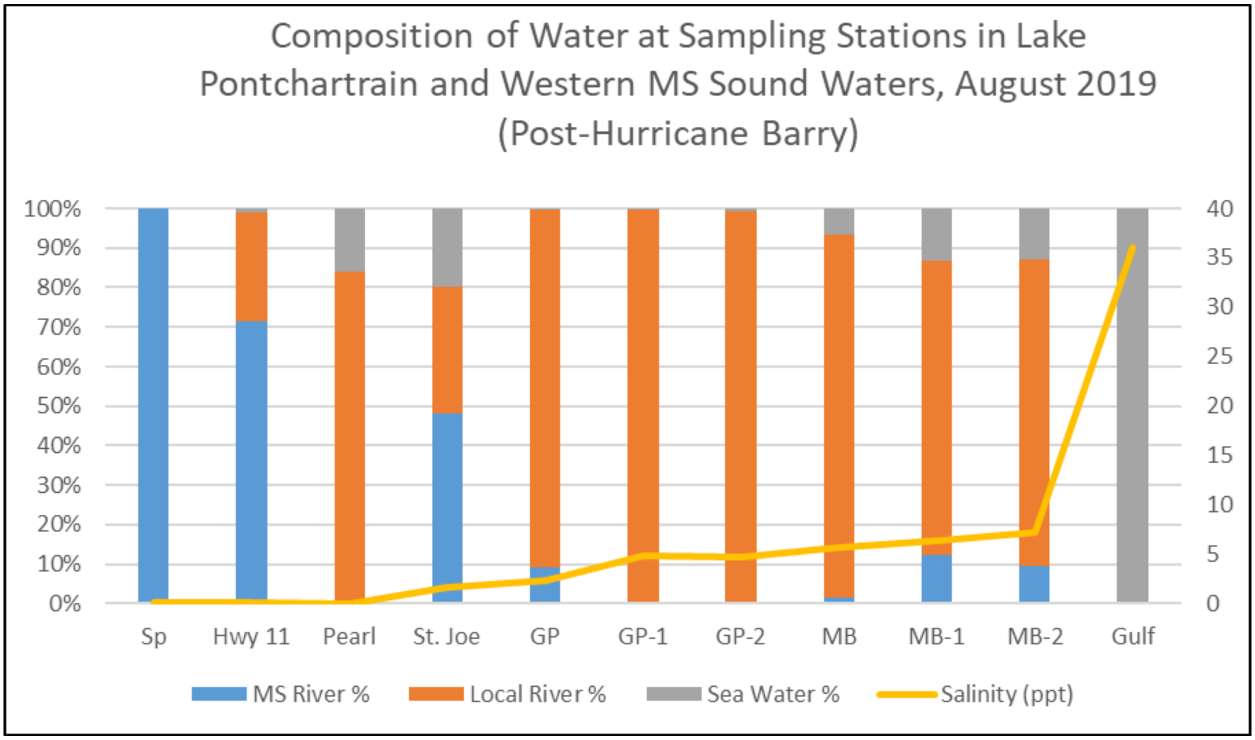

Figure 8: Oxygen Isotope Analysis (Post-Hurricane Barry)

Other factors (such as: algal blooms and contaminants) were considered, but no evidence was found to support that those factors contributed to the increase in sea turtle mortalities. A short-term increase in nutrients (Mississippi River water) can exacerbate existing algal blooms. Reports indicate this could have occurred along the Mississippi Coast. Toxic algal blooms can effect sea turtles, but CEMVN is not aware of any toxic "red-tide" events in the action area during the 2019 operation. Numerous blue-green algal blooms may have adversely effected food sources for sea turtles, but not enough data exist to postulate a conclusion. The Louisiana Department of Environmental Quality (https://deq.louisiana.gov/page/water-quality-integrated-report-305b303d) indicates the Mississippi River water quality is currently meeting its primary designated use for fish and wildlife propagation. Combined with the high levels of productivity in the lower Mississippi River Delta, CEMVN finds that the Mississippi River water released through the BCS has no adverse effect on long term productivity within the action area.

9.3 Potential Effects to West Indian Manatee.

West Indian Manatee are infrequent visitors to the area, but can be found within the action area during the warmer months. Manatees live in marine, brackish, and freshwater systems in coastal and riverine areas throughout their range. Preferred habitats include areas near the shore featuring underwater vegetation like seagrass and eelgrass. They feed along grass bed margins with access to deep water channels, where they flee when threatened. They cannot tolerate temperatures below 68 degrees Fahrenheit for extended periods of time (https://www.fws.gov/southeast/wildlife/mammals/manatee/). The operation of the BCS is not known to have any direct effects to Manatee. However, the 2019 operation potentially resulted in indirect effects due to the timing of the operation. Increases in turbidity and algal blooms can result in a lower growth rate of submerged aquatic vegetation which is the primary food source for manatee. The potential for contribution of the BCS to these factors are discussed above. In any event, Manatee are highly mobile and transient by nature. If they were not finding an adequate food supply or if water conditions necessitated, they would simply move to another area. However, limitations in their food supply or unfavorable water conditions would be an indirect effect to this species.

9.4 Discussion of Conservation Recommendations

In response to an emergency Section 7 coordination request by CEMVN, the USFWS responded on February 26, 2019, and provided six conservation recommendations for sturgeon that our agency could undertake to minimize the potential take of species during the structures operation. Those recommendations and CEMVN's responses follow:

Conservation Recommendation 1:
Recover pallid sturgeon entrained through the BCS and return them to the river.

Response: As mentioned above, a total of 19 Pallid and 239 shovelnose sturgeon were collected in the BCS in 2019. One hundred and sixty (160) sturgeon were observed within the Stilling Basin. Forty two percent (67) were characterized as live, 92 individuals were dead and 1 individual was reported as unknown. Of the processed individuals, 7 were pallid sturgeon (1 dead) and 153 shovelnose (91 dead). The incidence of mortality within the Stilling Basin began to increase after August 10 when leakage through the low bays began to be reduced. Additionally, one Gulf sturgeon was relocated to the Suction Canals draining into Lake Pontchartrain. CEMVN plans to continue recovery efforts during future events. The names of the water features found within the BCS are depicted in Figure 9.

Conservation Recommendation 2.
Tag and track (either actively and/or passively) shovelnose sturgeon (as a surrogate species for the pallid sturgeon) with sonic transmitters to determine movement within and out of the spillway and, if possible, relate those movements to environmental conditions.

Response: This effort requires prior purchase and staging of tracking equipment. This equipment was not available for the 2019 openings. We have requested funding for purchase of equipment to complete this recommendation during future operations.

Conservation Recommendation 3. Determine salinity tolerance of shovelnose as a means of possibly determining dispersal of pallid sturgeon during spillway operation.

Response: Funding was never available to conduct a salinity tolerance laboratory assessment and funding was better resourced for the pallid sturgeon rescue effort. The ERDC pallid sturgeon experts believe since shovelnose and pallid sturgeon are strictly freshwater, their tolerance to salinity is minimal and any sturgeon making their way to Lake Pontchartrain during or after an opening would probably die. When the Mississippi River falls below the concrete weir of the structure, which is approximately 16 ft (4.9 m) on the structure tile gage, or 11.8 ft (3.60 m) at Carrolton gage flow into the BCS stops and the area begins to drain towards Lake Pontchartrain.

The CEMVN believes that the BCS project would not result in additional information to disprove this outcome and therefore asks the USFWS to remove the salinity tolerance recommendation from future BCS opening recommendations.

Conservation Recommendation 4. To the maximum extent practicable, conduct a slow closure of the BCS.

Response: The Corps strives to close the structure slowly due to this request and the stability of downstream levees. The structure is designed such that when the Mississippi River stage falls below the concrete sill, all discharge ceases whether the bays are still open or not. Discharge begins at 14.9 feet on the Mississippi River at BCS or approximately 11.8 feet at Carrollton, therefore discharge through the structure will stop when the river stage falls below that level.

Conservation Recommendation 5. Reexamine pallid sturgeon demographics and update the 2013 population viability analysis.

Response: A draft population viability analysis has been provided to USFWS for review and comment.

Conservation Recommendation 6. Provide a report documenting completion of conservation recommendations.

Response: CEMVN believes this recommendation is best addressed through preparation of an after-the-fact BA (this document).

There are no known topographic or hydrographic features (apart from river current) that would appear to attract the sturgeon to the vicinity of the BCS. ERDC (2013) postulated various methods to establish the number of sturgeon "taken" and tried to incorporate most probable factors involved in their analysis of potential entrainment of sturgeon. Factors considered in some of their methods included the loss of sturgeon into Lake Pontchartrain through the BCS during the diversion, and/or through emigration once flows were reduced during the BCS closure, and the volume and/or duration of the diversion. The volume of water diverted through the BCS is primarily related to the river stage (a measurement of water volume in the river) at the structure and the number of bays that are opened. The 350 bays that comprise the structure are 20 ft-wide (6.1 m) and have two sill elevations of 16.8 ft (5.12 m) National Geodetic Vertical Datum 1927 (NGVD) and 14.8 ft (4.51 m) NGVD (a 2 ft [0.6 m] difference).

Other Species

The conservation measures implemented for the relocation of pallid sturgeon trapped behind the spillway structure back into the Mississippi River benefit Gulf sturgeon by relocating entrained individuals back into the Lake Pontchartrain basin. This occurred in the 2019 recovery operation. Since it hasn't happened prior to this event, USACE doesn't believe this to be a common problem requiring additional consideration. No other Gulf sturgeon conservation measures have been suggested or identified. No conservation recommendations have been suggested for sea turtles or manatee. CEMVN find current operational procedures adequate to insure the continued viability of those species and finds no direct effects to those listed species. CEMVN will continue to investigate opportunities to reduce the potential for indirect effects upon those species.

Figure 9. Water body names in the BCS.

9.5 Discussion of Effects From Recent Past Openings

Due to the number of entrained pallid sturgeon, this section will focus on the recent success from recovery and relocation of that species. The recovery team sampled the BCS after five openings: 2008, 2011, 2016, 2018 and 2019. The 2008 opening occurred in the early spring with a mean water temperature of 23.5 °C similar to the 2018 opening, while the 2011 and 2019 openings occurred late spring into summer with mean water temperatures around 30 °C. The 2016 opening in January was much colder with a mean water temperature of 10.8 °C. The relationship between water temperature and number of pallid sturgeon rescued was linear with a regression ($R^{2)}$ of 0.76 (Figure 10). More sturgeon are entrained as water temperature rises.

Other operating characteristics of the Spillway were also significantly ($p<0.05$) correlated to recovery efforts. The percentage of bays open out of a total of 350 bays was positively related to pallid sturgeon rescued. Number of bays opened depends on the magnitude and duration of the Mississippi River flood, but this data seems to indicate that entrainment increases with number of bays open. The reverse may be true when considering number of days the structure is open. A curvilinear response was measured between number of pallid sturgeon rescued and days open. Recovery is initially high but over time declines. Several reasons could explain this trend. Sampling efficiency and effort varies among recovery periods. However, the most likely explanation is that sturgeon are displaced further downstream and into Lake Pontchartrain during longer openings and cannot find their way back into the spillway.

Discharge through Barbar's Canal was measured during all five openings. Discharge is regulated by pin leakage and Mississippi River stage. In 2008, initial discharge when sampling began was 3,500 cfs compared to 2,732, 755, and 1,080 cfs in 2011, 2016, and 2019, respectively. Flow persisted in the canal for four weeks after closure in 2008 whereas canals became non-flowing 7 days after closure in 2011 and 2016. In 2018 and 2019, non-flowing conditions occurred approximate 5 days after closure impacting recovery efforts. Recovery efforts in the Canals and Stilling Basin should be prioritized according to discharge and water temperature (Table 7).

The five openings of the BCS had different outcomes in the recovery of sturgeon. A cumulative total of 31 pallid sturgeon were recovered after the 2008 and 2011 openings because flows persisted in the BCS long enough to complete recovery sampling as individuals moved up the canals towards the structure where they were effectively collected. No sturgeon were captured after the 2016 openings because water temperatures were much colder and fish were not moving along the channel border of the Mississippi River where they are more susceptible to entrainment. In 2018, the river dropped below the low bays before recovery efforts and canals were non-flowing. Therefore, sturgeon did not have the directional cues to swim upstream towards the structure and were displaced throughout the BCS or moved into Lake Pontchartrain where they likely perished due to the inability to osmoregulate in saline waters. The 2019 effort yielded 19 pallid sturgeon, similar to 2011. However, 239 shovelnose sturgeon were collected in 2019 almost 3 times higher than 2011 when 78 shovelnose sturgeon were collected. Similar to pallid sturgeon, length and seasonality of openings directly influence entrainment rate of shovelnose sturgeon.

The 2019 recovery effort was unusual in the number of sturgeon collected in the Stilling Basin. Seven of the 19 pallid sturgeon were collected in the Stilling Basin using GN-Seines and direct observation. A total of 153 of the shovelnose sturgeon were collected in the Stilling Basin using the same approach. Although daily fluctuations of dissolved oxygen was measured, waters of the Stilling Basin were apparently suitable for survival of most species collected over a 3-week period and perhaps beyond. Suitable water conditions persisted even after bays quit leaking apparently from infiltration of Mississippi River water. Regardless of the water quality, recovery efforts in the Stilling Basin should proceed quickly because large numbers of sturgeon become trapped in a concrete channel without any avenues to escape.

Table 7. Characteristics of the Bonnet Carré Spillway after closure from 2008 – 2019. Water quality measurements occurred after closure during sampling and included canals, ditches, and lakes.

Variable	2008	2011	2016	2018	2019
Days Open	31	42	22	22	122
Maximum Bays Open	160	330	210	168	206 – Feb to Apr 168 – May to July
Percent Open	45.7	94.3	60%	48	58.9 – Feb to Apr 48.0 – May to July
Maximum Discharge, cfs	160,144	315,930	203,000	196,000	213,000
Calendar Days	April 11 – May 8	May 9 – June 20	January 10-Feb 1	March 8 - 30	Feb 27-April 11 – 43 days May 10-July 22 – 79 days
Mean Water Temperature, °C	23.5	29.5	10.8	24.0	30.8
Mean Dissolved Oxygen, mg/l	7.0	6.9	12.0	8.5	7.4
Mean Turbidity, NTU	41.6	51.0	39.1	20.0	13.8
Number of Pallids Rescued	14	20	0	4	19
Number of Shovelnose Rescued	41	78	0	4	239

10.0 CONCLUSION

It is the CEMVN's determination that operation of the BCS in 2019 "*may affect, likely to adversely affect*" individual pallid and shovelnose sturgeon. Some incidental take did occur in 2019, however, the event did not adversely impact the Lower Mississippi River pallid and shovelnose populations. It has been demonstrated that the rapid rescue of entrained adult pallid and shovelnose sturgeon can be successfully accomplished to minimize impacts to these species. For future BCS openings, the CEMVN would contract the ERDC Fish Ecology Team to rescue and return pallid and shovelnose sturgeon back into the Mississippi River.

It is the CEMVN's determination that operation of the BCS in 2019 "*may affect, but is not likely to adversely affect*" the Gulf sturgeon. The relocated Gulf sturgeon likely rejoined the Pearl River population with no effect to that breeding population. CEMVN believes this trip up the BCS by that specific Gulf sturgeon to be an isolated incident that is not likely to occur on a frequent basis. This is based on the fact that no other Gulf sturgeon have been captured in previous Pallid sturgeon recovery events. In general, Gulf sturgeon are a highly mobile anadromous fish that spend a significant portion of their life in riverine systems. They are not going to be directly affected by river water from the BCS. Impacts to their forage habitat were not found to be significant in the 2009 Benthic Report (Ray, 2009). Based on the 2009 Benthic Report and life cycle characteristics of the species, CEMVN has determined that the BCS operation had no additional effects on the overall Gulf sturgeon population nor their critical habitat.

CEMVN determined the operation of the BCS had "*no effect*" on Piping plover, Red Knot, and Eastern black rail. The shorebirds would not be effected by the additional short-term input of freshwater into the local ecosystems.

The 2019 extreme flooding event that affected Louisiana, Mississippi, and Alabama due to heavy rains in the Mississippi and Ohio River valleys saw a high annual mortality of marine mammals and sea turtles in the North Central Gulf of Mexico. Some entities attribute that increase in mortality to additional freshwater entering the Mississippi Sound. There were many sources of freshwater including the natural passes of the Mississippi River, numerous regional rivers, local precipitation/runoff and the BCS. It is difficult to differentiate effects on sea turtles between other sources and the freshwater introduced from the BCS. CEMVN finds no firm link exists between the BCS operation and a discernable direct effect to sea turtles. However, the 2019 BCS operation potentially contributed to indirect effects on sea turtles. So, CEMVN finds the 2019 BCS operation "*may affect, but not likely to adversely affect*" the green sea turtle, the Kemp's Ridley sea turtle, and the loggerhead sea turtle.

The West Indian manatee is not directly affected by reductions in salinity. Further, Manatee rarely occur within the area influenced by the operation of the BCS. No mortalities of manatee were documented. However, the operation may have indirectly affected manatee through an effect to forage habitat. So, CEMVN finds the 2019 BCS operation "*may affect, but not likely to adversely affect*" manatee.

As stated in Section 2, the 2019 BCS operation had "*no effect*" on the giant manta ray (*Manta birostris*), the hawksbill (*Eretmochelys imbricata*), or the leatherback sea turtle (*Dermochelys coriacea*).

We request that you review this After-The-Fact BA, initiate consultation and provide us with your BO regarding the 2019 emergency operation of the BCS.

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Biological Opinion

Bonnet Carré Spillway 2019 Emergency Operations

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CONSULTATION HISTORY

February 21, 2019 – U.S. Army Corps of Engineers, New Orleans District (USACE) contacted the U.S. Fish and Wildlife Service's (Service) Louisiana Ecological Services Office, via telephone, to discuss the implications of a near-term, future 2019 Bonnet Carré Spillway (BCS) opening on the federally endangered pallid sturgeon and threatened shovelnose sturgeon, which was federally listed under the Similarity-of-Appearance Provisions of the ESA in 2010 (Service 2010).

February 25, 2019 – The USACE initiated, via letter dated February 22, 2019, emergency consultation for the pallid sturgeon and the shovelnose sturgeon.

February 26, 2019 – The Service provided a written response to the USACE containing six conservation recommendations for the operation of the BCS for the sturgeon that the USACE could undertake to minimize the potential for take of the species during the structure's operation. The conservation recommendations provided by the Service were as follows:

Task 1: Recover pallid sturgeon entrained through the BCS and return them to the river. Prior to their return, individuals should be tagged and appropriate data collected.

Task 2: Tag and track shovelnose sturgeon (as a surrogate species for the pallid sturgeon) with sonic transmitters to determine movement within and out of the spillway and, if possible, relate those movements to environmental conditions.

Task 3: Determine salinity tolerance of shovelnose as a means of possibly determining dispersal of pallid sturgeon during spillway operation.

Task 4: To the maximum extent practicable conduct a slow closure of the BCS once the flood threat is eliminated.

Task 5: Reexamine pallid sturgeon demographics and update the 2013 population viability analysis to determine if the spillway opening impacts the long-term viability of that species.

Task 6: Provide a report documenting completion of the above recommendations.

May 6, 2019 – The USACE contacted the Service's Louisiana Ecological Services Office, via telephone, to discuss the implications of a near-term, future unprecedented second opening of the BCS within the same calendar year on the federally listed endangered pallid sturgeon and the threatened shovelnose sturgeon.

May 7, 2019 – The USACE initiated, via letter dated May 7, 2019, emergency consultation for the pallid sturgeon and the shovelnose sturgeon for the unprecedented second opening of the BCS within the same calendar year.

May 8, 2019 - The Service provided a written response to the USACE containing six conservation recommendations for the operation of the BCS for the sturgeon that the USACE could undertake to minimize the potential for take of the species during the structure's operation. The conservation recommendations provided by the Service were identical to those provided in our February 26, 2019, letter (listed above).

September 17, 2020 – The USACE initiated, via letter dated September 17, 2020, formal consultation with the Service on the 2019 BCS Emergency Operations. Enclosed within the letter was a Final BA for the Emergency Operations.

October 20, 2020 – The Service responded via letter dated October 20, 2020, to the USACE providing confirmation that the initiation package was complete and that our biological opinion would be issued no later than January 30, 2021.

December 15, 2020 – The Service requested via electronic mail a 20-day extension for issuance of the final BO. The extension was granted by the USACE on December 15, 2020.

January 14, 2021 – The USACE contacted the Service, via electronic mail, to amend the BA for the 2019 BCS Emergency Operations. These amendments included clarification of the determination regarding Atlantic (Gulf subspecies) sturgeon and that Cat Island, included within piping plover critical habitat, is considered just inside the Action Area for the 2019 BCS Emergency Operations.

In their September 17, 2020, request for consultation and final BA, the USACE determined that the 2019 BCS Emergency Operations (i.e., the Action) had no effect on the hawksbill and leatherback sea turtles, the red knot, the eastern black rail, and the piping plover, as well as no adverse modification to piping plover critical habitat. The Service agrees that the Action had no impacts to the red knot, the eastern black rail, and the piping plover and no adverse modification to its critical habitat. The Service and National Marine Fisheries Service (NMFS) share jurisdiction over all five listed sea turtle species. The NMFS has jurisdiction over all five sea turtle species while they are in their aquatic habitat, while the Service carries jurisdictional authority for these species when they are in their terrestrial habitat. The Service agrees that the Action had no impacts on the terrestrial habitat for the sea turtles. Therefore, the five sea turtle species, in the aquatic habitat, will not be discussed further in this document.

In their September 17, 2020, request for consultation and final BA, the USACE determined that the Action may have affected, but was not likely to have adversely affected the Atlantic sturgeon (Gulf subspecies, GS), West Indian manatee, green sea turtle, Kemp's Ridley sea turtle, and loggerhead sea turtle. As discussed above, the Service carries jurisdictional authority for sea turtles when they are in their terrestrial habitat and believes that the Action had no impacts on the terrestrial habitat for sea turtles. The West Indian manatee is a transient visitor to Louisiana that can potentially be found in the Action Area. The increase in turbidity and algal blooms can result in lower growth rate of submerged aquatic vegetation, a food source for manatees; however, manatees are highly mobile and transient individuals by nature in search of adequate food supply and water conditions. For these reasons, the Service concurs that the Actions did not adversely affect the West Indian manatee. The Service and National Marine Fisheries Service

(NMFS) share jurisdiction over the GS and its critical habitat. When the federal action agency is the USACE, the NMFS has jurisdictional responsibilities for the GS in estuarine areas; however, one GS was captured within the BCS spillway during recovery operations for pallid and shovelnose sturgeon. Due to the location of the one captured GS, the Service agreed to handle that species for the purposes of this consultation. Because the capture of GS has never occurred during recovery efforts from past opening events, the USACE believes this capture to be an isolated event. GS are highly mobile fish that spend much of the year in riverine systems, and therefore, would not be significantly impacted by the Action. For these reasons, the Service concurs with the USACE's determination that the Action did not adversely affect the GS; however, the captured GS was tagged and relocated so impacts to that one fish will be assessed further in Section 5: Effects of the Action. According to the USACE's Biological Assessment and a 2009 Benthic Report (Ray 2009), impacts to GS foraging habitat in Lake Pontchartrain is not found to be significant. Therefore, the Service agrees that there was no adverse modifications to GS designated critical habitat.

BIOLOGICAL OPINION

1. INTRODUCTION

A biological opinion (BO) is the document that states the opinion of the U.S. Fish and Wildlife Service (Service) under the Endangered Species Act of 1973, as amended (ESA), as to whether a Federal action is likely to:

- jeopardize the continued existence of species listed as endangered or threatened; or
- result in the destruction or adverse modification of designated critical habitat.

The Federal action addressed in this BO is the U.S. Army Corps of Engineers, New Orleans District (USACE) Bonnet Carré Spillway (BCS) 2019 Emergency Operations.

Consultation was requested by the USACE on the effects of the Action on the endangered pallid sturgeon (PS; *Scaphirhynchus albus*) and threatened shovelnose sturgeon (SS; *Scaphirhynchus platorynchus*). The SS was listed under the ESA as a threatened species, due to its similarity of appearance to PS. When a species is considered threatened under the ESA, the Secretary may specify regulations, commonly referred to as ‘‘special rules,’’ that he deems necessary to provide for the conservation of that species. The special rule for SS prohibits take of any SS, SS-PS hybrids, or their roe when associated with or related to a commercial fishing activity in those portions of its range that commonly overlap with the range of the endangered PS. All otherwise legal activities involving SS and SS-PS hybrids that are conducted in accordance with applicable State, Federal, tribal, and local laws and regulations are not considered to be take under this regulation. This designation of similarity of appearance under §4(e) also does not extend any other protections of the ESA, such as the consultation requirements for Federal agencies under §7, to SS. Therefore, Federal agencies are not required to consult with us on activities they authorize, fund, or carry out that may affect SS.

This BO considers the effects of the Action on pallid sturgeon. There is no designated critical habitat for this species; therefore, none will be affected.

A BO evaluates the effects of a Federal action along with those resulting from interrelated and interdependent actions, and from non-Federal actions unrelated to the Action (cumulative effects), relative to the status of listed species and the status of designated critical habitat. A Service opinion that concludes a proposed Federal action is *not* likely to jeopardize species and is *not* likely to destroy or adversely modify critical habitat fulfills the Federal agency’s responsibilities under §7(a)(2) of the ESA. In this BO, only the jeopardy definition is relevant, because the Action does not affect designated critical habitat.

“*Jeopardize the continued existence*” means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02). The basis of our opinion for the PS and SS is developed by considering the status of the species, its environmental baseline, the effects of the Action, and cumulative effects.

This BO uses hierarchical numeric section headings. Primary (level-1) sections are labeled sequentially with a single digit (e.g., 2. PROPOSED ACTION). Secondary (level-2) sections within each primary section are labeled with two digits (e.g., 2.1. Action Area), and so on for level-3 sections.

2. PROPOSED ACTION

Heavy rains during early 2019 in the Mississippi and Ohio River valleys, prompted the USACE to initiate flood control activities along the Lower Mississippi River. In late February 2019, stage predictions for the Mississippi River indicated that the flow of water in the river below the BCS would exceed 1,250,000 cubic feet per second (cfs). As a result, the Commander of the USACE Mississippi Valley Division and President of the Mississippi River Commission, Major General Richard G. Kaiser, ordered the BCS to be partially opened on February 27, 2019, to prevent the loss of life and property from floodwaters on the Lower Mississippi River.

The BCS was partially opened on February 27, 2019, and remained partially opened until April 11, 2019. During the 44-day period, adjustments were made to the volume of water flowing through the structure and into the adjacent, brackish, Lake Pontchartrain by removing and then reinserting the wooden pins to control the diversion of water. Pins are removed and replaced incrementally in equal numbers from opposite sides of the structure per the sequence of operation. Two cranes, which move along tracks atop the structure, are used to individually lift each pin from the required number of bays. The pins are raised from their vertical position across the weir opening and are laid horizontally on top of the structure for later use in its closing. Within 13 days, the USACE opened 206 of the 350 total bays. Once the 206 bays were opened the discharge through the BCS increased to a maximum of approximately 213,000 cfs. On the 44th day of operation, April 11, 2019, the BCS was closed. River stages remained high following the April 11, 2019 closure of the BCS, which prompted a second opening of the BCS on May 10, 2019 and remained partially opened until July 27, 2019. This was the first time in the history of the BCS that the structure was opened twice within a calendar year. Within 12 days, the USACE opened 168 of the 350 total bays. Once the 168 bays were opened the discharge through the BCS increased to a maximum of approximately 161,000 cfs. The USACE began the closing sequence for the BCS on July 22, 2019. On the 79th day of operation, five days after the initiation of the second closure of operations began, the falling Mississippi River caused the BCS to become hydrologically disconnected. The openings lasted for a combined 123 days.

2.1. Action Area

For purposes of consultation under ESA §7, the action area is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR § 402.02). The BCS is located in St. Charles Parish, Louisiana, and protects New Orleans and other downstream communities during major floods on the Lower Mississippi River (Figures 1 & 2). The areas to be affected directly or indirectly will vary based on the duration and flow associated with a particular spillway opening. There are other sources of freshwater in the Lake Borgne/Mississippi Sound area, particularly during major flood events, making it difficult to estimate the exact limits of any potential effects from operating the BCS. To ensure this analysis captures all areas which could potentially be affected, the action area includes the BCS, Lake Pontchartrain, Lake Borgne, portions of the Biloxi Marsh, and the Western Mississippi Sound (West of the Gulfport Ship Channel). This determination was based on a combination of Hydrocoast maps (Lake Pontchartrain Basin Foundation) showing salinity gradients during and shortly after operation of the BCS in conjunction with USACE water quality monitoring.

2.2. Non-Federal Activities caused by the Federal Action

A BO evaluates the effects of a proposed Federal action. "Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action, and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action" (50 CFR §402.02).

The Service defines the action area as that area including all direct and indirect effects of the action. PS have been observed to exhibit seasonal variation in movement patterns based on temperature and discharge and are capable of moving long distances in search of favorable habitat. Given this information, it is probable that the most significant direct and indirect effects of this action occurred within the Mississippi River in the Coastal Plain Management Unit (as defined in the recovery plan).

2.3. Tables and Figures for Proposed Action

Figure 1. Location map of the Bonnet Carré Spillway on the Mississippi River and drainage into Lake Pontchartrain (USACE 2020).

Figure 2. Closer look at the Bonnet Carré Spillway and water body names in the Spillway (USACE 2020).

3. STATUS OF SPECIES

This section summarizes best available data about the biology and current condition of PS throughout its range that are relevant to formulating an opinion about the Action. The Service published its decision to list the PS as endangered on October 9, 1990 (55 FR 36641-36647). The reasons for listing were habitat modification, apparent lack of natural reproduction, commercial harvest, and hybridization in parts of its range. Critical habitat has not been proposed or designated for the PS. The Service conducted a 5-year review of the species' status and revised the recovery plan in 2014, and determined that no status change was needed at that time. Most of the background information on PS biology and status presented throughout this BO is taken directly from information presented in the recently revised recovery plan (Service 2014a) and five other BOs (Service 2009; Service 2010a; Service 2014b; Service 2018; Service 2020).

3.1. Species Description

The PS is a benthic, riverine fish that occupies the Mississippi River Basin, including the Mississippi River, Missouri River, and their major tributaries (i.e., Platte, Yellowstone, and Atchafalaya rivers) (Service 1990).

Recent studies have documented extensive hybridization between PS and SS in the Lower Mississippi River (Coastal Plain Management Unit) (Jordan et al., 2019). These studies also confirmed that small numbers of genetically pure PS continue to occupy the Lower Mississippi River; however, genetic analysis is required for their accurate identification. There is currently no official Service policy for the protection of hybrids under the Act, and the protection of hybrid progeny of endangered or threatened species is evaluated as necessary. For example, the protection of hybrids to facilitate law enforcement is recognized as appropriate under the Act (§4(3)) in cases where they are sympatric with pure species and morphologically difficult to distinguish. The duration and significance of hybridization between PS and SS is currently unknown, and it is not possible to visually distinguish pure PS from introgressed PS; therefore, for the purposes of management and consultation, we are considering all phenotypic PS as protected under the Act.

The PS can grow to lengths of over 6 feet (ft) (1.8 meters [m]) and weights in excess of 80 pounds (lbs) (36 kilograms [kg]) in the upper Missouri River portion of its range. In the Mississippi River, specimens seldom exceed 3 ft (1 m) in length, or 20 lbs (9 kg) in weight. PS have a flattened, shovel-shaped snout, a long, slender, and completely armored caudal peduncle, and lack a spiracle (Smith 1979). As with other sturgeon, the mouth is toothless, protrusible, and ventrally positioned under the snout. The skeletal structure is primarily cartilaginous (Gilbraith et al. 1988). PS are similar in appearance to the more common and darker SS, and may be visually distinguished by the proportional lengths of inner and outer barbels, mouth width, proportion of head width to head length, proportion of head length to body length, and other characteristics. As noted above, morphological PS require genetic analysis to determine hybridization.

3.2. Life History

Habitat

PS habitats can generally be described as large, free-flowing, warm water, turbid river habitats with a diverse assemblage of physical attributes that are in a constant state of change (Service 1993, 2014). Floodplains, backwaters, chutes, sloughs, islands, sandbars and main channel waters form the large river ecosystem that provide the macrohabitat requirements for all life stages of PS. Throughout its range, PS tend to select main channel habitats (Bramblett 1996; Sheehan et al. 1998; Service 2014a; Schramm et al. 2017); in the Lower Mississippi River (LMR), they have been found in a variety of main channel habitats, including natural and engineered habitats (Herrala et al. 2014).

PS are thought to occupy the sandy main channel in the Mississippi, Missouri, and Yellowstone rivers most commonly, but also are collected over gravel substrates (Service 2014a; Bramblett and White 200l; Hurley et al. 2004; Garvey et al. 2009; Koch et al. 2012). Several studies have documented PS near islands and dikes, and these habitats are thought to provide a break in water velocity and an increased area of depositional substrates for foraging (Garvey et al. 2009; Koch et al. 2012). Increased use of side channel and main channel islands has been noted in spring, and it is hypothesized that these habitats may be used as refugia during periods of increased flow (Garvey et al. 2009; Koch et al. 2012; Herrala et al. 2014). Recent telemetry monitoring of adult PS in the LMR indicates use of most channel habitats, including dikes, revetment, islands, secondary channels, etc. (Kroboth et al. 2013; Herrala et al. 2014). Islands and secondary channels are important in recruitment of larval sturgeon in the LMR (Hartfield et al. 2013).

PS occur within a variety of flow regimes (Garvey et al. 2009). In their upper range, adult PS are collected in depths that vary between 1.97-47.57 ft with bottom water velocities ranging from 2.20 ft/s and 2.62 ft/s (Service 2014a; Bramblett and White 2001; Gerrity 2005). PS in the LMR have been collected at depths greater than 65 ft with a mean value of 32.81 ft, and water velocities greater than 5.91 ft/s with a mean value of 2.30 ft/s (ERDC unpublished data; Herrala et al. 2014). Turbidity is thought to be an important factor in habitat selection by PS, which have a tendency to occupy more turbid habitats than SS (Blevins 2011). In the LMR, PS have been collected in turbidities up to 340 Nephelometric Turbidity Units (NTU's) with a mean value of 90 NTU's (ERDC unpublished data).

Much of the natural habitat throughout the range of PS has been altered by humans, and this is thought to have had a negative impact on this species (Service 2014a). Habitats were once very diverse, and provided a variety of substrates and flow conditions (Baker et al. 1991; Service 1993). Extensive modification of the Missouri and Mississippi rivers over the last 100 years has drastically changed the form and function of the river (Baker et al. 1991; Prato 2003). Today, habitats are reduced and fragmented and much of the Mississippi River basin has been channelized to aid in navigation and flood control (Baker et al. 1991). The extent of impacts from range-wide habitat alteration on the PS is unknown, but recent studies have shown that in the unimpounded reaches (i.e., LMR), suitable habitat is available and supports a diverse aquatic community (Service 2007).

Movement

Like other sturgeon, PS is a migratory fish species that moves upstream annually to spawn (Koch et al. 2012). Movements are thought to be triggered by increased water temperature and flow in spring months (Garvey et al. 2009; Blevins 2011). PS may remain sedentary, or remain in one area for much of the year, and then move either upstream or downstream during spring (Garvey et al. 2009; Herrala and Schramm 2017). It is possible that because movement in large, swift rivers requires a great amount of energy, this relatively inactive period may be a means to conserve energy (Garvey et al. 2009). Most active periods of movement in the upper Missouri River were between March 20 and June 20 (Bramblett and White 2001). In one study, individual fish traveled an average of 3.73 mi/day and one individual traveled over 9.94 mi/day (Garvey et al. 2009). PS in the Missouri River have been reported to travel up to 5.90 mi/hour and 13.30 mi/day during active periods (Bramblett and White 2001). Based on a surrogate study that documented recaptures of SS in the Missouri River originally tagged in the LMR, PS may similarly undertake long-distance, multi- year upstream movements. Upstream distances approaching 1,245 mi have been recorded (ERDC unpublished data) and similar distances have been recorded for downstream movements (Service unpublished data).

Aggregations of PS have been reported in several locations in the middle Mississippi River, particularly around gravel bars, including one annual aggregation at the Chain of Rocks Dam, which is thought to be related to spawning activities (Garvey et al. 2009). Aggregations of PS in the lower 8.70 mi of the Yellowstone River are also thought to be related to spawning activities of sturgeon from the Missouri River (Bramblett and White 2001). PS have been found to have active movement patterns during both the day and night, but they move mostly during the day (Bramblett and White 2001). There have been no verified spawning areas located in the LMR.

Feeding

Sturgeon are benthic feeders and are well adapted morphologically (ventral positioning of the mouth, laterally compressed body) for the benthic lifestyle (Service 1993; Findeis 1997). Adult PS are primarily piscivorous (but still consume invertebrates), and are thought to switch to piscivory around age 5 or 6 (Kallemeyn 1983; Carlson et al. 1985; Hoover et al. 2007; Grohs et al. 2009). In a study of PS in the middle and lower Mississippi River, fish were a common dietary component and were represented primarily by Cyprinidae, Sciaenidae, and Clupeidae (Hoover et al. 2007). Other important dietary items for PS in the Mississippi River were larval Hydropsychidae (lnsecta: Trichoptera), Ephemeridae (lnsecta: Ephemeroptera), and Chironomidae (lnsecta: Diptera) (Hoover et al. 2007). PS diet varies depending on season and location, and these differences probably are related to prey availability (Hoover et al. 2007). In a Mississippi River dietary study, Trichoptera and Ephemeroptera were consumed in greater quantities in winter months in the lower Mississippi River, while the opposite trend was observed in the middle Mississippi River (Hoover et al. 2007). Hoover et al. (2007) also found that in both the middle Mississippi River and the lower Mississippi River, dietary richness is greatest in winter months.

3.3. Numbers, Reproduction, and Distribution

Spawning

Freshwater sturgeon travel upstream to spawn between the spring equinox and summer solstice, and it is possible that either a second or an extended spawning period may occur in the fall in southern portions of the range (i.e., Mississippi River) (Service 2007; Wildhaber et al. 2007; Schramm et al. 2017). These spawning migrations are thought to be triggered by several cues, including water temperature, water velocity, photoperiod, presence of a mate, and prey availability (Keenlyne 1997; DeLonay et al. 2007; DeLonay et al. 2009; Blevins 2011). Gamete development is completed during the upstream migration and sturgeon are thought to spawn near the apex of their migration (Bemis and Kynard 1997). Data suggests that female *Scaphirhynchus* spp. do not reach sexual maturity until ages 6-17 and spawn every 2-3 years, and that males do not reach sexual maturity until ages 4-9 (Keenlyne and Jenkins 1993; Colombo et al. 2007; Stahl 2008; Divers et al. 2009). PS and SS at lower latitudes (e.g., lower Mississippi River) may begin spawning at an earlier age than those in upper portions of the range (e.g., Upper and Middle Mississippi and Missouri Rivers) because they are thought to have shorter lifespans and smaller sizes (George et al. 2012). Also, LMR PS may be more highly fecund than those in northern portions of their range (George et al.2012). It is thought that PS, like SS spawn over gravel substrates, but spawning has never been observed in this species (Service 1993; DeLonay et al. 2007; DeLonay et al. 2009).

Rearing

PS hatch when they reach a total length (TL) of approximately ¼-inch. Larvae feed on yolk reserves and drift downstream for l l-17 days, until yolk reserves are depleted (Snyder 2002; Braaten et al. 2008; DeLonay et al. 2009). Length of drift and rate of yolk depletion are dependent on several factors, including water temperature, photoperiod, and water velocity (Snyder 2002; DeLonay et al. 2009). Larval drift is not completely understood and the impacts of artificial structures, as well as the role of eddies, are unknown (Kynard et al. 2007; Braaten et al. 2008). During drift, sturgeon repeat a "swim up and drift" pattern, in which they swim up in the water column from the bottom (<10 in) and then drift downstream (Kynard et al. 2002; Kynard et al. 2007). A hatchery series of SS from the Natchitoches National Fish Hatchery (NNFH) in Louisiana (J. Dean, unpublished data) reports complete yolk sac absorption at days 8-9 post-hatch, which is several days sooner than SS from Gavins Point National Fish Hatchery in South Dakota, so there could be a latitudinal difference in yolk absorption and larval maturation rates throughout the range of PS (Snyder 2002). The timing of exogenous feeding, which begins when yolk reserves are depleted and drifting has ceased, can differ latitudinally (DeLonay et al. 2009). The switch from endogenous to exogenous feeding is known as the “critical period", because mortality is likely if sturgeon do not find adequate food (Kynard et al. 2002; DeLonay et al. 2009). PS begin exogenous feeding around 11-12 days post-hatch in upper portions of their range, but exogenous feeding was observed in fish as small as 17.82mm TL in the lower Mississippi River (Harrison et al., unpublished data), which could be as young as 6-8 days (based on unpublished age and growth data from NNFH) post-hatch (Braaten et al. 2007). The diets of young of year and juvenile PS and SS in upper portions of their ranges are much like those of the adult SS, and are primarily composed of aquatic insects and other benthic macroinvertebrates

(Braaten et al. 2007; Wanner et al. 2007; Grohs et al. 2009; Klumb et al. 2009). Young of year and juvenile PS in the LMR feed primarily on Chironomidae over sand in channel habitats (Harrison et al. 2012, unpublished data). Juvenile PS are thought to switch to piscivory around ages 5-6 (Kallemeyn 1983; Carlson et al. 1985; Hoover et al. 2007; Grohs et al. 2009).

Kynard et al. (2002) found larval PS to be photopositive and showed little preference to substrate color, except for a slight preference for light substrates when exogenous feeding began. It is thought that PS become increasingly photonegative starting around day 11 post-hatch (Kynard et al. 2002). In this same study, larval sturgeon swam in open habitats, seeking no cover under rocks in the swimming tube, and aggregated in small groups around days 3-5 post-hatch (Kynard et al. 2002). The black tail phenotype of these young sturgeon is thought to aid in recognition and aggregation (Kynard et al. 2002). PS have been observed swimming and drifting at a wide range (2-118 in) above the bottom depending on water velocities (although most fish are thought to stay in the lower 20 in of the water column), and drift velocities are thought to range from 0.98-2.29 ft/s (Kynard et al. 2002; Kynard et al. 2007; Braaten et al. 2008). Drift distance of larval sturgeon is thought to be between 85.75-329.33 mi (Kynard et al. 2007; Braaten et al. 2008). Juvenile PS have been found in water depths ranging from an average of 7.58-8.14 ft in the upper Missouri River (Gerrity 2005). Maximum critical swimming speeds for juvenile PS range from 0.32 ft/s to 0.82 ft/s, depending on size, with larger juveniles (6-8 in TL) able to withstand higher water velocities than their smaller counterparts (5-6 in TL) (Adams et al. 1999). In the Lower Mississippi River, larval sturgeon collections are associated with flooded sand bars in secondary channels and sand/gravel reefs in the main channel (Hartfield et al. 2013; Schramm et al 2017).

Distribution and Abundance

PS occur in parts of the Mississippi River Basin, including the Mississippi River below the confluence of the Missouri River, and its distributary, the Atchafalaya River; and the Missouri River and its tributaries the Yellowstone and Platte Rivers (Kallemeyn 1983; Killgore et al. 2007). Recovery efforts have divided the extensive range of PS into four management units (Service 2013b) based on population variation (i.e., morphological, genetic) and habitat differences (i.e., physiographic regions, impounded, unimpounded reaches) throughout the extensive range of the PS (Service 2013b). These are:

> *Great Plains Management Unit (GPMU)*: The GPMU extends from Great Falls of the Missouri River, Montana, to Fort Randall Dam, South Dakota, and includes the Yellowstone, Marias, and Milk Rivers.
>
> *Central Lowlands Management Unit (CLMU)*: The CLMU includes the Missouri River from Fort Randall Dam, South Dakota, to the confluence of the Grand River, Missouri, and includes the lower Platte and lower Kansas Rivers.
>
> *Interior Highlands Management Unit (IHMU)*: The IHMU includes the Missouri River from the confluence of the Grand River, Missouri, to the confluence of the Mississippi River, Missouri, and the Mississippi River from Keokuk, Iowa, to the confluence of the Ohio River, Illinois.

Coastal Plain Management Unit (CPMU): The CPMU includes the LMR from the confluence of the Ohio River, Illinois, to the Gulf of Mexico, Louisiana (the action area of this consultation), and the Atchafalaya River distributary system, Louisiana.

To date, >1,100 PS have been captured in the CPMU since listing (>500 PS from the LMR, and >600 from the Atchafalaya River) (Killgore et al. 2007; Service database 2018), exceeding capture numbers from all other management units combined. Pallid to shovelnose ratios range between 1:6 to l:3 in the LMR, depending upon river reach, and 1:6 in the Atchafalaya River (Killgore et al. 2007; Service 2007). The ratio of pallid to shovelnose sturgeon in the lower Mississippi River reach where the BCS is located is typically 1:3 (ERDC 2013). Age-0 PS have been captured in both the LMR and the Atchafalaya, although it is unclear exactly where and when spawning occurs (ERDC, unpublished data; Hartfield et al. 2013). Age-0 and immature PS are difficult to distinguish from SS (Hartfield et al. 2013); however, capture data indicates annual recruitment of immature PS since 1991 (Service database 2013). The occurrence of *Scaphirhynchus* was extended from River Mile 85 downstream 50 miles to River Mile 33, when ERDC collected two young-of-year *Scaphirhynchus* sturgeon with a trawl in the lower Mississippi River in November of 2016 (USACE 2017).

3.4. Conservation Needs and Threats

Much of the following information is taken from Service documents (Service 2000, 2007, 2014b, 2018). The PS was listed due to the apparent lack of recruitment for over 15 years, and the habitat threats existing at the time of listing. Destruction and alteration of habitats by human modification of the river system is believed to be the primary cause of declines in reproduction, growth, and survival of the PS. The historic range of PS as described by Bailey and Cross (1954) encompassed the middle and lower Mississippi River, the Missouri River, and the lower reaches of the Platte, Kansas, and Yellowstone Rivers. Bailey and Cross (1954) noted a PS was captured at Keokuk, Iowa, at the Iowa and Missouri state border. Duffy et al. (1996) stated that the historic range of PS once included the Mississippi River upstream to Keokuk , Iowa, before that reach of the river was converted into a series of locks and dams for commercial navigation (Coker 1930).

Habitat destruction/modification and the curtailment of range were primarily attributed to the construction and operation of dams on the upper Missouri River and modification of riverine habitat by channelization of the lower main stems of the Missouri and Mississippi Rivers. Dams substantially fragmented PS range in the upper Missouri River. However, free-flowing riverine conditions currently exist throughout the lower 2,000 mi (3,218 km) (60 percent) of the PS historical range. Although the lower Missouri River continues to be impacted by regulated flows and modified habitats, actions have been developed and are being implemented to address habitat issues. Recent studies and data from the Mississippi River suggests that riverine habitats are less degraded than previously believed, and that they continue to support diverse and productive aquatic communities, including PS. Although there are ongoing programs to protect and improve habitat conditions in the four management units, positive effects from these programs on PS have not been quantified.

Carlson and Pflieger (1981) stated that PS are rare but widely distributed in both the Missouri River and in the Mississippi River downstream from the mouth of the Missouri River. A comparison of PS and SS catch records provides an indication of the rarity of PS. At the time of their original description, PS composed 1 in 500 river sturgeon captured in the Mississippi River at Grafton, Illinois (Forbes and Richardson 1905). PS were more abundant in the lower Missouri River near West Alton, Missouri, representing one-fifth of the river sturgeon captured (Forbes and Richardson 1905). Carlson et al. (1985) captured 4,355 river sturgeon in 12 sampling stations on the Missouri and Mississippi Rivers. Field identification revealed 11 (0.25 percent) PS. Grady et al. (2001) collected 4,435 river sturgeon in the lower 850 mi (1,367 km) of the Missouri River and 100 mi (161 km) of the middle Mississippi River from November 1997 to April 2000. Field identification revealed nine wild (0.20 percent) and nine hatchery-origin PS.

Today, PS, although variable in abundance, are ubiquitous throughout most of the free-flowing Mississippi River. When the PS was listed as endangered they were only occasionally found in the following areas; from the Missouri River: 1) between the Marias River and Fort Peck Reservoir in Montana; 2) between Fort Peck Dam and Lake Sakakawea (near Williston, North Dakota); 3) within the lower 70 mi (113 km) of the Yellowstone River downstream of Fallon, Montana; 4) in the headwaters of Lake Sharpe in South Dakota; 5) near the mouth of the Platte River near Plattsmouth, Nebraska; and, 6) below River Mile 218 to the mouth in the State of Missouri.

Keenlyne (1989) updated previously published and unpublished information on distribution and abundance of PS. He reported pre-1980 catch records for the Mississippi River from its mouth upstream to its confluence with the Missouri River, a length of 1,153 mi (1,857 km); in the lower 35 mi (56 km) of the Yazoo/Big Sunflower and St. Francis Rivers (tributaries to the Mississippi); in the Missouri River from its mouth to Fort Benton, Montana, a length of 2,063 mi (3,323 km); and, in the lower 40 mi (64 km) of the Kansas River, the lower 21 mi (34 km) of the Platte River, and the lower 200 mi (322 km) of the Yellowstone River (tributaries to the Missouri River). The total range is approximately 3,500 mi (5,635 km) of river.

Currently, the Missouri River (1,154 mi) (1,857 km) has been modified significantly with approximately 36 percent of the riverine habitat inundated by reservoirs, 40 percent channelized, and the remaining 24 percent altered due to dam operations (Service 1993). Most of the major tributaries of the Missouri and Mississippi Rivers have also been altered to various degrees by dams, water depletions, channelization, and riparian corridor modifications.

The middle Mississippi River, from the mouth of the Missouri River to the mouth of the Ohio River, is principally channelized with few remaining secondary channels, sand bars, islands and abandoned channels. The middle Mississippi River has been extensively diked; navigation channels and flood control levees have reduced the size of the floodplain by 39 percent.

Levee construction along the lower Mississippi River, from the Ohio River to the Gulf, has eliminated major natural floodways and reduced the land area of the floodplain by more than 90 percent (Fremling et al. 1989). Fremling et al. (1989) also report that levee construction isolated many floodplain lakes and raised river banks. As a result of levee construction, 15 meander loops were severed between 1933 and 1942.

Destruction and alteration of big-river ecological functions and habitats once provided by the Missouri and Mississippi Rivers were believed to be the primary cause of declines in reproduction, growth, and survival of PS (Service 2014a). The physical and chemical elements of channel morphology, flow regime, water temperature, sediment transport, turbidity, and nutrient inputs once functioned within the big-river ecosystem to provide habitat for PS and other native species. On the main stem of the Missouri River today, approximately 36 percent of riverine habitat within the PS range has been transformed from river to lake by construction of six massive earthen dams by the USACE between 1926 and 1952 (Service 1993). Another 40 percent of the river downstream of the dams has been channelized. The remaining 24 percent of river habitat has been altered by changes in water temperature and flow caused by dam operations.

The channelized reach of the Missouri River downstream of Ponca, Nebraska, once a diverse assemblage of braided channels, sandbars, and backwaters, is now confined within a narrow channel of rather uniform width and swift current. Morris et al. (1968) found that channelization of the Missouri River reduced the surface area by approximately 67 percent. Funk and Robinson (1974) calculated that, following channelization, the length of the Missouri River between Rulo, Nebraska, and its mouth (~500 river miles) (310 km) had been reduced by 8 percent, and the water surface area had been reduced by 50 percent.

Missouri River aquatic habitat between and downstream of main stem dams has been altered by reductions in sediment and organic matter transport/deposition, flow modification, hypolimnetic releases, and narrowing of the river through channel degradation. Those activities have adversely impacted the natural river dynamics by reducing the diversity of bottom contours and substrates, slowing accumulation of organic matter, reducing overbank flooding, changing seasonal patterns, severing flows to backwater areas, and reducing turbidity and water temperature (Hesse 1987). The Missouri River dams also are believed to have adversely affected PS by blocking migration routes and fragmenting habitats (Service 2014a).

The pattern of flow velocity, volume, and timing of the pre-development rivers provided the essential life requirements of native large-river fishes like the PS and paddlefish. Hesse and Mestl (1993) found a significant relationship between the density of paddlefish larvae and two indices (timing and volume) of discharge from Fort Randall Dam. They concluded that when dam operations caused discharge to fluctuate widely during spring spawning, the density of drifting larvae was lower, and when annual runoff volume was highest, paddlefish larval density was highest. Hesse and Mestl (1987) also modeled these same two indices of discharge from Fort Randall Dam with an index of year-class strength. They demonstrated significant negative relationships between artificial flow fluctuations in the spring and poor year-class development for several native and introduced fish species including river carpsucker, shorthead redhorse, channel catfish, flathead catfish, sauger, smallmouth buffalo, and bigmouth buffalo. The sample size of sturgeon was too small to model in that study; however, a clear relationship existed between poor year-class development in most native species studied and the artificial hydrograph.

Modde and Schmulbach (1973) found that during periods of low dam releases, the secondary subsidiary channels, which normally feed into the river channel, become exposed to the atmosphere and thus cease to contribute littoral benthic organisms into the drift. Schmulbach (1974) states that use of sandbar habitats were second only to cattail marsh habitats as nursery ground for immature fishes of many species.

Even though extensive flood control, water supply, and navigation projects constrict and control the Missouri and Mississippi Rivers with reservoirs, stabilized banks, jetties, dikes, levees, and revetments, relatively unaltered remnant reaches of the Missouri River and the Mississippi River from the Missouri River confluence to the Gulf of Mexico still provide habitat useable by PS. However, anthropogenic alterations (i.e., levee construction) effectively increased river stage and velocities at higher discharges by preventing overbank flows on the adjacent floodplains (Baker et al. 1991).

The upper ends of the reservoirs in the upper basin may be influencing the recruitment of larval sturgeon. Both SS and PS larvae have a propensity to drift after hatching (Kynard et al. 1998a, 1998b). Bramblett (1996) found that the PS may be spawning in the Yellowstone River between River Mile 9 and River Rile 20 upriver, and that from historic catch records, there is some evidence to indicate that the occurrence of PS catches coincide with the spring spawning at the mouth of the Tongue River (Service 2000). SS have been found to spawn in the tributaries of the Yellowstone River as well as such areas as the Marias, Teton, Powder and Tongue Rivers (Service 2000). SS are successfully recruiting and reproducing in the river stretches in the upper basin and this may be directly related to the amount of larval and juvenile habitat they have available downstream of the spawning sites.

Early indications in culturing PS indicate that sturgeon larvae will not survive in a silty substrate. In 1998, most of the larval sturgeon held in tanks at Gavins Point NFH, experienced high mortality when the water supply contained a large amount of silt which settled on the bottom of the tanks. Migration routes to spawning sites on the lower Yellowstone River have been fragmented by low-head dams used for water supply intakes. Such habitat fragmentation has forced PS to spawn closer to reservoir habitats and reduced the distance larval sturgeon can drift after hatching.

Historically, pallid, shovelnose, and lake sturgeon were commercially harvested in all States on the Missouri and Mississippi Rivers (Helms 1974). The larger lake and PS were sought for their eggs which were sold as caviar, whereas SS were historically destroyed as bycatch. Commercial harvest of all sturgeon has declined substantially since record-keeping began in the late 1800s. Most commercial catch records for sturgeon have not differentiated between species and combined harvests as high as 430,889 lb (195,450 kg) were recorded in the Mississippi River in the early 1890s, but had declined to less than 20,061 lb (9,100 kg) by 1950 (Carlander 1954). Lower harvests reflected a decline in SS abundance since the early 1900s (Pflieger 1975). Today, commercial harvest of SS is still allowed in 5 of the 13 states where PS occur.

Mortality of PS occurs as a result of illegal and incidental harvest from both sport and commercial fishing activities (Service 2000). Sturgeon species, in general, are highly vulnerable to impacts from fishing mortality due to unusual combinations of morphology, habits, and life history characteristics (Boreman 1997). In 1990, the head of a PS was found at a sport-fish cleaning station in South Dakota, and in 1992 a PS was found dead in a commercial fisherman's hoop net in Louisiana. In 1997, four PS were found in an Illinois fish market (Sheehan et al. 1997). It is probable that PS are affected by the illegal take of eggs for the caviar market. In 1999, a PS that was part of a movement and habitat study on the lower Platte River was harvested by a recreational angler (Service 2000). Bettoli et al. (2008) found 1.8 percent of the total sturgeon catch in Tennessee caviar harvest were composed of PS. In addition, such illegal and incidental harvest may skew PS sex ratios such that hybridization with shovelnose is exacerbated. Killgore et al. (2007) indicated that higher mortality rates for PS in the Middle Mississippi River may be a result of habitat limitation and incidental take by the commercial shovelnose fishery.

Currently, only a sport and/or aboriginal fishery exist for lake sturgeon, due to such low population levels (Todd 1998). SS are commercially harvested in eight states and a sport fishing season exists in a number of states (Mosher 1998). Although information on the commercial harvest of SS is limited, Illinois reported the commercial harvest of SS was 43,406 lbs (19,689 kg) of flesh and 233 lbs (106 kg) of eggs in 1997 and Missouri reported a 52-year mean annual harvest of 8,157 lbs (3,700 kg) of flesh (Todd 1998) and an unknown quantity of eggs for 1998. Missouri also has a sport fishery for SS but has limited data on the quantities harvested (Mosher 1998).

The previous lack of genetic information on the PS and SS led to a hybridization debate. In recent years, however, several studies have increased our knowledge of the genetic, morphological, and habitat differences of those two species. Campton et al. (1995) collected data that support the hypothesis that PS and SS are reproductively isolated in less-altered habitats, such as the upper Missouri River. Campton et al. (2000) suggested that natural hybridization, backcrossing, and genetic introgression between PS and SS may be reducing the genetic divergence between those species. Sheehan has identified 86 separate loci for microsatellite analysis that are being used to differentiate between PS, SS, and suspected hybrid sturgeon (Service 2000).

Bramblett (1996) found substantial differences in habitat use and movements between adult PS and SS in less altered habitats. Presumably, the loss of habitat diversity caused by human-induced environmental changes inhibits naturally occurring reproductive isolating mechanisms. Campton et al. (1995) and Sheehan et al. (1997) note that hybridization suggests that similar areas are currently being used by both species for spawning.

Carlson et al. (1985) studied morphological characteristics of 4,332 sturgeon from the Missouri and middle Mississippi Rivers. Of that group, they identified 11 PS and 12 PS /SS hybrids. Suspected hybrids have recently been observed in commercial fish catches on the lower Missouri and the middle and lower Mississippi Rivers (Service 2000). Bailey and Cross (1954) did not report hybrids, which may indicate that hybridization is a recent phenomenon resulting from environmental changes caused by human-induced reductions in habitat diversity and measurable changes in environmental variables such as turbidity, flow regimes, and substrate types (Carlson et al. 1985). A study by Keenlyne et al. (1994) concluded that hybridization may be occurring in half the river reaches within the range of PS and that hybrids may represent a high proportion of remaining sturgeon stocks. Hartfield and Kuhajda (2009) stated that hybridization rates in the Mississippi River have been overestimated, and there is no direct evidence linking the morphological or genetic variation defined as hybridization between PS and SS in the lower Missouri, Mississippi, or Atchafalaya Rivers with recent anthropogenic activities. Hybridization could present a threat to the survival of PS through genetic swamping if the hybrids are fertile, and through competition for limited habitat (Carlson et al. 1985). Keenlyne et al. (1994) noted few hybrids showing intermediacy in all characteristics as would be expected in a first generation cross, indicating the hybrids are fertile and reproducing.

Hubbs (1955) indicated that the frequency of natural hybridization in fish was a function of the environment, and the seriousness of the consequences of hybridization depends on hybrid viability. Hybridization can occur in fish if spawning habitat is limited, if many individuals of one potential parent species lives in proximity to a limited number of the other parent species, if spawning habitat is modified and rendered intermediate, if spawning seasons overlap, or where movement to reach suitable spawning habitat is limited (Hubbs 1955). Any of those conditions, or a combination of them, could be causing the apparent breakdown of isolating mechanisms that prevented hybridization between these species in the past (Keenlyne et al. 1994). Hartfield and Kuhajada (2009) examined three of the five original specimens used to describe the PS and found that the character indices currently used to distinguish the fish identify some of the type specimens as hybrids. In conclusion, they stated they found no evidence directly linking habitat modification and hybridization particularly in the Mississippi River and no evidence that hybridization constitutes an anthropogenic threat to the PS.

More recent studies have documented extensive hybridization between PS and SS in the Lower Mississippi River (Coastal Plain Management Unit) (Jordan et al. 2019). These studies also confirmed that small numbers of genetically pure PS continue to occupy the Lower Mississippi River; however, genetic analysis is required for their accurate identification. Please refer to Section 3.1 Species Description for an explanation of why we consider all phenotypic PS as protected under the Act for the purposes of management and consultation.

Although more information is needed, pollution is also likely an exacerbating threat to the species over much of its range. Pollution of the Missouri River by organic wastes from towns, packing houses, and stockyards was evident by the early 1900s and continued to increase as populations grew and additional industries were established along the river. Due to the presence of a variety of pollutants, numerous fish-harvest and consumption advisories have been issued over the last decade or two from Kansas City, Missouri, to the mouth of the Mississippi River. That distance represents about 45 percent of the PS total range. Currently there are no advisories listed by the U.S. Environmental Protection Agency (EPA) south of Tennessee (approximately 710 miles).

Polychlorinated biphenyls (PCBs), cadmium, mercury, and selenium have been detected at elevated, but far below lethal, concentrations in tissue of three PS collected from the Missouri River in North Dakota and Nebraska. Detectable concentrations of chlordane, dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyltrichloroethane (DDT), and dieldrin also were found (Ruelle and Keenlyne 1994). The prolonged egg maturation cycle of PS, combined with bioaccumulation of certain contaminants in eggs, could make contaminants a likely agent adversely affecting eggs and embryos, as well as development or survival of fry, thereby reducing reproductive success.

In examining the similarities and differences between SS and PS, Ruelle and Keenlyne (1994) concluded that, while the SS may not meet all the traits desired for a surrogate, it may be the best available for contaminant studies. Conzelmann et al. (1997) reported that trace element concentrations in Old River Control Complex (ORCC) SS in Louisiana were generally higher than in SS from other areas. Certain trace elements can adversely affect reproduction, development, and may ultimately be lethal if concentrations are excessive. Most trace element levels were unremarkable; however, cadmium, copper, lead, and selenium concentrations were elevated in ORCC samples and may warrant concern (Conzelmann et al. 1997).

Conzelmann et al. (1997) also reported that organochlorine (OC) pesticide concentrations are the main environmental concern in Louisiana's SS, and consequently, in the PS. SS OC concentrations were generally greater than were observed in fishes from other areas, and ORCC SS toxaphene levels were elevated compared to the National Contaminants Biomonitoring Program. Toxaphene possesses known carcinogenic, teratogenic, xenotoxic, and mutagenic properties; can cause suppression of the immune system; and may function as an endocrine system imitator, blocker, or disrupter (Colburn and Clements 1992). Those factors make toxaphene the greatest OC concern in ORCC SS and, by extension, the ORCC PS (Conzelmann et al. 1997). Further investigations are needed to identify contaminant sources in the Mississippi and Atchafalaya Rivers and to assess the role, if any, of contaminants in the decline of PS populations.

Another issue that is negatively impacting PS throughout its range is entrainment. The loss of PS associated with water intake structures has not been accurately quantified. The EPA published final regulations on Cooling Water Intake Structures for Existing Facilities per requirements of Section 316(b) of the Clean Water Act. The rule making was divided into three phases. However, only Phase I and II appear applicable to inland facilities; Phase III applies to coastal and offshore cooling intake structures associated with coastal and offshore oil and gas extraction facilities. The following rule summaries are based on information found at https://www.epa.gov/cooling-water-intakes. Phase I rules, completed in 2001, require permit holders to develop and implement techniques that will minimize impingement mortality and entrainment. Phase II, completed in 2004, covers existing power generation facilities that are designed to withdraw 50 million gallons per day or more with 25 percent of that water used for cooling purposes only. Phase II and the existing facility portion of Phase III were remanded to EPA for reconsideration and a final rule combined the remands into one rule in 2014. This rule, implemented through National Pollutant Discharge Elimination System permits, is intended to minimize negative effects associated with water cooling structures.

Section 316(b) of the Clean Water Act requires the EPA to insure that aquatic organisms are protected from impingement or entrainment. As part of the Phase II ruling, some power plants have begun conducting required entrainment studies. Preliminary data on the Missouri River suggests that entrainment may be a serious threat that warrants more investigation. Initial results from work conducted by Mid-America at their Neal Smith power facilities found hatchery-reared PS were being entrained (Jordan in litt. 2006; Ledwin in litt. 2006; Williams in litt. 2006). Over a 5-month period, four known hatchery-reared PS have been entrained, of which two were released alive and two were found dead. Ongoing entrainment studies required by the Clean Water Act will provide more data on the effects of entrainment. However, addressing entrainment issues may not occur immediately and continued take of hatchery-reared or wild PS will limit the effectiveness of recovery efforts. In addition to cooling intake structures for power facilities, concerns have been raised regarding entrainment associated with dredge operations and irrigation diversions. Currently little data are available regarding the effects of dredge operations. However, the USACE St. Louis District, and the Dredging Operations and Environmental Research Program have initiated work to assess dredge entrainment of fish species and the potential effects that these operations may have on larval and juvenile *Scaphirhynchus*. Data for escape speed, station-holding ability, rheotaxis and response to noise, and dredge flow fields are being used to develop a risk assessment model for entrainment of sturgeon by dredges. Entrainment has been documented in the irrigation canal supplied by the Intake Dam on the Yellowstone River (Jaeger et al. 2004). Given that entrainment has been documented to occur in the few instances it has been studied, further evaluation of entrainment at other water withdrawal points is warranted across the PS range to adequately evaluate this threat. Entrainment of PS stocked in the Mississippi River into the Atchafalaya River via the ORCC has been documented by the capture of a tagged stocked sturgeon that was released into the Mississippi River.

BOs which allow the take of PS also represent a factor that should be considered when examining factors that could have an influence on the PS population. The table below (Table 1) presents all completed BOs for the LMR.

Table 1. BOs conducted for actions occurring on the Lower Mississippi River that impacted PS. Critical habitat is not designated for this species; thus, none is included here.

Opinions (year)	Action Affecting PS	Authorized Take	Take Reported
2003	BO addressing the Natchitoches National Fish Hatchery's Collection of Endangered Pallid Sturgeon from Louisiana Waters for Propagation and Research	90 adults/season for 5 season (harassment) 8 adults/season for 5 seasons (death)	23 harassment (2003)
2004	Modification to revise 2003 IT estimates for BO (4-7-3-702) on Natchitoches National Fish Hatchery's Activities	120 adults/season for 5 (harassment) 14 adults/season for (death) potential	329 (Atchafalaya) harassment (through 2010) 7 dead (2004)
2004	Programmatic BO addressing the effects of the Southeast region's Section 10(a)(1)(A) Permitting on the pallid sturgeon (5-years)	28 adults in captive propagation/year (death) 2,500 to 15,000 captive year-class 90 days old or older (one-time loss-death) 200 larval/juvenile/year sampling (death) 3, 5-inch or greater fish/year netting (death or injury) 3 fish/year external tagging (death or injury) 1 fish/year transport (death) 5 fish/year radio-tracking (death or injury)	461 (LMR) harassment (through 2012) 1 dead (2006) 2 dead (2007) 1 dead (2009)
2005	Modification 2 – adding new forms of take to the 2004 revised Incidental Take Statement (4-7-04-734) for the 2003 BO (4-7-03-702) on Natchitoches National Fish Hatchery's Activities	14 wild pallid sturgeon/season (death) 15,000 hatchery-reared pallid sturgeon/season (death)	NA
2009	BO addressing the 2008 Emergency Opening of Bonnet Carré Spillway, USACE	14 adults (harassment) 92 adults (death)	14 adult harassment Unknown deaths
2010	BO addressing the Medium White Ditch Diversion	23 adults/year (death) potential	0
2010	BO addressing the small diversion at Convent/Blind River	7 adults/year (death) potential	0
2010	BO addressing the Taxonomic ID study	100 adults (death)	76
2013	Modification of the Programmatic BO	21 adults/year(death) potential	0
2013	BO addressing the USACE CIP	Unspecified	0
2014	BO addressing the USACE Permits for Sand and Gravel Mining in the Lower Mississippi River	Unspecified	NA
2018	BO addressing the Bonnet Carré Spillway 2011 and 2016 Emergency Operations	2011 – 20 adults (harassment) 82 adults (death) 2016 – 26 adults (death)	2011 – 20 adults Unknown deaths 2016 – N/A Unknown deaths
2020	BO addressing the Bonnet Carré Spillway 2018 Emergency Operation	14 adults (death) 2 adults (harassment)	4 adults – 2 harassment, 2 dead
Total[1]		142 adults/yr (harassment) 314 adults (death) 14-28/year (potential death) 200 larval fish/year (potential death) 2,500-15,000 year-class 90 days old or older (one-time loss-death)	849 adult harassment 89 adult known dead Unknown <200/year larvae collected

[1] The original estimates for the 2003 BO are not included as they were revised in 2004.

[2] Hatchery propagation was terminated in Region 4 in 2005.

4. ENVIRONMENTAL BASELINE

This section is an analysis of the effects of past and ongoing human and natural factors leading to the current status of the PS, its habitat, and ecosystem within the Action Area. The environmental baseline is a "snapshot" of the species' health in the Action Area at the time of the consultation and does not include the effects of the Action under review.

4.1. Action Area Numbers, Reproduction, and Distribution

The action under consultation occurred within the LMR area of the Coastal Plains Management Area. The status of the PS within the action area is discussed within the STATUS OF THE SPECIES/CRITICAL HABITAT section above.

4.2. Action Area Conservation Needs and Threats

The action area conservation needs and threats would be among those previously discussed under STATUS OF THE SPECIES/CRITICAL HABITAT, but would include only those pertaining to the southern-portion (LMR) of the species' range as previously described.

5. EFFECTS OF THE ACTION

This section analyzes the direct and indirect effects of the Action on the PS and the one captured GS, which includes the direct and indirect effects of interrelated and interdependent actions. Direct effects are caused by the Action and occur at the same time and place. Indirect effects are caused by the Action, but are later in time and reasonably certain to occur. Our analyses are organized according to the description of the Action in section 2 of this BO.

5.1. Effects of 2019 Operations

The USACE operated the BCS, which is located on the left descending bank of the river at River Mile 128, for a total of 123 days (February 27, 2019 to April 11, 2019 and May 10, 2019 to July 27, 2019). Following the 2019 BCS second closure, the ERDC, the Louisiana Department of Wildlife and Fisheries (LDWF), and Bonnet Carré project staff sampled for approximately 3 weeks over a 10-day period in August 2019 and recovered 258 *Scaphirhynchus* (19 pallid and 239 shovelnose) sturgeon captured within the outfall of the BCS. One hundred and sixty (160) sturgeon were collected within the Stilling Basin in the spillway. Of those 160 sturgeon, seven were pallid sturgeon with one of the seven found dead. All live *Scaphirhynchus* sturgeon captured were returned to the Mississippi River. Additionally, one GS was captured, tagged, and relocated back into Lake Pontchartrain.

5.2. Summary of the Effects of the Action

GS are anadromous fish that are known to occur Lake Pontchartrain during winter months and migrate into river systems for spring and summer to spawn. Adult and sub-adult GS over-winter in estuarine habitat, such as Lake Pontchartrain, and marine habitat to feed and grow and migrate to freshwater habitats, such as tributaries of Lake Pontchartrain during spring and summer months. The first 2019 opening began at a time when GS would be over-wintering in Lake Pontchartrain while the second opening began around the timing of migration to freshwater systems of tributaries around the lake and the Pearl River. The BCS was open for a total of 123 days in 2019. In the past recovery efforts after the closing of the BCS in 2008, 2011, 2016, and 2018, no GS have been captured; therefore, it is believed to be an anomaly. The capture of the one GS after the 2019 closure could be contributed to the length of the opening as well as the timing of the second opening occurring during the time of year GS would be migrating and spending the warmer months in freshwater habitats. The GS that spend winters in Lake Pontchartrain either migrate to the Pearl River or up into the tributaries around the lake. The captured GS was tagged and then released into the Suction Canals draining into Lake Pontchartrain to rejoin the breeding population. The data that could come from tagging this GS could contribute vital migration and population information for the species. Because the capture of the one GS is believed to be an anomaly event, the Service anticipates only the one individual captured, tagged, and relocated was impacted by the 2019 opening.

PS were known to occur within this reach of the river prior to the BCS operations. Depths utilized by PS have been reported throughout its range; however, because of the varying total depth of the rivers throughout its range this information may have limited applicability to the LMR unless depth is expressed as a percent of the total river depth. Water depths in the Mississippi River at low water in front of the structure range from -2 to -119 feet North American Vertical Datum (NAVD); average minimum depth is -8.6 feet NAVD and average maximum depth is -86 NAVD feet (USACE 2004). The calculated percent of total river depth utilized by PS is approximately 70ft (Bramblett 1996 cited in Constant et al. 1997; Constant et al. 1997). Using that percentage compared to water depths during the diversion would indicate that PS should not be found on the batture in front of the structure during its operation. However, the usage of this habitat has never been quantified (incidental usage or actively used) or documented in literature. Incomplete knowledge of PS life history, especially in the LMR does not preclude high water usage of the batture as feeding habitat or velocity refugia.

The Pallid Sturgeon Lower Basin Recovery Workgroup has identified information gaps essential to the consultation and recovery processes in the Lower Mississippi River Basin. These include the following: relative abundance of PS, demographics, feeding habits, habitat use, hybridization ratios, presence of fish diseases in the wild, population anomalies, and reliable separation and identification of PS, SS, and hybrids. A more recent information gap identified by the Lower Basin Work Group is the entrainment of adult and juvenile PS through the ORCC and potential entrainment through the existing coastal wetland restoration diversions. The implications of the BCS operations on sturgeon populations within the LMR can be better understood due to the completion of the "Entrainment Studies of Pallid Sturgeon Associated with Water Diversions in the Lower Mississippi River" (ERDC 2013) although some data gaps remain. ERDC is currently conducting sturgeon entrainment studies at the ORCC, and has documented entrainment of sonic-tagged PS and SS. Therefore, the sturgeons' response to encountering the BCS flows (e.g., avoidance versus actively sought) is unknown. There are several hypotheses on possible sturgeon reactions to entrainment that must be considered to determine levels of take potential, as follows: (1) Only sturgeon located near the structure during its opening were entrained (i.e., no increase in sturgeon entrainment because of active avoidance); (2) sturgeon actively swam into the structure seeking velocity refuge from main-channel flows and/or seeking food sources on the batture and/or in a perceived secondary channel (i.e., the BCS); or, (3) sturgeon were entrained passively or actively during down-river migration. It is likely that the reaction to the BCS opening would vary with life stage of the sturgeon, and actual "take" may be due to a combination of any of the above hypotheses.

There are no known topographic or hydrographic features (apart from current) that would appear to attract the sturgeon to the vicinity of the BCS. ERDC (2013) postulated various methods to establish the number of sturgeon "taken" and tried to incorporate most probable factors involved in their analysis of potential entrainment of sturgeon. Factors considered in some of their methods included the loss of sturgeon into Lake Pontchartrain being either actively (swept out of the BCS) during the diversion and/or through emigration once flows were reduced during the structures closure and the volume and/or duration of the diversion.

The volume of water diverted through the BCS is primarily related to the river stage (a measurement of water volume in the river) at the structure and the number of bays that are opened. The 350 bays that comprise the structure are twenty-feet-wide and have two sill elevations of 16.8 ft National Geodetic Vertical Datum 1927 (NGVD) and 14.8 ft NGVD (2 feet difference). For the 2019 combined openings, the maximum number of bays opened during this diversion was 206 (Tables 2 and 3, Section 5.3). The combined 123-day period diverted the greatest amount of water during the opening with a maximum of 213,000 cfs, approximately 100,000 cfs less than the amount of the maximum discharge rate created by the 2011 operation (315,930 cfs) and with a difference of 17,000 cfs in the maximum discharge rate between the 2019 and 2018 operations. Although there is a decrease in magnitude of discharge through the BCS in 2019 from the 2011 operation, the recovery effort yielded a similar number of recovered sturgeon in 2011. PS, as well as other sturgeon species, are strongly rheotactic and will orient into the direction of water flow. Approximately five days after the 2019 BCS closing, the velocity in the canals below the structure dropped essentially to zero and the water levels dropped quickly throughout the spillway. Because of this, entrained sturgeon were less likely to move towards the base of the structure, unlike they did after the 2008 closure. The rapid drop in water levels hampered physical movement through and over road crossings that crisscross the spillway, thus, causing the sturgeon to become stranded in the stilling basin below the BCS structure or in the spillway lakes that become disconnected to the canals.

Effects of the action on larval, fry, and juvenile fish

No larval *Scaphirhynchus* were collected by LDWF or ERDC after the closure of the BCS; however, the collection of larval sturgeon within any habitat typically requires considerable efforts, which often only results in the capture of a few specimens (Quist 2004). The methods to collect larval and young-of-year (YOY) *Scaphirhynchus* have been refined during the past decade; therefore, the numbers of larval *Scaphirhynchus* collected within the Mississippi River have increased (Herzog et al. 2005; Hrabik et al. 2007; Phelps et al. 2010). In 1985, a SS larva was collected at White Castle (approximately 65 miles upstream; River Mile 193) (Constant et al. 1997). Larval SS have also been collected near Vicksburg, Mississippi, (River Mile 435) approximately 307 miles upstream of the BCS (Constant et al. 1997; Hartfield et al. 2013;

Schramm et al. 2017). Kynard et al. (2002) and Braaten et al. (2008) reported longer larval drift times; thus greater distances were traveled by PS larva when compared to SS larva. PS larvae were determined to travel at approximately the mean river velocity for the first 11 days after hatching and then slightly slower for the next 6 days because of the sturgeon's transition to a benthic life stage. Distances covered during larval drift are affected by water velocity; however, water temperature can affect larval/fry development rates (warmer temperatures increase development rates) which would also affect drift distances. Higher water velocities occur with larger flood events (USACE 2009). Water velocities in the Mississippi River south of Baton Rouge (River Mile 231) have been documented to range from 4.4 feet per second (fps) to 1.5 fps depending on the discharge. South of Baton Rouge the river channel is larger and the slope of the river decreases; thus, velocities are slower than those above Baton Rouge (Wells 1980). Surface water velocities measured north of Baton Rouge range from 2.9 fps to 5.6 fps for discharges of 200,000 cubic feet per second (cfs) to l million cfs, respectively. Three surface velocity cross-sections taken south of Baton Rouge at discharges of 350,000, 460,000, and 470,000 cfs never had velocities greater than 4 fps, but a surface velocity cross-section taken north of Baton Rouge measured velocities in excess of 5 fps for a discharge of 310,000 cfs (Wells 1980). The USACE has computed surface water velocities of the Mississippi River at New Orleans (River Mile 107; approximately 20 miles downstream). For the river stages when the BCS was operated in 2019, river velocities ranged from about 8.5 fps to slightly less than 10.3 fps. Velocities calculated for sixty percent of the river's depth ranged from 6.2 fps to under 7.3 fps. The opening and closing of the BCS occurred as the discharge below the ORCC reached 1.5 million cfs. The most southern PS spawning sites are unknown; however, potential gravel bar spawning sites occur at various locations between Baton Rouge, Louisiana, and Vicksburg, Mississippi, (River Mile 435) approximately 307 miles upstream of the BCS. If a mean water velocity of 5.9 fps (4 miles per hour) is assumed to have occurred from Vicksburg to the BCS, larvae could travel as much as 96 miles per day, barring entrainment into the eddies, the batture, and other areas.

One seven- and one nine-day post-hatch larval sturgeon were collected near Vicksburg, Mississippi, on May 20, which indicated that hatching occurred on the 13 and 11 of May, respectively. The previously mentioned larval sturgeon captured at White Castle was collected on May 15. Other larval sturgeon recently captured between Greenville and Vicksburg, Mississippi, (approximate Rivers Miles 540 and 440, respectively) would indicate hatching occurred in early to mid-May (Schramm et al. 2017). Although there could be limited spawning as early as late March, most spawning in the LMR occurs during late April through mid-May. Therefore, based on the Schramm et al. 2017 study, it is possible that the presence of larval sturgeon would not be expected the during the February 27, 2019 – April 11, 2019 operation; however, due to the timing of the second 2019 operation there is a possibility that larval sturgeon were present during that second operational period.

Effects of the action on sub-adult and adult

Hoover et al. (2005) examined swimming performance of juvenile PS (maximum size 6.3 inches) at different velocities. Minimum escape speeds for PS ranged from 1.6 to 1.7 fps and burst speeds were determined to range from 1.7 to 2.95 fps; however, because they frequently failed to exhibit rheotaxis, their ability to avoid entrainment based on swimming performance was determined to be relatively low. Overall, approximately 18 percent were not positively rheotatic; however, Adams et al. (1999) found only 7 percent were non-rheotatic. White and Mefford (2002) examined swimming behavior and performance of SS ranging from 25.2 to 31.5 inches in length. Their ability to navigate the length of the test flume was best (60 to 90 percent) over a smooth bottom followed by coarse sand, gravel, and then cobble, but the small sample size and large variability precluded this from being a definitive conclusion. The greatest success at negotiating the flume was determined to occur between the range of 2 and 4 fps; however, success at greater velocities (6 fps) did occur. Approximately 30 percent failed to exhibit rheotactic behavior at velocities below 1.6 fps. Conversely, Adams et al. (1997) found all adult shovelnose to be positively rheotactic. PS are believed to avoid areas that have very little or no water velocity (DeLonay and Little 2002, cited in Quist 2004; Erickson 1992 cited in Service, no date) and leave areas that no longer have flows (Backes et al. 1992; Constant et al. 1997).

The timing of PS movements and migration in the LMR may differ from that of other rivers and other portions of the Mississippi River (Constant et al. 1997). Migrations and movement in the Atchafalaya River was associated with water temperatures between 14º and 21º Celsius (C) (Constant et al. 1997) and spring and early summer seasons (Schramm and Dunn 2008). USACE's Biological Assessment stated that the mean water temperature of the Mississippi River during the 2019 opening was 30ºC, higher than the above range.

Because of the size of PS captured in the BCS in 2019, it is believed that the presence of the vertical wall would preclude any of them from returning to the river. The velocities within the BCS and the topography would provide sufficient areas where sturgeon could seek velocity refuge and remain in the BCS even until its closure. Downstream migrating sturgeon could swim into the lake, lose orientation to any flow fields and not return to the BCS. Information on PS preference for flows indicates that this number would be relatively small, but not discountable.

With assistance from ERDC, the Service utilized a hydrology based method to determine the number of sturgeon entrained during the 2008 opening of the BCS. The hydrology method is based upon a proposed relationship between the volume of water diverted and the number of sturgeon entrained. The hydrology methodology is similar to those recommended to determine entrainment by power plants (Goodyear 1977). However, methods proposed by Goodyear could not be used because of insufficient information for some model parameters. While the method below is similar to that used to determine take in the 2018 BO for the 2011 and 2016 BCS openings, using the data from the Davis Pond Outfall Canal, changes were made based on the re-examination of those entrainment calculations by Applied Biomathematics which resulted in a revised technique based on a mark-recapture method (Fiedenberg and Siegrist 2019). This revised technique uses the volume of water discharged per each entrained fish to calculate the possible maximum number of sub-adult and adult PS entrained. The methodology currently utilized represents the Service's best efforts to determine entrainment; however, the Service recognizes that as more information about PS life history, behavior, and abundance becomes available these methods may need to be revised or totally replaced.

The Service based the effects of the Action on sub-adult/adult PS using the following assumptions:

1) All fish entrained will not return to the river.
2) Adult PS and adult SS will be entrained at the same approximate ratio found in the Davis Pond Outfall Canal study.
3) With increases in the duration and volume of water diverted, additional fish will be entrained (i.e., the level of entrainment considered is directly proportional to the duration or volume of diverted water).
4) All tagged fish occurring near sampling efforts will have equal probability of being captured.
5) The percentage of tagged sturgeon captured of all tagged sturgeon available for capture in the Davis Pond Outfall Canal represents the effectiveness of sampling efforts (i.e., percent success) in determining the total number of sturgeon entrained.

The Service recognizes that the assumptions made may not be totally accurate for all sturgeon entrained but believes that this represents a scenario that is most likely to be the response of the majority of the sturgeon that will be entrained and, therefore, represents utilization of the best available information.

The Service calculated the maximum take of sub-adult/adult PS by finding the mean discharge for the operation (i.e., cfs) and converting the mean discharge to total volume of water discharged (i.e., cubic feet). To calculate the maximum number of PS entrained, the total volume of water discharged through the BCS during the operation was divided by the volumetric entrainment rate (i.e., cf) from Applied Biomathematics (Friedenberg and Siegrist 2019):

1.5577×10^{7} cfs $*(24*60*60) = 1.3459 \times 10^{12}$ cf (total volume of water discharged)

1.3459×10^{12} cf/ 1.6440×10^{10} cf = 81.9 fish for this operation (rounded to 82)

Based on the calculations above, the estimated maximum number of PS entrained through the BCS during the 2019 openings is 82.

5.3. Tables and Figures for Effects of the Action

Table 2. Bonnet Carré Sequence of First Operation in 2019 (USACE 2020).

Day	Date	Bays Opened	Total Opened	Discharge
1	Feb. 27	28	28	23,000 cfs
2	Feb. 28	20	48	37,000 cfs
3	Mar. 1	40	88	74,000 cfs
4	Mar. 2	20	108	91,000 cfs
5	Mar. 3	0	108	94,000 cfs
6	Mar. 4	40	148	138,000 cfs
7	Mar. 5	0	148	148,000 cfs
8	Mar. 6	0	148	148,000 cfs
9	Mar. 7	20	168	169,000 cfs
10	Mar. 8	20	188	187,000 cfs
11	Mar. 9	0	188	176,000 cfs
12	Mar. 10	10	198	197,000 cfs
13	Mar. 11	8	206	198,000 cfs
14	Mar. 12	0	206	196,000 cfs
15	Mar. 13	0	206	202,000 cfs
16	Mar. 14	0	206	207,000 cfs
17	Mar. 15	-10	196	207,000 cfs
18	Mar. 16	0	196	207,000 cfs
19	Mar. 17	0	196	199,000 cfs
20	Mar. 18	0	196	207,000 cfs
21	Mar. 19	0	196	213,000 cfs
22	Mar. 20	0	196	210,000 cfs
23	Mar. 21	0	196	196,000 cfs
24	Mar. 22	0	196	194,000 cfs
25	Mar. 23	0	196	184,000 cfs
26	Mar. 24	0	196	179,000 cfs
27	Mar. 25	0	196	177,000 cfs
28	Mar. 26	-20	176	158,000 cfs
29	Mar. 27	-24	152	135,000 cfs
30	Mar. 28	-17	135	131,000 cfs
31	Mar. 29	0	135	131,000 cfs
32	Mar. 30	0	135	135,000 cfs
33	Mar. 31	0	135	133,000 cfs
34	Arp. 1	0	135	135,000 cfs
35	Arp. 2	0	135	126,000 cfs
36	Apr. 3	0	135	114,000 cfs
37	Apr. 4	0	135	107,000 cfs
38	Apr. 5	0	135	105,000 cfs
39	Apr. 6	0	135	96,000 cfs
40	Apr. 7	0	135	85,000 cfs
41	Apr. 8	-36	99	66,000 cfs

Day	Date	Bays Opened	Total Opened	Discharge
42	Apr. 9	-47	52	38,000 cfs
43	Apr. 10	-34	18	11,000 cfs
44	Apr. 11	-18	0	0 cfs

Table 3. Bonnet Carré Sequence of Second Operation in 2019 (USACE 2020).

Day	Date	Bays Opened	Total Opened	Discharge
1	May 10	60	60	79,000 cfs
2	May 11	10	70	83,000 cfs
3	May 12	0	70	86,000 cfs
4	May 13	58	128	116,000 cfs
5	May 14	10	138	127,000 cfs
6	May 15	0	138	128,000 cfs
7	May 16	0	138	122,000 cfs
8	May 17	0	138	124,000 cfs
9	May 18	0	138	127,000 cfs
10	May 19	10	148	142,000 cfs
11	May 20	0	148	148,000 cfs
12	May 21	20	168	161,000 cfs
13	May 22	0	168	161,000 cfs
14	May 23	0	168	158,000 cfs
15	May 24	0	168	155,000 cfs
16	May 25	0	168	158,000 cfs
17	May 26	0	168	159,000 cfs
18	May 27	0	168	158,000 cfs
19	May 28	0	168	157,000 cfs
20	May 29	0	168	149,000 cfs
21	May 30	0	168	145,000 cfs
22	May 31	0	168	141,000 cfs
23	June 1	0	168	143,000 cfs
24	June 2	0	168	135,000 cfs
25	June 3	0	168	140,000 cfs
26	June 4	0	168	138,000 cfs
27	June 5	0	168	136,000 cfs
28	June 6	0	168	138,000 cfs
29	June 7	0	168	138,000 cfs
30	June 8	0	168	144,000 cfs
31	June 9	0	168	146,000 cfs
32	June 10	0	168	146,000 cfs
33	June 11	0	168	147,000 cfs
34	June 12	0	168	147,000 cfs
35	June 13	0	168	144,000 cfs
36	June 14	0	168	147,000 cfs
37	June 15	0	168	150,000 cfs
38	June 16	0	168	146,000 cfs

Day	Date	Bays Opened	Total Opened	Discharge
39	June 17	0	168	147,000 cfs
40	June 18	0	168	142,000 cfs
41	June 19	0	168	137,000 cfs
42	June 20	0	168	131,000 cfs
43	June 21	0	168	130,000 cfs
44	June 22	0	168	124,000 cfs
45	June 23	0	168	115,000 cfs
46	June 24	0	168	116,000 cfs
47	June 25	0	168	110,000 cfs
48	June 26	0	168	108,000 cfs
49	June 27	0	168	108,000 cfs
50	June 28	0	168	104,000 cfs
51	June 29	0	168	105,000 cfs
52	June 30	0	168	99,000 cfs
53	July 1	0	168	110,000 cfs
54	July 2	0	168	108,000 cfs
55	July 3	0	168	104,000 cfs
56	July 4	0	168	103,000 cfs
57	July 5	0	168	102,000 cfs
58	July 6	0	168	106,000 cfs
59	July 7	0	168	109,000 cfs
60	July 8	0	168	112,000 cfs
61	July 9	0	168	108,000 cfs
62	July 10	0	168	110,000 cfs
63	July 11	0	168	117,000 cfs
64	July 12	0	168	131,000 cfs
65	July 13	0	168	133,000 cfs
66	July 14	0	168	117,000 cfs
67	July 15	0	168	111,000 cfs
68	July 16	0	168	106,000 cfs
69	July 17	0	168	103,000 cfs
70	July 18	0	168	103,000 cfs
71	July 19	0	168	96,000 cfs
72	July 20	0	168	90,000 cfs
73	July 21	0	168	84,000 cfs
74	July 22	-10	158	72,000 cfs
75	July 23	-22	136	57,000 cfs
76	July 24	-42	94	40,000 cfs
77	July 25	-30	64	25,000 cfs
78	July 26	-38	26	11,000 cfs
79	July 27	-26	0	0 cfs

6. CUMULATIVE EFFECTS

For purposes of consultation under ESA §7, cumulative effects are those caused by future state, tribal, local, or private actions that are reasonably certain to occur in the Action Area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate consultation under ESA §7.

We know that the Mid-Barataria Sediment Diversion and the Mid-Breton Sediment Diversion Projects are reasonably certain to be implemented downstream of the BCS. However, those projects are federal actions that will require separate consultation under ESA §7. We are not aware of any non-federal actions in the action area that may affect the PS. Therefore, cumulative effects are not relevant to formulating our opinion for the action.

7. CONCLUSION

In this section, we summarize and interpret the findings of the previous sections (status, baseline, effects, and cumulative effects) relative to the purpose of a BO under §7(a)(2) of the ESA, which is to determine whether a Federal action is likely to:

a) jeopardize the continued existence of species listed as endangered or threatened; or
b) result in the destruction or adverse modification of designated critical habitat.

"Jeopardize the continued existence" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02).

After reviewing the current status of the PS, the effects of the 2019 BCS openings, and the cumulative effects, it is the Service's biological opinion that the 2019 BCS emergency operations are not likely to have jeopardized the continued existence of the species. No critical habitat has been designated for the PS; therefore, none was affected. After reviewing the effects of the 2019 BCS openings on the GS, it is the Service's biological opinion that the 2019 BCS emergency operations are not likely to have jeopardized the continued existence of the species.

8. INCIDENTAL TAKE STATEMENT

ESA §9(a)(1) and regulations issued under §4(d) prohibit the take of endangered and threatened fish and wildlife species without special exemption. The term "take" in the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (ESA §3). In regulations at 50 CFR §17.3, the Service further defines:

- "harass" as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering;"
- "harm" as "an act which actually kills or injures wildlife. Such acts may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering;" and,

- “incidental take” as “any taking otherwise prohibited, if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.”

Under the terms of ESA §7(b)(4) and §7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered prohibited, provided that such taking is in compliance with the terms and conditions of an incidental take statement (ITS).

The Action considered in this BO includes a conservation measure to recover entrained PS from the BCS and return them to the LMR, as well as, capturing a GS and returning it to Lake Pontchartrain. Through this statement, the Service authorizes this conservation measure as an exception to the prohibitions against trapping, capturing, or collecting listed species. This conservation measure is identified as a Reasonable and Prudent Measure below, and we provide Terms and Conditions for its implementation.

8.1. Amount or Extent of Take

This section specifies the amount or extent of take of PS that the Action is reasonably certain to cause, which we estimated in the “Effects of the Action” section of this BO. We reference, but do not repeat, these analyses here. The Service believes incidental take in the form of mortality and harassment resulted from the emergency operation of the BCS. Our assessment of take did not anticipate the death of any adult sturgeon captured and released back into the Mississippi River but did include mortality associated with entrapment behind the BCS structure.

The Service acknowledges the incidental take in the form of harassment of 18 PS resulted from the entrainment, recovery, and release of those individuals back into the Mississippi River. Nineteen PS were collected in the recovery effort; however, one was dead. While handling of fish can induce stress that may lead to mortality the Service does not believe that the recovery and return to the LMR of those 18 PS resulted in any of their deaths.

The Service acknowledges incidental loss in the form of death of one PS resulted from the entrainment. That one PS collected was found dead.

The Service estimated incidental loss (by death or serious injury) of 82 PS adults. These 82 adults estimated to be incidentally lost by death or serious injury are in addition to the one dead PS that were collected during the recovery efforts after the structure closed.

The Service anticipated the incidental take (direct death) of an unknown number of larval/juvenile PS due to entrainment but that number cannot be quantified.

The Service acknowledges the incidental take in the form of harassment of one GS resulted from the capture, tagging, and release of that individual back into the Lake Pontchartrain. While handling of fish can induce stress that may lead to mortality, the Service does not believe that the capture, tagging, and return to the Lake Pontchartrain of that one GS resulted in its death.

9. CONSERVATION RECOMMENDATIONS

ESA §7(a)(1) directs Federal agencies to use their authorities to further the purposes of the ESA by conducting conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary activities that an action agency may undertake to avoid or minimize the adverse effects of a proposed action, implement recovery plans, or develop information that is useful for the conservation of listed species.

Following the 2008 flood event, the USACE and the Mississippi Valley Division (MVD) initiated studies to comply with Conservation Recommendations from the 2009 BO. These studies have:

- • Documented and quantified sturgeon entrainment in existing diversions compared to adjacent river reaches;
- Estimated population size of PS in river reaches associated with diversions; and,
- • Developed population viability models of PS to analyze impacts of entrainment-based "take" by water diversions (ERDC-EL, 2013).

Additional studies are currently in progress to determine sturgeon entrainment rates at the ORCC, including seasons and conditions in which entrainment occurs, as well as studies on the role of the batture to the LMR ecosystem. The USACE Mississippi Valley Division has also developed and implemented a Conservation Plan for listed species in the LMR, which promotes conservation of PS through their engineering and construction activities (Killgore et al. 2014). An updated methodology to determine PS entrainment and the population-level risk has been developed based on data from the past BCS operations as well as the Davis Pond Diversion, which has been developed for use in future entrainment estimates (Friedenberg and Siegrist 2019). The Service encourages the USACE to continue these studies and conservation measures.

10.REINITIATION NOTICE

Formal consultation for the Action considered in this BO is concluded. Reinitiating consultation is required if the USACE retains discretionary involvement or control over the Action (or is authorized by law) when:

a. the amount or extent of incidental take is exceeded;
b. new information reveals that the Action may affect listed species or designated critical habitat in a manner or to an extent not considered in this BO;
c. the Action is modified in a manner that causes effects to listed species or designated critical habitat not considered in this BO; or,
d. a new species is listed or critical habitat designated that the Action may affect.

In instances where the amount or extent of incidental take is exceeded, the USACE is required to immediately request a reinitiation of formal consultation.

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Louisiana Ecological Services
200 Dulles Drive
Lafayette, Louisiana 70506

December 13, 2021

Colonel Stephen Murphy
District Commander
U.S. Army Corps of Engineers
7400 Leake Avenue
New Orleans, Louisiana 70118

Dear Colonel Murphy:

This document transmits the Fish and Wildlife Service's (Service) biological opinion (enclosed), regarding the Coastal Protection and Restoration Authority's (CPRA) proposed Mid-Barataria Sediment Diversion (MBSD or project), authorized by the U.S. Army Corps of Engineers (USACE), New Orleans District, located in St. Charles Parish, Louisiana, and its potential effects on the endangered pallid sturgeon (*Scaphirhynchus albus*), the threatened West Indian manatee (*Trichechus manatus*), the threatened piping plover (*Charadrius melodus*) and its critical habitat, the threatened red knot (*Calidris canutus rufa*) and its proposed critical habitat, the threatened Eastern black rail (*Laterallus jamaicensis ssp. jamaicensis*), and five species of sea turtles in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 United States Code [U.S.C.] 1531 *et seq*.).

The enclosed biological opinion, is based on information provided in the Louisiana Trustee Group's (LA TIG) July 2, 2021, biological assessment (BA). A complete administrative record of this consultation (Service Log No. 04EL1000-2022-F-0601) is on file at the Service's Louisiana Ecological Services Office.

The Service appreciates the USACE's continued cooperation in the conservation of the threatened and endangered species, and their critical habitats. If you have any questions regarding the enclosed biological opinion, please contact Ms. Amy Trahan (337-291-3126) of this office.

Sincerely,

Brigette D. Firmin
Acting Field Supervisor
Louisiana Ecological Services Office

Enclosure

cc (w/Enclosure): FWS, Atlanta, GA (Attn: Heath Rauschenberger)
LDWF, Natural Heritage Program, Baton Rouge, LA

Biological Opinion

Mid-Barataria Sediment Diversion

FWS Log #: 04EL1000-2022-F-0601

Prepared by:

U.S. Fish and Wildlife Service
Louisiana Ecological Services Field Office
200 Dulles Drive
Lafayette, LA 70506

December 13, 2021

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EXECUTIVE SUMMARY

This Endangered Species Act (ESA) Biological Opinion (BO) of the U.S. Fish and Wildlife Service (Service) addresses the potential effects of the Mid-Barataria Sediment Diversion (MBSD) Project being proposed by the Coastal Protection and Restoration Authority (CPRA) of Louisiana. The U.S. Army Corps of Engineers (USACE), New Orleans District is evaluating CPRA's application to construct, operate, and maintain the MBSD for a Department of the Army permit under Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act and a permission request under Section 14 (33 U.S. Code [USC] 408) (Section 408) of the Rivers and Harbors Act of 1899. The MBSD is also being evaluated for funding under the Deepwater Horizon Oil Spill Final Programmatic Damages Assessment and Restoration Plan (DWH PDARP) restoration planning process by the Louisiana Trustee Implementation Group (LA TIG) which will make the final decision on funding. The LA TIG is comprised of the State of Louisiana [which includes the following state agencies: CPRA, Louisiana Department of Wildlife and Fisheries (LDWF), Louisiana Oil Spill Coordinator's Office (LOSCO), Louisiana Department of Natural Resources (LDNR), and Louisiana Department of Environmental Quality (LDEQ)], the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), the U.S. Department of the Interior (DOI), and the U.S. Department of Agriculture (USDA).

The proposed project consists of a multi-component river diversion system intended to convey sediment, freshwater, and nutrients from the Mississippi River at approximately River Mile (RM) 60.7 in the vicinity of the town of Ironton, in Plaquemines Parish, Louisiana to the mid-Barataria Basin to maintain and rebuild eroding upland and marsh habitat within the Barataria Basin. It is also intended to restore injuries to natural resources caused by the 2010 Deepwater Horizon oil spill. After passing through a proposed intake structure complex at the confluence of the Mississippi River and the proposed intake channel, the sediment-laden water would be transported through a conveyance channel to an outfall area in the mid-Barataria Basin located in Plaquemines and Jefferson Parishes. The USACE and LA TIG have determined that the Action is likely to adversely affect the pallid sturgeon (*Scaphirhynchus albus*) and requested formal consultation with the Service. The BO concludes that the Action is not likely to jeopardize the continued existence of this species. This conclusion fulfills the requirements applicable to the Action for completing consultation under §7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended, with respect to these species and designated critical habitats.

The USACE and LA TIG also determined that the Action is not likely to adversely affect the Eastern black rail (*Laterallus jamaicensis jamaicensis*), the piping plover (*Charadrius melodus*), the Rufus red knot (*Calidris canutus rufa*), the West Indian manatee (*Trichechus manatus*), Kemp's ridley sea turtle (*Lepidochelys kempii)*, and loggerhead sea turtle (*Caretta caretta*), and requested the Service's concurrence. The USACE and LA TIG also determined that the Action would have no effect on critical habitat for the piping plover or proposed critical habitat for the red knot, as well as, nesting beaches for the green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricate*), and leatherback sea turtle (*Dermochelys coriacea*). The Service concurs with that determination and provides our basis for this concurrence in section 3 of the BO. This concurrence fulfills the requirements applicable to the Action for completing consultation with respect to these species and designated critical habitats.

It is the Service's opinion that the project would not jeopardize the pallid sturgeon.

The BO includes an Incidental Take Statement that requires the USACE and the LA TIG to implement reasonable and prudent measures that the Service considers necessary or appropriate to minimize the impacts of anticipated taking on the listed species. Incidental taking of listed species that is in compliance with the terms and conditions of this statement is exempted from the prohibitions against taking under the ESA.

In the Conservation Recommendations section, the BO outlines voluntary actions that are relevant to the conservation of the listed species addressed in this BO and are consistent with the authorities of the USACE.

Reinitiating consultation is required if the USACE and LA TIG retains discretionary involvement or control over the Action (or is authorized by law) when:

(a) the amount or extent of incidental take is exceeded;
(b) new information reveals that the Action may affect listed species or designated critical habitat in a manner or to an extent not considered in this BO;
(c) the Action is modified in a manner that causes effects to listed species or designated critical habitat not considered in this BO; or
(d) a new species is listed or critical habitat designated that the Action may affect.

CONSULTATION HISTORY

This section lists key events and correspondence during the course of this consultation. A complete administrative record of this consultation is on file in the Service's Louisiana Ecological Services Office.

2016-11-10 – The USACE formally requests federal, state, and tribal agencies to be cooperating or commenting agencies for National Environmental Policy Act Environmental Impact Statement (NEPA EIS) and permitting process for the Mid-Barataria Sediment Diversion Project.

2017-04-04 – The Service attends EIS kickoff meeting with other federal, state, and tribal agencies including USACE, CPRA, NOAA, etc. The Service informed the USACE of the pallid sturgeon issues for the proposed project.

2018-06-20 – Endangered Species Act (ESA) and Essential Fish Habitat (EFH) consultation kickoff meeting with representatives of the USACE, CPRA, NOAA, DOI, and Confluence Environmental Company (Confluence) to discuss the ESA section 7 and EFH consultations for the proposed project.

2018-07-20 – The Service attends a conference call with Confluence, the USACE's Engineer Research and Development Center (ERDC), and Nick Friedenberg from Applied Biomathematics regarding a pallid sturgeon population viability analysis (PVA).

2018-12-12 – Confluence provides the Service with Package 1 of the draft BA for review and comment.

2019–01-03 – The Service provides Confluence with comments on Package 1 of the draft BA.

2019–01-24 – Confluence provides the Service with Package 2 of the draft BA for review and comment.

2019–02-15 – The Service provides Confluence with comments on Package 2 of the draft BA.

2019–07-19 – The Service attends a call with the ERDC, Confluence, and Nick Friedenberg from Applied Mathematics to discuss the pallid sturgeon PVA that Applied Mathematics prepared.

2019-11-18 – Confluence provides the Service with the draft BA for review and comment; the Service provides comments on the draft BA.

2021-04-15 – The Service's DWH Gulf Restoration Office initiated, via letter, formal consultation with the Service on the proposed Mid-Barataria Sediment Diversion Project. Enclosed with the letter was a final BA.

2021-07-02 – The USACE initiated, via letter, formal consultation with the Service on the proposed Mid-Barataria Sediment Diversion Project. A link to the final BA was provided in the letter due to the size of the BA.

2021-08-02 – The Service responded, via letters, to USACE and the DWH Gulf Restoration Office providing the confirmation that the initiation package was complete and that our Biological Opinion would be issued no later than November 14, 2021. The Service's letters deeming the initiation package complete requested a determination of impacts to the red knot proposed critical habitat that was published after the final BA was received by the Service. The letter to the DWH Gulf Restoration Office stated that the Service's BO would be responding to the USACE's request but a copy of the BO would be provided to the Gulf Restoration Office and be sufficient to conclude as one consultation.

2021-10-08 – The Service requested, via electronic mail, a 30-day extension for issuance of the final BO. The USACE granted the extension on October 13, 2021.

2021-10-28 – USACE provided, via letter, a determination of impacts to the red knot proposed critical habitat.

BIOLOGICAL OPINION

1. INTRODUCTION

A biological opinion (BO) is the document that states the opinion of the U.S. Fish and Wildlife Service (Service) under the Endangered Species Act (ESA) of 1973, as amended, as to whether a Federal action is likely to:

- jeopardize the continued existence of species listed as endangered or threatened; or
- result in the destruction or adverse modification of designated critical habitat.

The Federal action addressed in this BO is the proposed Mid-Barataria Sediment Diversion (MBSD) Project (the Action) being developed by the Coastal Protection and Restoration Authority (CPRA). This BO considers the effects of the Action on the pallid sturgeon (*Scaphirhynchus albus*).

The U.S. Army Corps of Engineers (USACE), New Orleans District and Louisiana Trustee Implementation Group (LA TIG) also determined that the Action is not likely to adversely affect the Eastern black rail (*Laterallus jamaicensis jamaicensis*), the piping plover (*Charadrius melodus*), the Rufus red knot (*Calidris canutus rufa*), the West Indian manatee (*Trichechus manatus*), Kemp's ridley sea turtle (*Lepidochelys kempii)*, and loggerhead sea turtle (*Caretta caretta*) and requested Service concurrence. The USACE and LA TIG also determined that the Action would have no effect on critical habitat for the piping plover or proposed critical habitat for the red knot, as well as, nesting beaches for the green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricate*), and leatherback sea turtle (*Dermochelys coriacea*). The Service concurs with these determinations for reasons we explain in section 3 of the BO.

A BO evaluates the consequences to listed species and designated critical habitat caused by a Federal action, activities that would not occur but for the Federal action, and non-Federal actions unrelated to the proposed Action that are reasonably certain to occur (cumulative effects), relative to the status of listed species and the status of designated critical habitat. A Service opinion that concludes a proposed Federal action is *not* likely to jeopardize species and is *not* likely to destroy or adversely modify critical habitat fulfills the Federal agency's responsibilities under §7(a)(2) of the ESA.

"*Jeopardize the continued existence*" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02). "*Destruction or adverse modification*" means a direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (50 CFR §402.02).

This BO uses hierarchical numeric section headings. Primary (level-1) sections are labeled sequentially with a single digit (e.g., 2. PROPOSED ACTION). Secondary (level-2) sections within each primary section are labeled with two digits (e.g., 2.1. Action Area), and so on for level-3 sections. The basis of our opinion for each listed species and each designated critical habitat identified in the first paragraph of this introduction is wholly contained in a separate level-1 section that addresses its status, environmental baseline, effects of the Action, cumulative effects, and conclusion.

2. PROPOSED ACTION

The CPRA is proposing to construct, operate, and maintain the Mid-Barataria Sediment Diversion Project (MBSD), as authorized by USACE and being evaluated for funding by the LA TIG. The proposed project consists of a multi-component river diversion system intended to convey sediment, fresh water, and nutrients from the Mississippi River at river mile (RM) 60.7 near the town of Ironton, in Plaquemines Parish, Louisiana to the mid-Barataria Basin. After passing through a proposed intake structure complex on the Mississippi River and proposed intake channel, the sediment-laden water would be transported through a conveyance channel to an outfall area in the mid-Barataria Basin located in Plaquemines and Jefferson Parishes.

It should be noted that the specific construction details and drawings referenced in the Biological Assessment (BA) and this BO are based on the latest designs available at the time of submittal, approximately 30 percent design. As the project continues toward final design and ultimately construction, some project details are likely to be modified and refined during final design, value engineering, and other project optimization steps. Any such changes and modifications are not expected to change the mechanisms of impact to listed species and habitats discussed in the BA and this BO and therefore would not change the analyses or conclusions in this BO.

Once construction has been completed, the MBSD will be operated based on a diversion operations plan using flows measured at the Mississippi River gage at Belle Chasse. Operation of the diversion would be triggered with gates opening for flow when the Mississippi River gage at Belle Chasse reaches 450,000 cubic feet per second (cfs) and would reduce to a permanent base flow of 5,000 cfs when flow at the Belle Chasse gage falls below 450,000 cfs. When the Mississippi River flows exceed 450,000 cfs, the flow through the diversion will vary, with a maximum flow of 75,000 cfs. Flow rates through the diversion will increase proportionately to flow rates in the Mississippi River until the gage at Belle Chasse reaches 1,000,000 cfs, at which point flow through the diversion will be capped at a maximum of 75,000 cfs. At times river flows may be low and/or water levels on the basin side may be high (i.e., storm surge), which would prevent maintenance of a full 5,000 cfs base flow. Operations of the diversion will be maintained to prevent reverse flow from the Barataria Bain to the Mississippi River and operations will be suspended prior to and during major storm events.

The design elements of the proposed project are separated into 3 categories:

- Diversion Complex – The diversion complex will comprise features that form the basic structural elements for water inlet and conveyance from the Mississippi River to the basin outfall area. These features include the intake system, the gated control structure, the conveyance channel, and the guide levees.
- Basin Outfall Area – The basin side of the outfall area within the action area, where the initial delta formation is anticipated from the sediment-laden water. The features to be

constructed here are intended to increase the efficiency of water and sediment accumulation.

- Auxiliary Features – The project elements that accommodate existing or future services and infrastructure, including road, rail, and utilities and drainage systems. These features also include the placement of dredged materials in beneficial use placement areas and other mitigation measures designed to offset impacts of the construction process.

The proposed project will require 3 to 5 years of construction, depending on the extent of needed ground modifications and soil stabilization measures that may be necessary. A detailed description of the major project elements from construction through operation and maintenance are in the following section.

Site preparation for construction of the major project features includes clearing and grubbing, stockpiling and placement of material, excavating and constructing haul roads (including drainage channels, cross-drain structures, and access fencing), hauling of material, grading and paving, dredging, pumping of dredged material to prepared disposal site(s), installation of sediment and erosion control measures and slop protection, permanent and final stabilization, and extension of utilities to serve the proposed project operations. A more detailed description of the proposed construction plan for the proposed project is provided in Appendix B of the Biological Assessment.

Various types of equipment will be present and operating throughout the construction of the proposed project, including trucks, excavators, dozers, loaders, rollers, scrapers, cranes, pile drivers, barges, and well point drill rigs for dewatering. The means and methods implemented by the construction contractor will determine what equipment will be necessary on site. To produce the large volumes of concrete needed for the large structure, a concrete batch plant will be placed in the proposed construction footprint. On either the river or basin side of the construction area (or both), a temporary offloading facility may be constructed by the contractor to accommodate safe material transfer.

Areas associated with project construction activities will be located within the overall footprint of the construction limits (Figure 1). Staging areas and construction yards will be approximately 8 acres. The concrete batch plant will use an additional 4 acres. The final size and locations of these areas will be selected by the contractor. The staging areas will include the following:

- Haul and access roads
- A concrete batch plant
- Barge offloading facilities located on the Mississippi River and in the Barataria Basin
- A staging area for barge-delivered materials
- Construction yards
- A laydown area for drying and processing clay borrow from excavations.

To transport construction equipment and to dredge the outfall transition feature, access routes will be used within the Barataria Basin. A planned access route, from the north to the proposed outfall area, follows a route used for previous restoration projects requiring similar draft for vessels. This route can be accessed from the Gulf Intracoastal Waterway via the Barataria Bay Waterway. The Mississippi River, which is navigable by ocean-going vessels up to Baton Rouge and by barge traffic all the way to the Port of Minneapolis, Minnesota, will also be utilized by the project.

During construction of the diversion complex, a pile supported trestle with a total surface area of approximately 36,000 square feet (ft^2) would be installed just downstream of the intake along the Mississippi River for material transfer (Figure 2). The proposed construction limits for the diversion complex would be approximately 1,015.4 acres. The intake system of the diversion consists of an intake structure (with two flared training walls and an intake channel), a gated control structure, and a transition channel that will connect to the larger conveyance channel (Figure 3). The training walls will extend into the Mississippi River approximately 950 feet shoreward (west) of the Mississippi River navigation channel limits and be located on the bed slope of the river adjacent to the sand bar which occurs at approximate depth elevations of -50 feet and -70 feet.

The training walls will be to direct flow of sediment from the river into the intake and restrict riverbank soils from filling the channel. The walls will be inverted pile-founded T-walls that would gradually increase in elevation from 0.0 and -13.0 feet, respectively, in the river to approximately 16.4 feet where they would connect to the intake channel walls. To dewater the area during construction, a temporary cofferdam system would be built around the proposed training walls. Installation methods for the cofferdam system may include impact, auguring, vibrating, or other methods. Generally, upland pile driving may use either impact or vibratory pile drivers without noise attenuation. Sheet piles will be installed using vibratory methods to the extent practicable and in-water pilings may be driven with impact or vibratory pile drivers. While it is estimated that the cofferdam will remain in place for up to 3.5 years, after construction, it will be removed.

The gated control structure will consist of four 45-foot-wide steel tainter gates with a top-of-wall elevation of 16.4ft and an inverted elevation of -40ft which will regulate flow by raising or lowering the gates. The river side of the structure will tie into the current Mississippi River and Tributaries (MR&T) Project Levee alignment, with a maintenance bridge across the top and four machine rooms. Water from the gated control structure would be funneled through a U-shaped transition channel with widths increasing from the gated control structure to the trapezoidal conveyance channel. The transition wall system under consideration will be pile-supported inverted T-walls. Detailed construction methods for this gated control structure are provided in EIS Section 2.8 (CPRA 2021).

The conveyance channel will be lined with bedding stone and riprap. It will have a 300-foot bottom width with an invert elevation of -25ft, setback berms between the top of channel and toe of the guide levees, and guide levees. The total width of the conveyance channel, guide levees, and stability berms will measure 734ft and would occupy about 563 acres, including the guide levees. Detailed construction methods of the conveyance channel are provided in the EIS Section 2.8 (CPRA 2021).

Along both sides of the conveyance channel, earthen guide levees will be constructed as a linear feature designed to constrain project flows. It is anticipated that multiple lifts and construction sequences will be needed to bring the guide levees to their final design height. These levees will also serve as hurricane flood protection against storm surge and be built to an elevation of 15.6ft, which is the USACE Design Grade for the proposed upgraded New Orleans to Venice Hurricane Risk Reduction Project: Incorporation of Non-Federal Levees (NFL) from Oakville to St. Jude and New Orleans to Venice Federal Hurricane Protection Levee (NOV HPL) (collectively referred to as NOV-NFL) levee. They would include a 10-foot-wide levee crown topped with a gravel access road and will be constructed using soil material excavated for construction of the intake and conveyance channels.

The outfall area is defined as the area on the basin side of the conveyance channel that will receive fresh water, sediment, and nutrients from the Mississippi River via the conveyance channel. This area is approximately 676 acres and is delineated by Cheniere Traverse Bayou to the north, Wilkinson Canal to the south, and the Barataria Bay Waterway to the west. Currently, this area largely consists of degraded wetland, shallow open water, and oil and gas canals. It is anticipated that a delta will form in the outfall area. Further details about project-induced land building in the basin can be found in the EIS Section 4.2.

According to the modeling efforts, upon proposed project initiation, sand and coarse-grained sediments will be deposited within the outfall area in an initial delta formation with deposition of finer-grained sediment extending farther gulfward in the basin, forming a subaqueous delta just below the low-tide water level. The subaqueous delta will evolve, over time, into a subaerial delta above the low-tide water level as vegetation becomes established and encourages additional deposits of sediment. In turn this will extend the formation of new subaqueous delta farther gulfward into the basin. Fine-grained sediments transported by the diversion will travel farther from the outfall area and be dispersed throughout the proposed project area.

In the project design, the creation of an outfall transition feature (OTF) is included to increase the efficiency of water and sediment delivery. To create this feature, the receiving basin surrounding the outlet will be dredged to create a gradual gradient from the diversion channel invert elevation of -25ft (the grade elevation of the channel) to the existing bed elevation of the receiving basin (-4ft). It is designed to provide sufficient bed topography for the diversion to flow at maximum capacity, expediting initial delta formation. The OTF will be created by dredging bottom sediment from the open water area within approximately 640 acres (1 square mile) of the outfall transition walls of the structure. Dredged sediments will be place at designated beneficial use locations in the receiving basin and the bottom of the OTF will be armored with riprap.

The proposed MBSD includes a 50-year operations plan based on initial sediment transport and deposition modeling. To observe and evaluate system performance and environmental response, a monitoring and adaptive management plan will be implemented. This plan may prescribe operational changes when necessary to improve system performance or if certain threshold environmental conditions are reached.

Proposed conservation measures to be implemented during construction of the proposed project include environmental protection measures and best management practices (BMPs) to avoid or minimize potential environmental effects. CPRA will develop an Environmental Protection Plan (EPP) detailing the Best Management Practices (BMPs) and environmental protection measures

(EPMs) for the prevention and/or control of pollution and habitat disruption that may occur during construction and operations.

<u>West Indian Manatee Protection Measures</u>

During in-water work in areas that potentially support manatees all personnel associated with the project should be instructed about the potential presence of manatees, manatee speed zones, and the need to avoid collisions with and injury to manatees. All personnel should be advised that there are civil and criminal penalties for harming, harassing, or killing manatees, which are protected under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. Additionally, personnel should be instructed not to attempt to feed or otherwise interact with the animal, although passively taking pictures or video would be acceptable. All on-site personnel are responsible for observing water-related activities for the presence of manatee(s). We recommend the following to minimize potential impacts to manatees in areas of their potential presence:

- All work, equipment, and vessel operation should cease if a manatee is spotted within a 50-foot radius (buffer zone) of the active work area. Once the manatee has left the buffer zone on its own accord (manatees must not be herded or harassed into leaving), or after 30 minutes have passed without additional sightings of manatee(s) in the buffer zone, in-water work can resume under careful observation for manatee(s).

- If a manatee(s) is sighted in or near the project area, all vessels associated with the project should operate at “no wake/idle” speeds within the construction area and at all times while in waters where the draft of the vessel provides less than a four-foot clearance from the bottom. Vessels should follow routes of deep water whenever possible.

- If used, siltation or turbidity barriers should be properly secured, made of material in which manatees cannot become entangled, and be monitored to avoid manatee entrapment or impeding their movement.

- Temporary signs concerning manatees should be posted prior to and during all in-water project activities and removed upon completion. Each vessel involved in construction activities should display at the vessel control station or in a prominent location, visible to all employees operating the vessel, a temporary sign at least 8½ " X 11" reading language similar to the following: “CAUTION BOATERS: MANATEE AREA/ IDLE SPEED IS REQUIRED IN CONSRUCTION AREA AND WHERE THERE IS LESS THAN FOUR FOOT BOTTOM CLEARANCE WHEN MANATEE IS PRESENT”. A second temporary sign measuring 8½ " X 11” should be posted at a location prominently visible to all personnel engaged in water-related activities and should read language similar to the following: “CAUTION: MANATEE AREA/ EQUIPMENT MUST BE SHUTDOWN IMMEDIATELY IF A MANATEE COMES WITHIN 50 FEET OF OPERATION”.

- Collisions with, injury to, or sightings of manatees should be immediately reported to the Service's Louisiana Ecological Services Office (337-291-3100) and the Louisiana Department of Wildlife and Fisheries, Natural Heritage Program (225-765-2821). Please provide the nature of the call (i.e., report of an incident, manatee sighting, etc.); time of incident/sighting; and the approximate location, including the latitude and longitude coordinates, if possible.

Pile Driving Noise Attenuation

A pile-driving plan to guide pile-driving operations will be developed. The plan will identify locations, approximate timing, and installation methods including any noise attenuation methods.

Stormwater Pollution Prevention Plan

The stormwater pollution prevention plan (SWPPP) will be prepared to meet National Pollutant Discharge Elimination System (NPDES) permit requirements and implemented to minimize and control pollution and erosion due to stormwater runoff. A temporary erosion and sediment control (TESC) plan is required to prevent erosive forces from damaging project sites, adjacent properties, and the environment. The TESC plan may be a component of the SWPPP.

Spill Prevention, Control and Countermeasure Plan

A spill prevention, control and countermeasure (SPCC) plan would be prepared by the contractor to prevent and minimize spills that may contaminate soil or nearby waters.

Monitoring and Adaptive Management Plan (MAMP)

A MAMP is being developed by CPRA, in association with the project, which will guide field monitoring of species, habitats, and water quality considerations during operation of the MBSD. The plan will include monitoring efforts and management actions that may affect operations based on identified thresholds and planning processes. Specific measures for monitoring project impacts on pallid sturgeon are included in the Terms and Conditions (Section 5.3) of this Opinion.

2.1. Action Area

For purposes of consultation under ESA §7, the action area is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR § 402.02). The action area includes the proposed MBSD location and all surrounding areas where effects due to the sediment diversion may reasonably be expected to occur. This area includes the Barataria Basin and the Mississippi River Delta Basin (Birdfoot Delta) (Figure 4). The action area also includes the Mississippi River in the vicinity of RM 60.7 in Plaquemines Parish, Louisiana.

2.2. Non-Federal Activities caused by the Federal Action

A BO evaluates the effects of a proposed Federal action. "Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action" (50 CFR §402.02).

Activities that would not occur but for the proposed Federal action include relocation or modification of existing infrastructure within the action area (i.e., roads, railways, pipelines, utilities, levees). The auxiliary actions identified by CPRA are described in detail in the EIS Section 2.8. The proposed activities related to the construction of these features are not anticipated to impact federally listed species or designated critical habitat under the Service's jurisdiction. Therefore, these proposed activities will not be discussed further in this BO.

2.3. Tables and Figures for Proposed Action

Figure 1. Project design features and construction footprint (LA TIG 2021)

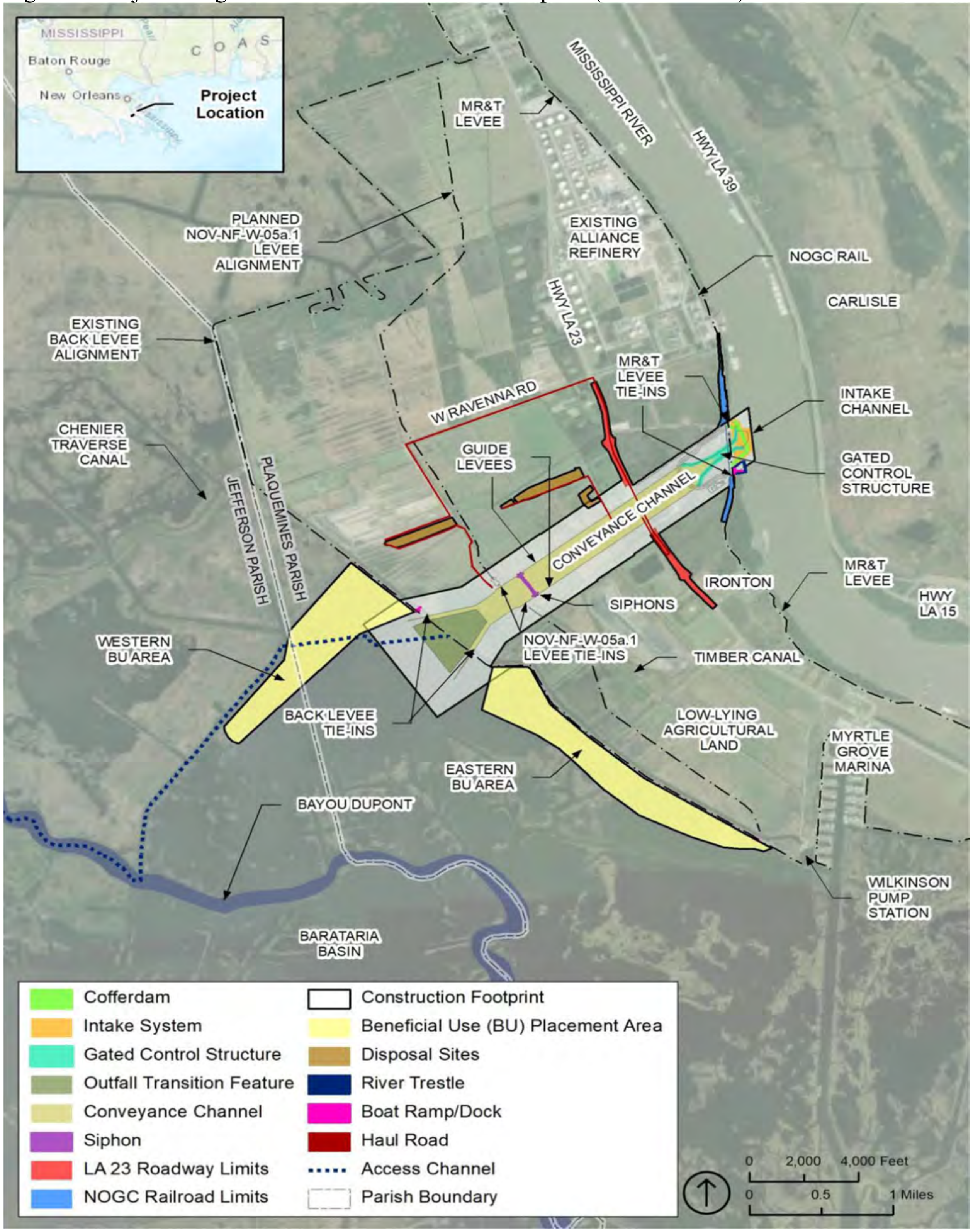


Figure 2. Proposed trestle and construction cofferdam overview. (LA TIG 2021)

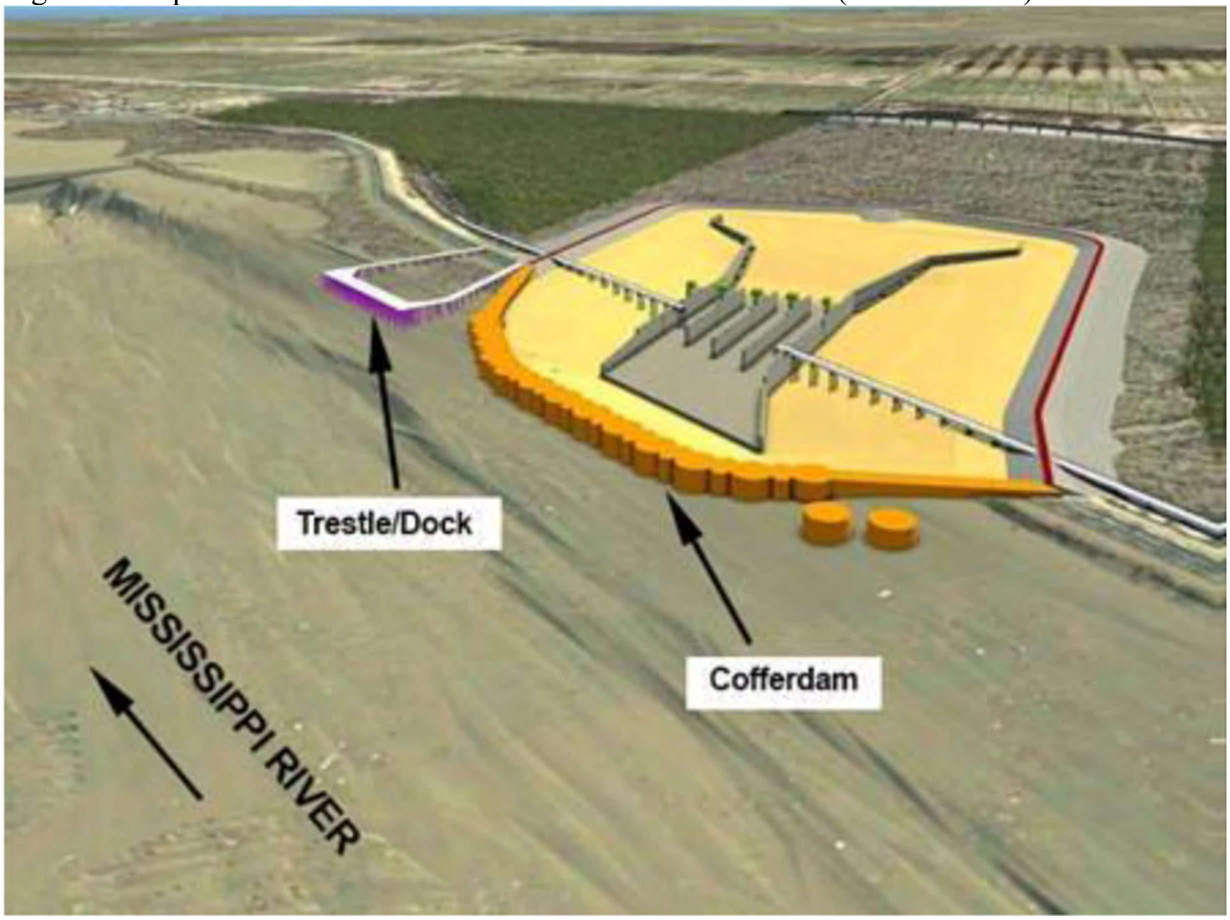


Figure 3. Proposed project design features as viewed from the Mississippi River (LA TIG 2021)

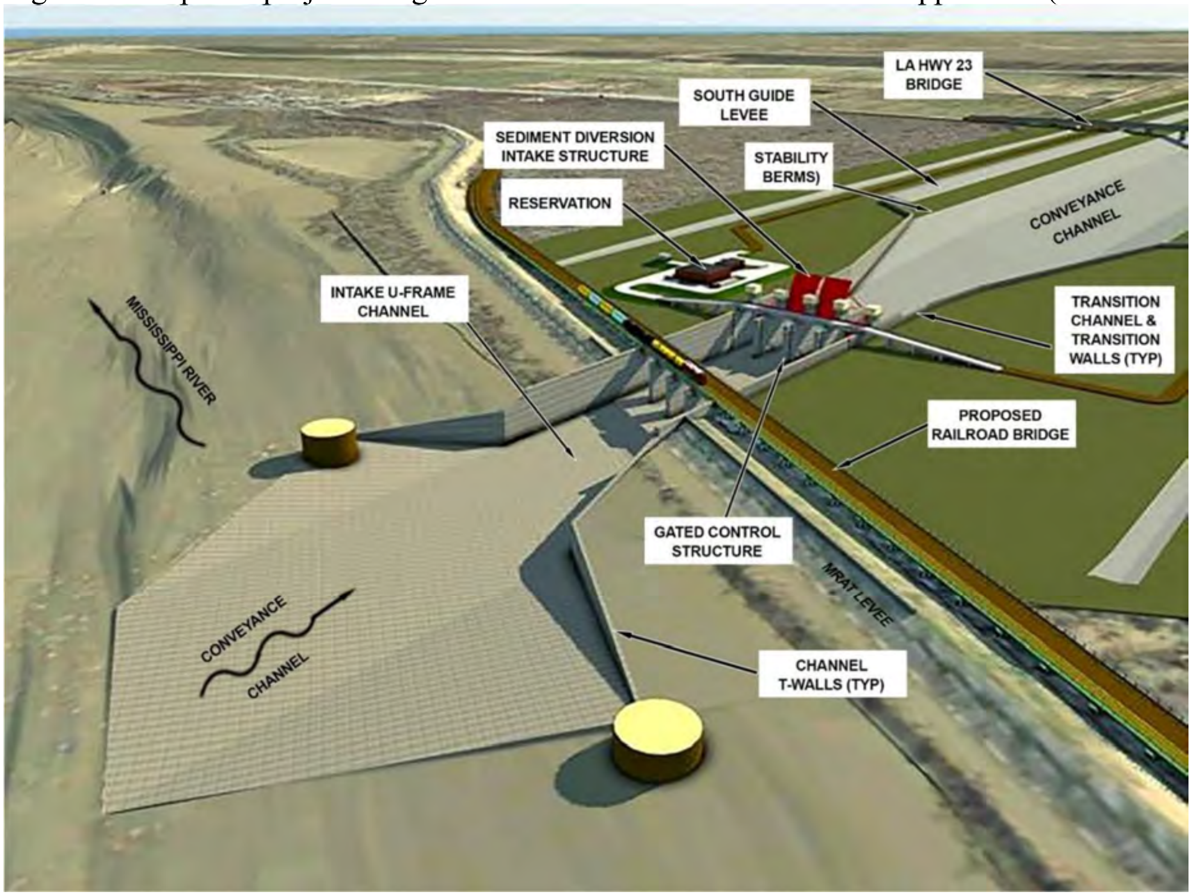
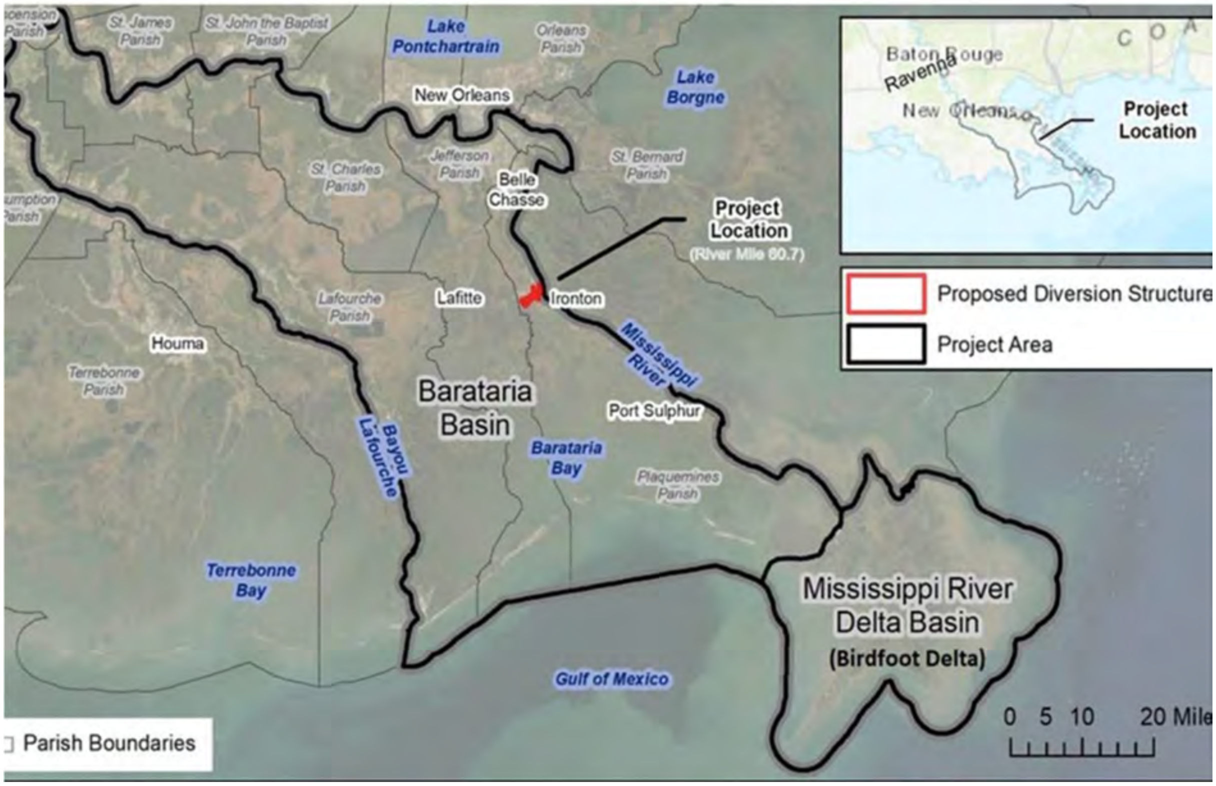


Figure 4. Project Action Area – Barataria Basin, Birdfoot Delta Basin and proposed diversion structure (LA TIG 2021).



3. CONCURRENCE

The USACE and LA TIG determined that the Action is not likely to adversely affect the Eastern black rail, piping plover, red knot, West Indian manatee, and nesting beaches for the Kemp's ridley sea turtle, and the loggerhead sea turtle. The USACE and LA TIG also determined that the Action would have no effect on critical habitat for the piping plover or proposed critical habitat for the red knot, as well as, nesting beaches for the green sea turtle, hawksbill sea turtle, and leatherback sea turtle. The Service concurs with these determinations, for reasons we explain in this section.

Eastern Black Rail

The Eastern black rail is a small, secretive marsh bird that inhabits both freshwater and saltwater marshes. The cryptic nature of this species makes accurate assessments of its range and habits difficult. A small number of observations were recorded in Louisiana between 2010 and 2017 (Service 2018). They are known to winter in the marshes of Vermilion and Cameron Parishes. There is anecdotal reports suggesting black rails may be on Grand Isle and Elmer's Island; however, surveys conducted since the Deepwater Horizon oil spill have not documented black rails there. Suitable habitat for this species is found within the project area and will be impacted, the predominantly brackish marsh in this area will transition to fresh/intermediate marsh within the mid-basin over time, and black rails are also known to utilize that marsh type. In addition, although temporary construction activities may disturb or displace the species present in the habitat near the activities, these impacts are temporary; therefore, the Service concurs with the USACE's and LA TIG's determination that the proposed project may affect, but is not likely to adversely affect the Eastern black rail.

Piping Plover and Designated Critical Habitat

The piping plover is a small (7 inches long), pale, sand-colored shorebird that winters in coastal Louisiana and may be present for 8 to 10 months annually. Piping plovers arrive from their northern breeding grounds as early as late July and remain until late March or April. They feed on polychaete marine worms, various crustaceans, insects and their larvae, and bivalve mollusks that they peck from the top of or just beneath the sand. Piping plovers forage on intertidal beaches, mudflats, sand flats, algal flats, and wash-over passes with no or very sparse emergent vegetation. They roost in unvegetated or sparsely vegetated areas, which may have debris, detritus, or micro-topographic relief offering refuge to plovers from high winds and cold weather. They also forage and roost in wrack (i.e., seaweed or other marine vegetation) deposited on beaches. In most areas, wintering piping plovers are dependent on a mosaic of sites distributed throughout the landscape, because the suitability of a particular site for foraging or roosting is dependent on local weather and tidal conditions. Plovers move among sites as environmental conditions change, and studies have indicated that they generally remain within a 2-mile area. Infrequently during migration, piping plovers occur within mudflats and estuarine habitat in the Barataria Basin. Within the action area, wintering piping plovers have been documented on the barrier islands of the lower Barataria Basin including Grand Isle and Elmer's

Island as well as barrier islands adjacent to the South Pass entrance to the Mississippi River (Elliot-Smith et al. 2015).

On July 10, 2001, the Service designated critical habitat for wintering piping plovers (Federal Register Volume 66, No. 132); a map and descriptions of the seven critical habitat units in Louisiana can be found at https://www.fws.gov/plover/FR_notice/finalchnotice-91-95%20Louisiana.pdf. Their designated critical habitat identifies specific areas that are essential to the conservation of the species. Designated critical habitat for wintering piping plovers in the action area include the coastal shoreline and barrier islands extending from the western edge of the action area east to the Grande Terre Islands, and certain barrier islands in the Birdfoot Delta at the mouth of the Mississippi River.

Piping plovers are not likely to occur within the construction area of the project and operation of the diversion is not likely to change the coastal processes that influence barrier island morphology. Impacts to piping plover critical habitat are not anticipated. Accordingly, the Service concurs with the USACE's and LA TIG's determination that the Action may affect, but is not likely to adversely affect the piping plover and will have no effect on piping plover critical habitat.

Red Knot and Proposed Critical Habitat

The red knot is a medium-sized shorebird about 9 to 11 inches in length with a proportionately small head, small eyes, short neck, and short legs. The red knot breeds in the central Canadian arctic but is found in Louisiana during spring and fall migrations and the winter months (generally September through early May). During migration and on their wintering grounds, red knots forage along sandy beaches, tidal mudflats, salt marshes, and peat banks. In wintering and migration habitats, red knots commonly forage on bivalves, gastropods, and crustaceans. Coquina clams (*Donax variabilis*), a frequent and often important food resource for red knots, are common along many gulf beaches.

On July 15, 2021, the Service proposed to designate 649,066 acres of critical habitat across 13 states for the red knot. Much of the area proposed for critical habitat in Louisiana, overlaps the designated critical habitat for piping plover.

Much like the piping plover and its designated critical habitat, red knots are not likely to occur within the construction area of the project and operation of the diversion is not likely to change the coastal processes that influence barrier island morphology. Impacts to red knot proposed critical habitat are also not anticipated. Therefore, the Service concurs with the USACE's and LA TIG's determination that the Action may affect, but is not likely to adversely affect the red knot and will have no effect on red knot proposed critical habitat.

West Indian Manatee

The West Indian manatee is a large gray or brown marine mammal known to regularly occur in Lakes Pontchartrain and Maurepas and their associated coastal waters and streams. It also can be found less regularly in other Louisiana coastal areas, most likely while the average water temperature is warm. Based on data maintained by the LDWF, there were 269 reported manatee sightings from 1990-2020 in Louisiana, 14 of which occurred within the Barataria Basin. Presence of manatee in the action area is possible; however, they are transient visitors during warmer months and are not a resident species. While construction activities may temporarily disturb or displace manatees present near construction activities, manatee protection measures identified in Section 2 are anticipated to avoid or minimize impacts to manatees. Operation of the diversion is predicted to reduce water temperatures in the Barataria Basin greatest during the winter and early spring and near the outfall site; however, manatees are present in the action area during summer months or when water temperatures are tolerable for them. Accordingly, the Service concurs with the USACE's and LA TIG's determination that the proposed project may affect, but is not likely to adversely affect the West Indian manatee.

Sea Turtles

There are five species of federally listed threatened or endangered sea turtles (green sea turtle, hawksbill sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, and loggerhead sea turtle) that forage in the near shore waters, bays, and estuaries of Louisiana. The Service and National Marine Fisheries Service (NMFS) share jurisdiction over five listed sea turtle species. When sea turtles leave the marine environment and come onshore to nest, the Service is responsible for those species. Two species, the loggerhead sea turtle (*Caretta caretta*) and Kemp's ridley (*Lepidochelys kempii*) could potentially nest in Louisiana during the summer months (i.e., May through November). Historical records indicate that loggerheads nested on the Chandeleur Islands. On June 29 and July 3, 2015, two records of adult female loggerhead sea turtles nesting on Grand Isle represent the first confirmed sea turtle nesting on the coast of Louisiana for 30 years (Louisiana Sportsman 2015). The Kemp's ridley is known to nest in coastal Texas and Alabama, and nesting attempts were observed on the Chandeleur Islands of Louisiana; thus, nesting attempts could possibly occur in Louisiana as that species achieves recovery. There are no records indicating nesting of the green sea turtle, hawksbill sea turtle, or leatherback sea turtle on Louisiana beaches. Upland nesting habitat for sea turtles are not anticipated to experience impacts from the proposed project. Therefore, the Service concurs with the USACE's and LA TIG's determination that the proposed project may affect, but is not likely to adversely affect the Kemp's ridley sea turtle and loggerhead sea turtle and will have no effect on the green sea turtle, hawkbill sea turtle, and leatherback sea turtle.

This concurrence concludes consultation for the listed species and designated critical habitats named in this section, and these are not further addressed in this BO. The circumstances described in the Reinitiation Notice (Section 7) of this BO that require reinitiating consultation for the Action, except for exceeding the amount or extent of incidental take, also apply to these species and critical habitats.

4. PALLID STURGEON

4.1. Status of Pallid Sturgeon

This section summarizes best available data about the biology and current condition of pallid sturgeon throughout its range that are relevant to formulating an opinion about the Action. The

Service published its decision to list the pallid sturgeon as endangered on October 9, 1990 (55 FR 36641-36647). The reasons for listing were habitat modification, apparent lack of natural reproduction, commercial harvest, and hybridization in parts of its range. Critical habitat has not been proposed or designated for the pallid sturgeon. The Service conducted a 5-year review of the species' status and revised the recovery plan in 2014, and determined that no status change was needed at that time. Most of the background information on pallid sturgeon biology and status presented throughout this BO is taken directly from information presented in the recently revised recovery plan (Service 2014a) and eight other BOs involving the species (Service 2009; Service 2010a; Service 2014b; Service 2018; Service 2020, Service 2021a, and Service 2021b).

4.1.1. Description of Pallid Sturgeon

The pallid sturgeon is a benthic, riverine fish that occupies the Mississippi River Basin, including the Mississippi River, Missouri River, and their major tributaries (i.e., Platte, Yellowstone, and Atchafalaya rivers) (Service 1990).

Recent studies have documented extensive hybridization between pallid sturgeon and shovelnose sturgeon in the Lower Mississippi River (Coastal Plain Management Unit) (Jordan et al., 2019). These studies also confirmed that small numbers of genetically pure pallid sturgeon continue to occupy the Lower Mississippi River; however, genetic analysis is required for their accurate identification. There is currently no official Service policy for the protection of hybrids under the Act, and the protection of hybrid progeny of endangered or threatened species is evaluated as necessary. For example, the protection of hybrids to facilitate law enforcement is recognized as appropriate under the Act (§4(3)) in cases where they are sympatric with pure species and morphologically difficult to distinguish. The duration and significance of hybridization between pallid sturgeon and shovelnose sturgeon is currently unknown, and it is not possible to visually distinguish pure pallid sturgeon from introgressed pallid sturgeon; therefore, for the purposes of management and consultation, we are considering all phenotypic pallid sturgeon as protected under the Act.

The pallid sturgeon can grow to lengths of over 6 feet (ft) (1.8 meters [m]) and weights in excess of 80 pounds (lbs) (36 kilograms [kg]) in the upper Missouri River portion of its range. In the Mississippi River, specimens seldom exceed 3 ft (1 m) in length, or 20 lbs (9 kg) in weight. Pallid sturgeon have a flattened, shovel-shaped snout, a long, slender, and completely armored caudal peduncle, and lack a spiracle (Smith 1979). As with other sturgeon, the mouth is toothless, protrusible, and ventrally positioned under the snout. The skeletal structure is primarily cartilaginous (Gilbraith et al. 1988). Pallid sturgeon are similar in appearance to the more common and darker SS, and may be visually distinguished by the proportional lengths of inner and outer barbels, mouth width, proportion of head width to head length, proportion of head length to body length, and other characteristics. As noted above, morphological pallid sturgeon require genetic analysis to determine hybridization.

4.1.2. Life History of Pallid Sturgeon

Habitat

Pallid sturgeon habitats can generally be described as large, free-flowing, warm water, turbid river habitats with a diverse assemblage of physical attributes that are in a constant state of change (Service 1993, 2014). Floodplains, backwaters, chutes, sloughs, islands, sandbars and main channel waters form the large river ecosystem that provide the macrohabitat requirements for all life stages of pallid sturgeon. Throughout its range, pallid sturgeon tend to select main channel habitats (Bramblett 1996; Sheehan et al. 1998; Service 2014a; Schramm et al. 2017); in the Lower Mississippi River (LMR), they have been found in a variety of main channel habitats, including natural and engineered habitats (Herrala et al. 2014).

Pallid sturgeon are thought to occupy the sandy main channel in the Mississippi, Missouri, and Yellowstone rivers most commonly, but also are collected over gravel substrates (Service 2014a; Bramblett and White 200l; Hurley et al. 2004; Garvey et al. 2009; Koch et al. 2012). Several studies have documented pallid sturgeon near islands and dikes, and these habitats are thought to provide a break in water velocity and an increased area of depositional substrates for foraging (Garvey et al. 2009; Koch et al. 2012). Increased use of side channel and main channel islands has been noted in spring, and it is hypothesized that these habitats may be used as refugia during periods of increased flow (Garvey et al. 2009; Koch et al. 2012; Herrala et al. 2014). Recent telemetry monitoring of adult pallid sturgeon in the LMR indicates use of most channel habitats, including dikes, revetment, islands, secondary channels, etc. (Kroboth et al. 2013; Herrala et al. 2014). Islands and secondary channels are important in recruitment of larval sturgeon in the LMR (Hartfield et al. 2013).

Pallid sturgeon occur within a variety of flow regimes (Garvey et al. 2009). In their upper range, adult pallid sturgeon are collected in depths that vary between 1.97-47.57 ft with bottom water velocities ranging from 2.20 ft/s and 2.62 ft/s (Service 2014a; Bramblett and White 2001; Gerrity 2005). Pallid sturgeon in the LMR have been collected at depths greater than 65 ft with a mean value of 32.81 ft, and water velocities greater than 5.91 ft/s with a mean value of 2.30 ft/s (ERDC unpublished data; Herrala et al. 2014). Turbidity is thought to be an important factor in habitat selection by pallid sturgeon, which have a tendency to occupy more turbid habitats than shovelnose sturgeon (Blevins 2011). In the LMR, pallid sturgeon have been collected in turbidities up to 340 Nephelometric Turbidity Units (NTU's) with a mean value of 90 NTU's (ERDC unpublished data).

Much of the natural habitat throughout the range of pallid sturgeon has been altered by humans, and this is thought to have had a negative impact on this species (Service 2014a). Habitats were once very diverse, and provided a variety of substrates and flow conditions (Baker et al. 1991; Service 1993). Extensive modification of the Missouri and Mississippi rivers over the last 100 years has drastically changed the form and function of the river (Baker et al. 1991; Prato 2003). Today, habitats are reduced and fragmented and much of the Mississippi River basin has been channelized to aid in navigation and flood control (Baker et al. 1991). The extent of impacts from range-wide habitat alteration on the pallid sturgeon is unknown, but recent studies have shown that in the unimpounded reaches (i.e., LMR), suitable habitat is available and supports a diverse aquatic community (Service 2007).

Movement

Like other sturgeon, pallid sturgeon is a migratory fish species that moves upstream annually to spawn (Koch et al. 2012). Movements are thought to be triggered by increased water temperature and flow in spring months (Garvey et al. 2009; Blevins 2011). Pallid sturgeon may remain sedentary, or remain in one area for much of the year, and then move either upstream or downstream during spring (Garvey et al. 2009; Herrala and Schramm 2017). It is possible that because movement in large, swift rivers requires a great amount of energy, this relatively inactive period may be a means to conserve energy (Garvey et al. 2009). Most active periods of movement in the upper Missouri River were between March 20 and June 20 (Bramblett and White 2001). In one study, individual fish traveled an average of 3.73 mi/day and one individual traveled over 9.94 mi/day (Garvey et al. 2009). Pallid sturgeon in the Missouri River have been reported to travel up to 5.90 mi/hour and 13.30 mi/day during active periods (Bramblett and White 2001). Based on a surrogate study that documented recaptures of shovelnose sturgeon in the Missouri River originally tagged in the LMR, pallid sturgeon may similarly undertake long-distance, multi- year upstream movements. Upstream distances approaching 1,245 mi have been recorded (ERDC unpublished data) and similar distances have been recorded for downstream movements (Service unpublished data).

Aggregations of pallid sturgeon have been reported in several locations in the middle Mississippi River, particularly around gravel bars, including one annual aggregation at the Chain of Rocks Dam, which is thought to be related to spawning activities (Garvey et al. 2009). Aggregations of pallid sturgeon in the lower 8.70 mi of the Yellowstone River are also thought to be related to spawning activities of sturgeon from the Missouri River (Bramblett and White 2001). Pallid sturgeon have been found to have active movement patterns during both the day and night, but they move mostly during the day (Bramblett and White 2001). There have been no verified spawning areas located in the LMR.

Feeding

Sturgeon are benthic feeders and are well adapted morphologically (ventral positioning of the mouth, laterally compressed body) for the benthic lifestyle (Service 1993; Findeis 1997). Adult pallid sturgeon are primarily piscivorous (but still consume invertebrates), and are thought to switch to piscivory around age 5 or 6 (Kallemeyn 1983; Carlson et al. 1985; Hoover et al. 2007; Grohs et al. 2009). In a study of pallid sturgeon in the middle and lower Mississippi River, fish were a common dietary component and were represented primarily by Cyprinidae, Sciaenidae, and Clupeidae (Hoover et al. 2007). Other important dietary items for pallid sturgeon in the Mississippi River were larval Hydropsychidae (lnsecta: Trichoptera), Ephemeridae (lnsecta: Ephemeroptera), and Chironomidae (lnsecta: Diptera) (Hoover et al. 2007). Pallid sturgeon diet varies depending on season and location, and these differences probably are related to prey availability (Hoover et al. 2007). In a Mississippi River dietary study, Trichoptera and Ephemeroptera were consumed in greater quantities in winter months in the lower Mississippi River, while the opposite trend was observed in the middle Mississippi River (Hoover et al.

2007). Hoover et al. (2007) also found that in both the middle Mississippi River and the lower Mississippi River, dietary richness is greatest in winter months.

4.1.3. Numbers, Reproduction, and Distribution of Pallid Sturgeon

Spawning

Freshwater sturgeon travel upstream to spawn between the spring equinox and summer solstice, and it is possible that either a second or an extended spawning period may occur in the fall in southern portions of the range (i.e., Mississippi River) (Service 2007; Wildhaber et al. 2007; Schramm et al. 2017). These spawning migrations are thought to be triggered by several cues, including water temperature, water velocity, photoperiod, presence of a mate, and prey availability (Keenlyne 1997; DeLonay et al. 2007; DeLonay et al. 2009; Blevins 2011). Gamete development is completed during the upstream migration and sturgeon are thought to spawn near the apex of their migration (Bemis and Kynard 1997). Data suggests that female *Scaphirhynchus* spp. do not reach sexual maturity until ages 6-17 and spawn every 2-3 years, and that males do not reach sexual maturity until ages 4-9 (Keenlyne and Jenkins 1993; Colombo et al. 2007; Stahl 2008; Divers et al. 2009). Pallid sturgeon and shovelnose sturgeon at lower latitudes (e.g., lower Mississippi River) may begin spawning at an earlier age than those in upper portions of the range (e.g., Upper and Middle Mississippi and Missouri Rivers) because they are thought to have shorter lifespans and smaller sizes (George et al. 2012). Also, LMR pallid sturgeon may be more highly fecund than those in northern portions of their range (George et al. 2012). It is thought that pallid sturgeon, like shovelnose sturgeon spawn over gravel substrates, but spawning has never been observed in this species (Service 1993; DeLonay et al. 2007; DeLonay et al. 2009).

Rearing

Pallid sturgeon hatch when they reach a total length (TL) of approximately ¼-inch. Larvae feed on yolk reserves and drift downstream for l l-17 days, until yolk reserves are depleted (Snyder 2002; Braaten et al. 2008; DeLonay et al. 2009). Length of drift and rate of yolk depletion are dependent on several factors, including water temperature, photoperiod, and water velocity (Snyder 2002; DeLonay et al. 2009). Larval drift is not completely understood and the impacts of artificial structures, as well as the role of eddies, are unknown (Kynard et al. 2007; Braaten et al. 2008). During drift, sturgeon repeat a "swim up and drift" pattern, in which they swim up in the water column from the bottom (<10 in) and then drift downstream (Kynard et al. 2002; Kynard et al. 2007). A hatchery series of shovelnose sturgeon from the Natchitoches National Fish Hatchery (NNFH) in Louisiana (J. Dean, unpublished data) reports complete yolk sac absorption at days 8-9 post-hatch, which is several days sooner than shovelnose sturgeon from Gavins Point National Fish Hatchery in South Dakota, so there could be a latitudinal difference in yolk absorption and larval maturation rates throughout the range of pallid sturgeon (Snyder 2002). The timing of exogenous feeding, which begins when yolk reserves are depleted and drifting has ceased, can differ latitudinally (DeLonay et al. 2009). The switch from endogenous to exogenous feeding is known as the “critical period", because mortality is likely if sturgeon do not find adequate food (Kynard et al. 2002; DeLonay et al. 2009). Pallid sturgeon begin exogenous feeding around 11-12 days post-hatch in upper portions of their range, but exogenous feeding was observed in fish as small as 17.82mm TL in the lower Mississippi River (Harrison et al., unpublished data), which could be as young as 6-8 days (based on unpublished age and growth data from NNFH) post-hatch (Braaten et al. 2007). The diets of young of year and juvenile pallid sturgeon and shovelnose sturgeon in upper portions of their ranges are much like those of the adult shovelnose sturgeon, and are primarily composed of aquatic insects and other benthic macroinvertebrates (Braaten et al. 2007; Wanner et al. 2007; Grohs et al. 2009; Klumb et al. 2009). Young of year and juvenile pallid sturgeon in the LMR feed primarily on Chironomidae over sand in channel habitats (Harrison et al. 2012, unpublished data). Juvenile pallid sturgeon are thought to switch to piscivory around ages 5-6 (Kallemeyn 1983; Carlson et al. 1985; Hoover et al. 2007; Grohs et al. 2009).

Kynard et al. (2002) found larval pallid sturgeon to be photopositive and showed little preference to substrate color, except for a slight preference for light substrates when exogenous feeding began. It is thought that pallid sturgeon become increasingly photonegative starting around day 11 post-hatch (Kynard et al. 2002). In this same study, larval sturgeon swam in open habitats, seeking no cover under rocks in the swimming tube, and aggregated in small groups around days 3-5 post-hatch (Kynard et al. 2002). The black tail phenotype of these young sturgeon is thought to aid in recognition and aggregation (Kynard et al. 2002). Pallid sturgeon have been observed swimming and drifting at a wide range (2-118 in) above the bottom depending on water velocities (although most fish are thought to stay in the lower 20 in of the water column), and drift velocities are thought to range from 0.98-2.29 ft/s (Kynard et al. 2002; Kynard et al. 2007; Braaten et al. 2008). Drift distance of larval sturgeon is thought to be between 85.75-329.33 mi (Kynard et al. 2007; Braaten et al. 2008). Juvenile pallid sturgeon have been found in water depths ranging from an average of 7.58-8.14 ft in the upper Missouri River (Gerrity 2005). Maximum critical swimming speeds for juvenile pallid sturgeon range from 0.32 ft/s to 0.82 ft/s, depending on size, with larger juveniles (6-8 in TL) able to withstand higher water velocities than their smaller counterparts (5-6 in TL) (Adams et al. 1999). In the Lower Mississippi River, larval sturgeon collections are associated with flooded sand bars in secondary channels and sand/gravel reefs in the main channel (Hartfield et al. 2013; Schramm et al 2017).

Distribution and Abundance

Pallid sturgeon occur in parts of the Mississippi River Basin, including the Mississippi River below the confluence of the Missouri River, and its distributary, the Atchafalaya River; and the Missouri River and its tributaries the Yellowstone and Platte Rivers (Kallemeyn 1983; Killgore et al. 2007). Recovery efforts have divided the extensive range of pallid sturgeon into four management units (Service 2013b) based on population variation (i.e., morphological, genetic) and habitat differences (i.e., physiographic regions, impounded, unimpounded reaches) throughout the extensive range of the pallid sturgeon (Service 2013b). These are:

> *Great Plains Management Unit (GPMU)*: The GPMU extends from Great Falls of the Missouri River, Montana, to Fort Randall Dam, South Dakota, and includes the Yellowstone, Marias, and Milk Rivers.
>
> *Central Lowlands Management Unit (CLMU)*: The CLMU includes the Missouri River from Fort Randall Dam, South Dakota, to the confluence of the Grand River, Missouri, and includes the lower Platte and lower Kansas Rivers.

Interior Highlands Management Unit (IHMU): The IHMU includes the Missouri River from the confluence of the Grand River, Missouri, to the confluence of the Mississippi River, Missouri, and the Mississippi River from Keokuk, Iowa, to the confluence of the Ohio River, Illinois.

Coastal Plain Management Unit (CPMU): The CPMU includes the LMR from the confluence of the Ohio River, Illinois, to the Gulf of Mexico, Louisiana (the action area of this consultation), and the Atchafalaya River distributary system, Louisiana.

To date, more than 1,100 pallid sturgeon have been captured in the CPMU since listing (more than 500 pallid sturgeon from the LMR, and more than 600 from the Atchafalaya River) (Killgore et al. 2007; Service database 2018), exceeding capture numbers from all other management units combined. Pallid to shovelnose ratios range between 1:6 to l:3 in the LMR, depending upon river reach, and 1:6 in the Atchafalaya River (Killgore et al. 2007; Service 2007). The ratio of pallid to shovelnose sturgeon in the lower Mississippi River reach where the BCS is located is typically 1:3 (ERDC 2013). Age-0 pallid sturgeon have been captured in both the LMR and the Atchafalaya, although it is unclear exactly where and when spawning occurs (ERDC, unpublished data; Hartfield et al. 2013). Age-0 and immature pallid sturgeon are difficult to distinguish from shovelnose sturgeon (Hartfield et al. 2013); however, capture data indicates annual recruitment of immature pallid sturgeon since 1991 (Service database 2013). The occurrence of *Scaphirhynchus* was extended from River Mile 85 downstream 50 miles to River Mile 33, when ERDC collected two young-of-year *Scaphirhynchus* sturgeon with a trawl in the lower Mississippi River in November of 2016 (USACE 2017).

4.1.4. Conservation Needs of and Threats to Pallid Sturgeon

Much of the following information is taken from Service documents (Service 2000, 2007, 2014b, 2018). The pallid sturgeon was listed due to the apparent lack of recruitment for over 15 years, and the habitat threats existing at the time of listing. Destruction and alteration of habitats by human modification of the river system is believed to be the primary cause of declines in reproduction, growth, and survival of the pallid sturgeon. The historic range of pallid sturgeon as described by Bailey and Cross (1954) encompassed the middle and lower Mississippi River, the Missouri River, and the lower reaches of the Platte, Kansas, and Yellowstone Rivers. Bailey and Cross (1954) noted a pallid sturgeon was captured at Keokuk, Iowa, at the Iowa and Missouri state border. Duffy et al. (1996) stated that the historic range of pallid sturgeon once included the Mississippi River upstream to Keokuk , Iowa, before that reach of the river was converted into a series of locks and dams for commercial navigation (Coker 1930).

Habitat destruction/modification and the curtailment of range were primarily attributed to the construction and operation of dams on the upper Missouri River and modification of riverine habitat by channelization of the lower main stems of the Missouri and Mississippi Rivers. Dams substantially fragmented pallid sturgeon range in the upper Missouri River. However, free-flowing riverine conditions currently exist throughout the lower 2,000 mi (3,218 km) (60 percent) of the pallid sturgeon historical range. Although the lower Missouri River continues to be impacted by regulated flows and modified habitats, actions have been developed and are being implemented to address habitat issues. Recent studies and data from the Mississippi River suggests that riverine habitats are less degraded than previously believed, and that they continue to support diverse and productive aquatic communities, including pallid sturgeon. Although there are ongoing programs to protect and improve habitat conditions in the four management units, positive effects from these programs on pallid sturgeon have not been quantified.

Carlson and Pflieger (1981) stated that pallid sturgeon are rare but widely distributed in both the Missouri River and in the Mississippi River downstream from the mouth of the Missouri River. A comparison of pallid sturgeon and shovelnose sturgeon catch records provides an indication of the rarity of pallid sturgeon. At the time of their original description, pallid sturgeon composed 1 in 500 river sturgeon captured in the Mississippi River at Grafton, Illinois (Forbes and Richardson 1905). Pallid sturgeon were more abundant in the lower Missouri River near West Alton, Missouri, representing one-fifth of the river sturgeon captured (Forbes and Richardson 1905). Carlson et al. (1985) captured 4,355 river sturgeon in 12 sampling stations on the Missouri and Mississippi Rivers. Field identification revealed 11 (0.25 percent) pallid sturgeon. Grady et al. (2001) collected 4,435 river sturgeon in the lower 850 mi (1,367 km) of the Missouri River and 100 mi (161 km) of the middle Mississippi River from November 1997 to April 2000. Field identification revealed nine wild (0.20 percent) and nine hatchery-origin pallid sturgeon.

Today, pallid sturgeon, although variable in abundance, are ubiquitous throughout most of the free flowing Mississippi River. When the pallid sturgeon was listed as endangered they were only occasionally found in the following areas; from the Missouri River: 1) between the Marias River and Fort Peck Reservoir in Montana; 2) between Fort Peck Dam and Lake Sakakawea (near Williston, North Dakota); 3) within the lower 70 mi (113 km) of the Yellowstone River downstream of Fallon, Montana; 4) in the headwaters of Lake Sharpe in South Dakota; 5) near the mouth of the Platte River near Plattsmouth, Nebraska; and, 6) below River Mile 218 to the mouth in the State of Missouri.

Keenlyne (1989) updated previously published and unpublished information on distribution and abundance of pallid sturgeon. He reported pre-1980 catch records for the Mississippi River from its mouth upstream to its confluence with the Missouri River, a length of 1,153 mi (1,857 km); in the lower 35 mi (56 km) of the Yazoo/Big Sunflower and St. Francis Rivers (tributaries to the Mississippi); in the Missouri River from its mouth to Fort Benton, Montana, a length of 2,063 mi (3,323 km); and, in the lower 40 mi (64 km) of the Kansas River, the lower 21 mi (34 km) of the Platte River, and the lower 200 mi (322 km) of the Yellowstone River (tributaries to the Missouri River). The total range is approximately 3,500 mi (5,635 km) of river.

Currently, the Missouri River (1,154 mi) (1,857 km) has been modified significantly with approximately 36 percent of the riverine habitat inundated by reservoirs, 40 percent channelized, and the remaining 24 percent altered due to dam operations (Service 1993). Most of the major tributaries of the Missouri and Mississippi Rivers have also been altered to various degrees by dams, water depletions, channelization, and riparian corridor modifications.

The middle Mississippi River, from the mouth of the Missouri River to the mouth of the Ohio River, is principally channelized with few remaining secondary channels, sand bars, islands and abandoned channels. The middle Mississippi River has been extensively diked; navigation channels and flood control levees have reduced the size of the floodplain by 39 percent.

Levee construction along the lower Mississippi River, from the Ohio River to the Gulf, has eliminated major natural floodways and reduced the land area of the floodplain by more than 90 percent (Fremling et al. 1989). Fremling et al. (1989) also report that levee construction isolated many floodplain lakes and raised river banks. As a result of levee construction, 15 meander loops were severed between 1933 and 1942.

Destruction and alteration of big-river ecological functions and habitats once provided by the Missouri and Mississippi Rivers were believed to be the primary cause of declines in reproduction, growth, and survival of pallid sturgeon (Service 2014a). The physical and chemical elements of channel morphology, flow regime, water temperature, sediment transport, turbidity, and nutrient inputs once functioned within the big-river ecosystem to provide habitat for pallid sturgeon and other native species. On the main stem of the Missouri River today, approximately 36 percent of riverine habitat within the pallid sturgeon range has been transformed from river to lake by construction of six massive earthen dams by the USACE between 1926 and 1952 (Service 1993). Another 40 percent of the river downstream of the dams has been channelized. The remaining 24 percent of river habitat has been altered by changes in water temperature and flow caused by dam operations.

The channelized reach of the Missouri River downstream of Ponca, Nebraska, once a diverse assemblage of braided channels, sandbars, and backwaters, is now confined within a narrow channel of rather uniform width and swift current. Morris et al. (1968) found that channelization of the Missouri River reduced the surface area by approximately 67 percent. Funk and Robinson (1974) calculated that, following channelization, the length of the Missouri River between Rulo, Nebraska, and its mouth (~500 river miles) (310 km) had been reduced by 8 percent, and the water surface area had been reduced by 50 percent.

Missouri River aquatic habitat between and downstream of main stem dams has been altered by reductions in sediment and organic matter transport/deposition, flow modification, hypolimnetic releases, and narrowing of the river through channel degradation. Those activities have adversely impacted the natural river dynamics by reducing the diversity of bottom contours and substrates, slowing accumulation of organic matter, reducing overbank flooding, changing seasonal patterns, severing flows to backwater areas, and reducing turbidity and water temperature (Hesse 1987). The Missouri River dams also are believed to have adversely affected pallid sturgeon by blocking migration routes and fragmenting habitats (Service 2014a).

The pattern of flow velocity, volume, and timing of the pre-development rivers provided the essential life requirements of native large-river fishes like the pallid sturgeon and paddlefish. Hesse and Mestl (1993) found a significant relationship between the density of paddlefish larvae and two indices (timing and volume) of discharge from Fort Randall Dam. They concluded that when dam operations caused discharge to fluctuate widely during spring spawning, the density of drifting larvae was lower, and when annual runoff volume was highest, paddlefish larval density was highest. Hesse and Mestl (1987) also modeled these same two indices of discharge from Fort Randall Dam with an index of year-class strength. They demonstrated significant negative relationships between artificial flow fluctuations in the spring and poor year-class development for several native and introduced fish species including river carpsucker, shorthead redhorse, channel catfish, flathead catfish, sauger, smallmouth buffalo, and bigmouth buffalo. The sample size of sturgeon was too small to model in that study; however, a clear relationship existed between poor year-class development in most native species studied and the artificial hydrograph.

Modde and Schmulbach (1973) found that during periods of low dam releases, the secondary subsidiary channels, which normally feed into the river channel, become exposed to the atmosphere and thus cease to contribute littoral benthic organisms into the drift. Schmulbach (1974) states that use of sandbar habitats were second only to cattail marsh habitats as nursery ground for immature fishes of many species.

Even though extensive flood control, water supply, and navigation projects constrict and control the Missouri and Mississippi Rivers with reservoirs, stabilized banks, jetties, dikes, levees, and revetments, relatively unaltered remnant reaches of the Missouri River and the Mississippi River from the Missouri River confluence to the Gulf of Mexico still provide habitat useable by pallid sturgeon. However, anthropogenic alterations (i.e., levee construction) effectively increased river stage and velocities at higher discharges by preventing overbank flows on the adjacent floodplains (Baker et al. 1991).

The upper ends of the reservoirs in the upper basin may be influencing the recruitment of larval sturgeon. Both shovelnose sturgeon and pallid sturgeon larvae have a propensity to drift after hatching (Kynard et al. 1998a, 1998b). Bramblett (1996) found that the pallid sturgeon may be spawning in the Yellowstone River between River Mile 9 and River Rile 20 upriver, and that from historic catch records, there is some evidence to indicate that the occurrence of pallid sturgeon catches coincide with the spring spawning at the mouth of the Tongue River (Service 2000). Shovelnose sturgeon have been found to spawn in the tributaries of the Yellowstone River as well as such areas as the Marias, Teton, Powder and Tongue Rivers (Service 2000). Shovelnose sturgeon are successfully recruiting and reproducing in the river stretches in the upper basin and this may be directly related to the amount of larval and juvenile habitat they have available downstream of the spawning sites.

Early indications in culturing pallid sturgeon indicate that sturgeon larvae will not survive in a silty substrate. In 1998, most of the larval sturgeon held in tanks at Gavins Point National Fish Hatchery (NFH), experienced high mortality when the water supply contained a large amount of silt which settled on the bottom of the tanks. Migration routes to spawning sites on the lower Yellowstone River have been fragmented by low-head dams used for water supply intakes. Such habitat fragmentation has forced pallid sturgeon to spawn closer to reservoir habitats and reduced the distance larval sturgeon can drift after hatching.

Historically, pallid, shovelnose, and lake sturgeon were commercially harvested in all States on the Missouri and Mississippi Rivers (Helms 1974). The larger lake sturgeon and pallid sturgeon were sought for their eggs which were sold as caviar, whereas shovelnose sturgeon were historically destroyed as bycatch. Commercial harvest of all sturgeon has declined substantially since record-keeping began in the late 1800s. Most commercial catch records for sturgeon have not differentiated between species and combined harvests as high as 430,889 lb (195,450 kg) were recorded in the Mississippi River in the early 1890s, but had declined to less than 20,061 lb (9,100 kg) by 1950 (Carlander 1954). Lower harvests reflected a decline in shovelnose sturgeon abundance since the early 1900s (Pflieger 1975). Today, commercial harvest of SS is still allowed in 5 of the 13 states where pallid sturgeon occur.

Mortality of pallid sturgeon occurs as a result of illegal and incidental harvest from both sport and commercial fishing activities (Service 2000). Sturgeon species, in general, are highly vulnerable to impacts from fishing mortality due to unusual combinations of morphology, habits, and life history characteristics (Boreman 1997). In 1990, the head of a pallid sturgeon was found at a sport-fish cleaning station in South Dakota, and in 1992 a pallid sturgeon was found dead in a commercial fisherman's hoop net in Louisiana. In 1997, four pallid sturgeon were found in an Illinois fish market (Sheehan et al. 1997). It is probable that pallid sturgeon are affected by the illegal take of eggs for the caviar market. In 1999, a pallid sturgeon that was part of a movement and habitat study on the lower Platte River was harvested by a recreational angler (Service 2000). Bettoli et al. (2008) found 1.8 percent of the total sturgeon catch in Tennessee caviar harvest were composed of pallid sturgeon. In addition, such illegal and incidental harvest may skew pallid sturgeon sex ratios such that hybridization with shovelnose is exacerbated. Killgore et al. (2007) indicated that higher mortality rates for pallid sturgeon in the Middle Mississippi River may be a result of habitat limitation and incidental take by the commercial shovelnose fishery.

Currently, only a sport and/or aboriginal fishery exist for lake sturgeon, due to such low population levels (Todd 1998). SS are commercially harvested in eight states and a sport fishing season exists in a number of states (Mosher 1998). Although information on the commercial harvest of shovelnose sturgeon is limited, Illinois reported the commercial harvest of shovelnose sturgeon was 43,406 lbs (19,689 kg) of flesh and 233 lbs (106 kg) of eggs in 1997 and Missouri reported a 52-year mean annual harvest of 8,157 lbs (3,700 kg) of flesh (Todd 1998) and an unknown quantity of eggs for 1998. Missouri also has a sport fishery for shovelnose sturgeon but has limited data on the quantities harvested (Mosher 1998).

The previous lack of genetic information on the pallid sturgeon and shovelnose sturgeon led to a hybridization debate. In recent years, however, several studies have increased our knowledge of the genetic, morphological, and habitat differences of those two species. Campton et al. (1995) collected data that support the hypothesis that pallid sturgeon and shovelnose sturgeon are reproductively isolated in less altered habitats, such as the upper Missouri River. Campton et al. (2000) suggested that natural hybridization, backcrossing, and genetic introgression between pallid sturgeon and shovelnose sturgeon may be reducing the genetic divergence between those species. Sheehan has identified 86 separate loci for microsatellite analysis that are being used to differentiate between pallid sturgeon, shovelnose sturgeon, and suspected hybrid sturgeon (Service 2000).

Bramblett (1996) found substantial differences in habitat use and movements between adult pallid sturgeon and shovelnose sturgeon in less altered habitats. Presumably, the loss of habitat diversity caused by human-induced environmental changes inhibits naturally occurring reproductive isolating mechanisms. Campton et al. (1995) and Sheehan et al. (1997) note that hybridization suggests that similar areas are currently being used by both species for spawning.

Carlson et al. (1985) studied morphological characteristics of 4,332 sturgeon from the Missouri and middle Mississippi Rivers. Of that group, they identified 11 pallid sturgeon and 12 pallid sturgeon /shovelnose sturgeon hybrids. Suspected hybrids have recently been observed in commercial fish catches on the lower Missouri and the middle and lower Mississippi Rivers (Service 2000). Bailey and Cross (1954) did not report hybrids, which may indicate that hybridization is a recent phenomenon resulting from environmental changes caused by human-induced reductions in habitat diversity and measurable changes in environmental variables such as turbidity, flow regimes, and substrate types (Carlson et al. 1985). A study by Keenlyne et al. (1994) concluded that hybridization may be occurring in half the river reaches within the range of pallid sturgeon and that hybrids may represent a high proportion of remaining sturgeon stocks. Hartfield and Kuhajda (2009) stated that hybridization rates in the Mississippi River have been overestimated, and there is no direct evidence linking the morphological or genetic variation defined as hybridization between pallid sturgeon and shovelnose sturgeon in the lower Missouri, Mississippi, or Atchafalaya Rivers with recent anthropogenic activities. Hybridization could present a threat to the survival of pallid sturgeon through genetic swamping if the hybrids are fertile, and through competition for limited habitat (Carlson et al. 1985). Keenlyne et al. (1994) noted few hybrids showing intermediacy in all characteristics as would be expected in a first generation cross, indicating the hybrids are fertile and reproducing.

Hubbs (1955) indicated that the frequency of natural hybridization in fish was a function of the environment, and the seriousness of the consequences of hybridization depends on hybrid viability. Hybridization can occur in fish if spawning habitat is limited, if many individuals of one potential parent species lives in proximity to a limited number of the other parent species, if spawning habitat is modified and rendered intermediate, if spawning seasons overlap, or where movement to reach suitable spawning habitat is limited (Hubbs 1955). Any of those conditions, or a combination of them, could be causing the apparent breakdown of isolating mechanisms that prevented hybridization between these species in the past (Keenlyne et al. 1994). Hartfield and Kuhajada (2009) examined three of the five original specimens used to describe the pallid sturgeon and found that the character indices currently used to distinguish the fish identify some of the type specimens as hybrids. In conclusion, they stated they found no evidence directly linking habitat modification and hybridization particularly in the Mississippi River and no evidence that hybridization constitutes an anthropogenic threat to the pallid sturgeon.

More recent studies have documented extensive hybridization between pallid sturgeon and shovelnose sturgeon in the Lower Mississippi River (Coastal Plain Management Unit) (Jordan et al. 2019). These studies also confirmed that small numbers of genetically pure pallid sturgeon continue to occupy the Lower Mississippi River; however, genetic analysis is required for their accurate identification. Please refer to Section 3.1 Species Description for an explanation of why we consider all phenotypic pallid sturgeon as protected under the Act for the purposes of management and consultation.

Although more information is needed, pollution is also likely an exacerbating threat to the species over much of its range. Pollution of the Missouri River by organic wastes from towns, packing houses, and stockyards was evident by the early 1900s and continued to increase as populations grew and additional industries were established along the river. Due to the presence of a variety of pollutants, numerous fish-harvest and consumption advisories have been issued over the last decade or two from Kansas City, Missouri, to the mouth of the Mississippi River. That distance represents about 45 percent of the pallid sturgeon total range. Currently there are no advisories listed by the U.S. Environmental Protection Agency (EPA) south of Tennessee (approximately 710 miles).

Polychlorinated biphenyls (PCBs), cadmium, mercury, and selenium have been detected at elevated, but far below lethal, concentrations in tissue of three pallid sturgeon collected from the Missouri River in North Dakota and Nebraska. Detectable concentrations of chlordane, dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyltrichloroethane (DDT), and dieldrin also were found (Ruelle and Keenlyne 1994). The prolonged egg maturation cycle of pallid sturgeon, combined with bioaccumulation of certain contaminants in eggs, could make contaminants a likely agent adversely affecting eggs and embryos, as well as development or survival of fry, thereby reducing reproductive success.

In examining the similarities and differences between shovelnose sturgeon and pallid sturgeon, Ruelle and Keenlyne (1994) concluded that, while the shovelnose sturgeon may not meet all the traits desired for a surrogate, it may be the best available for contaminant studies. Conzelmann et al. (1997) reported that trace element concentrations in Old River Control Complex (ORCC) shovelnose sturgeon in Louisiana were generally higher than in shovelnose sturgeon from other areas. Certain trace elements can adversely affect reproduction, development, and may ultimately be lethal if concentrations are excessive. Most trace element levels were unremarkable; however, cadmium, copper, lead, and selenium concentrations were elevated in ORCC samples and may warrant concern (Conzelmann et al. 1997).

Conzelmann et al. (1997) also reported that organochlorine (OC) pesticide concentrations are the main environmental concern in Louisiana's shovelnose sturgeon, and consequently, in the pallid sturgeon. Shovelnose sturgeon OC concentrations were generally greater than were observed in fishes from other areas, and ORCC shovelnose sturgeon toxaphene levels were elevated compared to the National Contaminants Biomonitoring Program. Toxaphene possesses known carcinogenic, teratogenic, xenotoxic, and mutagenic properties; can cause suppression of the immune system; and may function as an endocrine system imitator, blocker, or disrupter (Colburn and Clements 1992). Those factors make toxaphene the greatest OC concern in ORCC SS and, by extension, the ORCC pallid sturgeon (Conzelmann et al. 1997). Further investigations are needed to identify contaminant sources in the Mississippi and Atchafalaya Rivers and to assess the role, if any, of contaminants in the decline of pallid sturgeon populations.

Another issue that is negatively impacting pallid sturgeon throughout its range is entrainment. The loss of pallid sturgeon associated with water intake structures has not been accurately quantified. The EPA published final regulations on Cooling Water Intake Structures for Existing Facilities per requirements of Section 316(b) of the Clean Water Act. The rule making was divided into three phases. However, only Phase I and II appear applicable to inland facilities; Phase III applies to coastal and offshore cooling intake structures associated with coastal and offshore oil and gas extraction facilities. The following rule summaries are based on information found at https://www.epa.gov/cooling-water-intakes. Phase I rules, completed in 2001, require permit holders to develop and implement techniques that will minimize impingement mortality and entrainment. Phase II, completed in 2004, covers existing power generation facilities that are designed to withdraw 50 million gallons per day or more with 25 percent of that water used for cooling purposes only. Phase II and the existing facility portion of Phase III were remanded to EPA for reconsideration and a final rule combined the remands into one rule in 2014. This rule, implemented through National Pollutant Discharge Elimination System permits, is intended to minimize negative effects associated with water cooling structures.

Section 316(b) of the Clean Water Act requires the EPA to insure that aquatic organisms are protected from impingement or entrainment. As part of the Phase II ruling, some power plants have begun conducting required entrainment studies. Preliminary data on the Missouri River suggests that entrainment may be a serious threat that warrants more investigation. Initial results from work conducted by Mid-America at their Neal Smith power facilities found hatchery-reared pallid sturgeon were being entrained (Jordan in litt. 2006; Ledwin in litt. 2006; Williams in litt. 2006). Over a 5-month period, four known hatchery-reared pallid sturgeon have been entrained, of which two were released alive and two were found dead. Ongoing entrainment studies required by the Clean Water Act will provide more data on the effects of entrainment. However, addressing entrainment issues may not occur immediately and continued take of hatchery reared or wild pallid sturgeon will limit the effectiveness of recovery efforts. In addition to cooling intake structures for power facilities, concerns have been raised regarding entrainment associated with dredge operations and irrigation diversions. Currently little data are available regarding the effects of dredge operations. However, the USACE St. Louis District, and the Dredging Operations and Environmental Research Program have initiated work to assess dredge entrainment of fish species and the potential effects that these operations may have on larval and juvenile *Scaphirhynchus*. Data for escape speed, station-holding ability, rheotaxis and response to noise, and dredge flow fields are being used to develop a risk assessment model for entrainment of sturgeon by dredges. Entrainment has been documented in the irrigation canal supplied by the Intake Dam on the Yellowstone River (Jaeger et al. 2004). Given that entrainment has been documented to occur in the few instances it has been studied, further evaluation of entrainment at other water withdrawal points is warranted across the pallid sturgeon range to adequately evaluate this threat. Entrainment of pallid sturgeon stocked in the Mississippi River into the Atchafalaya River via the ORCC has been documented by the capture of a tagged stocked sturgeon that was released into the Mississippi River.

BOs which allow the take of pallid sturgeon also represent a factor that should be considered when examining factors that could have an influence on the pallid sturgeon population. The table below (Table 1) presents all completed BOs for the LMR.

4.1.5. Tables and Figures for Status of Pallid Sturgeon

Table 1. BOs conducted for actions occurring on the Lower Mississippi River that impacted pallid sturgeon. Critical habitat is not designated for this species; thus, none is included here.

BOs (year)	Action Affecting PALLID STURGEON	Authorized Take	Take Reported
2003	BO addressing the Natchitoches National Fish Hatchery's Collection of Endangered Pallid Sturgeon from Louisiana Waters for Propagation and Research	90 adults/season for 5 season (harassment) 8 adults/season for 5 seasons (death)	23 harassment (2003)
2004	Modification to revise 2003 IT estimates for BO (4-7-3-702) on Natchitoches National Fish Hatchery's Activities	120 adults/season for 5 (harassment) 14 adults/season for (death) potential	329 (Atchafalaya) harassment (through 2010) 7 dead (2004)
2004	Programmatic BO addressing the effects of the Southeast region's Section 10(a)(1)(A) Permitting on the pallid sturgeon (5-years)	28 adults in captive propagation/year (death) 2,500 to 15,000 captive year-class 90 days old or older (one-time loss-death) 200 larval/juvenile/year sampling (death) 3, 5-inch or greater fish/year netting (death or injury) 3 fish/year external tagging (death or injury) 1 fish/year transport (death) 5 fish/year radio-tracking (death or injury)	461 (LMR) harassment (through 2012) 1 dead (2006) 2 dead (2007) 1 dead (2009)
2005	Modification 2 – adding new forms of take to the 2004 revised Incidental Take Statement (4-7-04-734) for the 2003 BO (4-7-03-702) on Natchitoches National Fish Hatchery's Activities	14 wild pallid sturgeon/season (death) 15,000 hatchery-reared pallid sturgeon/season (death)	NA
2009	BO addressing the 2008 Emergency Opening of Bonnet Carré Spillway, USACE	14 adults (harassment) 92 adults (death)	14 adult harassment Unknown deaths
2010	BO addressing the Medium White Ditch Diversion	23 adults/year (death) potential	0
2010	BO addressing the small diversion at Convent/Blind River	7 adults/year (death) potential	0
2010	BO addressing the Taxonomic ID study	100 adults (death)	76
2013	Modification of the Programmatic BO	21 adults/year(death) potential	0
2013	BO addressing the USACE CIP	Unspecified	0
2014	BO addressing the USACE Permits for Sand and Gravel Mining in the Lower Mississippi River	Unspecified	NA
2018	BO addressing the Bonnet Carré Spillway 2011 and 2016 Emergency Operations	2011 – 20 adults (harassment) 82 adults (death) 2016 – 26 adults (death)	2011 – 20 adults Unknown deaths 2016 – N/A Unknown deaths
2020	BO addressing the Bonnet Carré Spillway 2018 Emergency Operation	14 adults (death) 2 adults (harassment)	4 adults – 2 harassment, 2 dead
2021	BO addressing the Bonnet Carré Spillway 2019 Emergency Operations	83 adults (death) 18 adults (harassment)	19 adults – 18 harassment, 1 dead
2021	BO addressing the Bonnet Carré Spillway 2020 Emergency Operations	9 adults (death) 9 adults (harassment)	12 adults – 9 harassment, 3 dead
Total[1]		160 adults/year (harassment) 397 adults (death) 14-28/year (potential death) 200 larval fish/year (potential death) 2,500-15,000 year-class 90 days old or older (one-time loss-death)	867 adult harassment 90 adult known dead Unknown <200/year larvae collected

4.2. Environmental Baseline

This section is an analysis of the effects of past and ongoing human and natural factors leading to the current status of the pallid sturgeon, its habitat, and ecosystem within the Action Area. The environmental baseline refers to the condition of the listed species or its designated critical habitat in the Action Area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the Action Area, the anticipated impacts of all proposed Federal projects in the Action Area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR §402.02).

4.2.1. Action Area Numbers, Reproduction, and Distribution

The Action under consultation occurs within the LMR area of the Coastal Plains Management Area. The range-wide status of the pallid sturgeon within the action area is discussed within the STATUS OF THE SPECIES/CRITICAL HABITAT section above. As noted in that section, the abundance of pallid sturgeon in the Mississippi River is not precisely known; however, collection efforts show the species is widespread and not uncommon in the LMR. There is an estimated 95 percent probability that the population has more than four age 3+ pallid sturgeon per 6.44 RM (Friedenberg et al. 2018). Pallid sturgeon have been documented as occurring in the LMR adjacent to the Barataria Basin (LDWF 2014). While evidence of the abundance and age structure of the pallid sturgeon population downstream of New Orleans is scarce, two young-of-year *Scaphirhynchus spps.* were collected at RM 33, well below the proposed location of the Action, and the farthest downstream a mature individual has been captured was at RM 95 near New Orleans (Friedenberg and Siegrist 2019). The low numbers detected south of RM 85 could be due to low abundance of the species; however, it could also be attributed to the limited sampling effort in that area (J. Kilgore, personal communication, 2018).

Three potential density scenarios were used to estimate abundance of pallid sturgeon in the action area (Friedenberg and Siegrist 2019). These estimates were calculated on the local level, the LMR from the location of the sand weir to the Atchafalaya River at RM 312, as well as on the a scale occupying the entire LMR up to RM 953 at the confluence of the Ohio River (Table 2) The population density scenarios used to estimate pallid sturgeon population size are described as follows:

- **50% population density** – The assumption that pallid sturgeon population density falls by half downstream of New Orleans. The scenarios assumed there were 3.22 age 3+ pallid sturgeon/RM in the 45 RM between the sand weir and New Orleans, and for the 217 RM upstream to the Atchafalaya River, there were 6.44 age 3+ pallid sturgeon/RM.
- **10% population density** – Due to general agreement that pallid sturgeon population density decreases in the lower reaches of the LMR, it assumed a population density of 0.644 age 3+ pallid sturgeon/RM downstream of New Orleans.

- **Juveniles only** – Assumed the pallid sturgeon population in the vicinity of the diversion only included juveniles

The hard substrates that act as natural spawning habitat for pallid sturgeon are lacking in the LMR; therefore, spawning is assumed not to occur in this reach of the river (Baker et al. 1991, Dryer and Sandvol 1993, Friedenberg and Siegrist 2019).

4.2.2. Action Area Conservation Needs of and Threats

The action area conservation needs and threats would be among those previously discussed under STATUS OF THE SPECIES/CRITICAL HABITAT, but would include only those pertaining to the southern portion (LMR) of the species' range as previously described. This section of the river has been heavily modified for the purposes of navigation and has few remaining natural features necessary for the pallid sturgeon. Contaminants in water, sediments, or prey species could float down river and be in the vicinity of the action area which could affect any pallid sturgeon present.

While the Action Area would occur at RM 60.7 of the Mississippi River, north of this area other diversion structures are in operation that either are known to (Old River Control Complex and Bonnet Carré Spillway) or are suspected to (Caernarvon and Davis Pond) entrain pallid sturgeon. Since the pallid sturgeon has been listed, the Bonnet Carré Spillway has been opened nine times (1994, 1997, 2008, 2011, 2016, 2018, twice in 2019, and 2020). Entrainment rates of pallid sturgeon through the Bonnet Carré Spillway depend on water volume and velocity through structure, length of operation, and time of year of operation. At RM 50, below the Action Area, the USACE constructs a temporary sand weir using dredge material during low water months to manage salinity. It is believed that individuals below the temporary weir may be lost from the population due to low quality habitat as well as seasonal inhibition to upstream movement due to the weir.

4.2.3. Tables and Figures for Environmental Baseline

Table 2. Abundance of age 1+ pallid sturgeon used to calculate entrainment mortality at the scale of the local population and the LMR (Friedenberg and Siegrist 2019).

Age Structure	Pallid Sturgeon Abundance	
	Local Population	Lower Mississippi River Population
50% Density	1,954	7,177
10% Density	1,806	7,031
Juveniles Only	1,769	6,994
Source: Friedenberg et al. 2018		

4.3. Effects of the Action

This section analyzes the effects of the Action on the pallid sturgeon. Effects of the Action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the Action may occur later in time and may include consequences occurring outside the immediate area involved in the Action (50 CFR §402.02). Our analyses are organized according to the description of the Action and the defined Action Area in Section 2 of this BO.

4.3.1. Effects of Project Construction

Pallid sturgeon are known to occur within the Mississippi River near the diversion. During construction activities in the Mississippi River, such as dredging, vessel operations, pile driving and pier construction, there is a potential to disturb or injure pallid sturgeon near the action area. These sounds would be added to the baseline sound conditions of the Mississippi River. Noises from natural sources, such as wind-driven waves, storms, fish, currents, and vocalizing marine mammals are represented as ambient underwater sound levels. Underwater noise levels increase when anthropogenic sources are added to ambient noises. Anthropogenic underwater sound in the Mississippi River could be generated by fishing and recreational vessels, large commercial vessels, pile-driving, and dredging.

Collaboratively, NOAA, the Service, and the U.S. Federal Highway Administration established underwater sound levels for noise thresholds for fish behavior disruption and injury shown in Table 3 (WSDOT 2008). "Effective quiet" or safe exposure levels recognized by the National Marine Fisheries Service (NMFS) are as low as 150 decibels (dB); therefore, sounds below that level of effective quiet will not harass fish (NMFS 2016b). In-water construction and maintenance activities that could potentially increase underwater sound levels are described in Table 5.3.8-1 of the BA (LA TIG 2021). Vibratory pile driving generates generally 10 dBA to 20 dBA (A-weighted decibel scale) lower than impact driving; thus, the proposed project intends to use vibratory pile driving hammers where possible (WSDOT 2019). However, while quieter than impact pile driving, vibratory pile driving can still result in a cumulative sound energy effect. While vessel operations that occur in the river could produce in-water noise disturbance, those noise levels are less than the injury effects threshold (i.e., 206 dB_{PEAK}) and are composed of a different sound signature than pile driving activities.

Underwater noise calculations for impact pile driving in the Mississippi River are expected to produce underwater sound levels of up to 208 dB_{Peak}, 190 dB_{RMS}, and 180 dB SEL, while vibratory pile driving is expected to produce underwater sounds levels of 182 dB_{Peak}, 165 dB_{Rms}, and 165 dB SEL (NOAA 2018). Over a duration of 1 to 2 months, a total of 132, 30- to 36-inch-diameter pilings are proposed to be installed in the river using impact pile driving. Vibratory pile driving is anticipated to occur for 5 to 10 months in the river cofferdam vicinity.

Underwater sounds would be generated from impact pile driving activities to construct a pier and the cofferdam may be encountered by sturgeon within 3,281ft of these activities which could potentially injure those sturgeon, while behavioral impacts could extend to approximately 15,230 ft. The sounds from the impact pile driving activities would be the loudest underwater sound the species will encounter. These activities will be located along the western bank of the Mississippi River, where the river is approximately one-half mile wide near RM 60.7, which might not allow for unobstructed passage by fish through the areas of higher noise. Barotraumas (injuries caused by pressure waves, such as hemorrhage and rupture of internal organs), temporary stunning, and alterations in behavior are known to be caused by high underwater sound pressure levels (SPL) which can injure and/or kill fish (Turnpenny et al. 1994, Turnpenny and Nedwell 1994, Popper 2003, Hastings and Popper 2005). Sturgeon have swim bladders which makes them more susceptible to barotraumas from impulsive sounds than fish without swim bladders. Juvenile white sturgeon have been found to be more susceptible to barotrauma after initial feeding due to the potential for herniation in their intestines. While the swim bladders partially inflate later in development because of the physiology of the swim bladder in sturgeon, gas transfers from the swim bladder can be released through the sturgeon's mouth (Brown et al. 2013).

Although behavioral responses in fish due to elevated underwater sound are not well understood, the responses could include a startle response, delayed foraging, or avoidance of the area. Feist et al. (1992) found that broad-band pulsed noise, such as impact pile driving noise, rather than continuous, pure tone noise like vibratory pile driving were more effective at altering fish behavior. Studies found that juvenile salmonids (40- to 60-millimeter in length) exhibit a startle response followed by an adjustment to low frequency noise in the 7 to 14 hertz (Hz) range (Knudsen et al. 1992 and 1994, Mueller et al. 1998). Those same studies also showed that noise intensity level must be 70 dB to 80 dB above the hearing threshold of 150 Hz to achieve a behavior response. To produce a behavioral response in herring, Olsen (1969) found ambient sound must be at least 24 dB less than the minimum audible field of the fish, and pile driving noise levels have to be 20 dB to 30 dB higher than sound levels. Juvenile sturgeon and herring are of similar size; therefore, herring can serve as a surrogate. Behavioral responses of pallid sturgeon are expected to be short-term and intermittent while construction is being conducted (approximately 8-12 hours/day).

A cofferdam with about 60-foot-wide cells supported by a stability berm, would be constructed to isolate approximately 9.25 acres of the Mississippi River of which about 8 acres of the isolated area will be excavated for the intake structure development. The isolated area of the river using the cofferdam could reduce habitat available to sturgeon, and any fish within the cofferdam area during installation may be lost. Temporary construction activities of the MBSD could potentially alter pallid sturgeon habitat downstream, such as scour holes, sandbars, and flow refugia, due to the alteration of the Mississippi River flow volumes downstream of the construction area; however, because of the dynamic system of the river these alterations are not likely to be significant. Habitats used by larvae, juveniles, or migrating adults could be altered but spawning habitat for pallid sturgeon is not known to occur in the area of the river near the proposed project area so spawning habitat will not be altered.

Studies have collected pallid sturgeon from a range of turbidity conditions, including highly altered areas with consistently low turbidities (i.e., 5-100 nephelometric turbidity units (NTU)) to comparatively natural systems such as the Yellowstone River that has seasonally high turbidity levels (>1,000 NTU) (Braaten and Fuller 2002, 2003; Erickson 1992, Jordan et al. 2006, Peters and Parham 2008). Highly turbid river systems such as the Mississippi River are components of natural ecological processes in which pallid sturgeon evolved. Therefore, increased turbidity in the river from the construction activities is not anticipated to directly impact the pallid sturgeon.

Table 3. Guidance on Fish Underwater Noise Thresholds.

Functional Hearing Group	Noise Thresholds	
	Behavioral Disruption Threshold	Injury Threshold
Fish > 2 grams Fish < 2 grams Fish all sizes	150 dB RMS	187 dB Cumulative SEL 183 dB Cumulative SEL Peak 206 dB
SEL = sound exposure level = 1 dB re 1 μPa2 -sec RMS = For pile driving, this is the square root of the mean square of a single pile driving impulse pressure event Source: WSDOT 2018, NMFS 2018		

4.3.2. Effects of Diversion Operation

Depths utilized by pallid sturgeon have been reported throughout its range; however, because of the varying total depth of the rivers throughout its range this information may have limited applicability to the LMR, unless depth is expressed as a percent of the total river depth. Water depth elevations in the Mississippi River where the training walls and intake channel of the structure occur are approximately -50 feet to -70 feet North American Vertical Datum (NAVD) (LA TIG 2021). The calculated percent of total river depth utilized by pallid sturgeon is approximately 70ft (Bramblett 1996 cited in Constant et al. 1997; Constant et al. 1997). Using that percentage compared to water depths during the diversion would indicate that pallid sturgeon should not be found in the batture in front of the structure during its operation. However, the usage of this habitat has never been quantified (incidental usage or actively used) or documented in literature. Incomplete knowledge of pallid sturgeon life history, especially in the LMR, does not preclude high water usage of the batture as feeding habitat or velocity refugia.

Depending on annual flow cycles, the MBSD is anticipated to operate at high-flow of 75,000 cfs for an average of 9 months out of the year for the first few decades and is anticipated to slowly increase peak flow operations to a maximum of 11 months out of the year by 2070. Base flow operations would keep a flow of 5,000 cfs through the MBSD. Past operations of the Bonnet Carré Spillway (at RM 133) have various numbers of pallid sturgeon entrained depending on factors such as flow, length of opening, and temperature (Service 2021a). During the 2011 emergency operation of the Bonnet Carré Spillway, which had a maximum flow of 315,930 cfs, entrainment of 20 pallid sturgeon was recorded compared to the entrainment one pallid sturgeon recorded after the emergency operations in 2020 with a maximum flow of 90,000 cfs (Service 2021b). Schultz (2013) found that small numbers of pallid sturgeon were entrained by the Davis Pond Freshwater Diversion (RM 119) while no pallid sturgeon were detected at smaller diversions that were sampled (at RM 83.8, 81.5, 64.5, and 63.9).

The Pallid Sturgeon Lower Basin Recovery Workgroup (Workgroup) has identified information gaps essential to the consultation and recovery processes in the Lower Mississippi River Basin. These include the following: relative abundance of pallid sturgeon, demographics, feeding habits, habitat use, hybridization ratios, presence of fish diseases in the wild, population anomalies, and reliable separation and identification of pallid sturgeon, shovelnose sturgeon, and hybrids. A more recent information gap identified by the Workgroup is the entrainment of adult and juvenile pallid sturgeon through the ORCC and potential entrainment through the existing coastal wetland restoration diversions. The implications of the MBSD operations on sturgeon populations within the LMR can be better understood due to the completion of the "Entrainment Studies of Pallid Sturgeon Associated with Water Diversions in the Lower Mississippi River" (ERDC 2013), although some data gaps remain. ERDC is currently conducting sturgeon entrainment studies at the ORCC, and has documented entrainment of sonic-tagged pallid sturgeon and shovelnose sturgeon. While the specific reasons for sturgeon entrainment are unknown, researchers hypothesize one or more of the following reasons: (1) sturgeon located near the structure during the opening are immediately entrained; (2) sturgeon actively swim into the structure to obtain refuge or prey, or to move into a perceived transit path; or, (3) sturgeon are entrained passively or actively during down-river migration (Service 2018d). Pallid sturgeon, as well as other sturgeon species, have positive rheotaxis and will orient into the direction of water flow (Hoover et al. 2011). Based on past collections of pallid sturgeon after Bonnet Carré Spillway emergency operations, near the spillway structure and in the depression being dewatered after closure of the spillway, it is possible pallid sturgeon would be found near the MBSD when it transitions from peak to base flow.

There are no known topographic or hydrographic features (apart from current) that would appear to attract the sturgeon to the vicinity of the MBSD.

Effects of the action on larval, fry, and juvenile fish

The presence of two larval *Scaphirhynchus* collected at RM 33, well below the proposed location of the MBSD, provided evidence for the presence of early life stages in the proposed project area (Friedenberg and Siegrist 2019). The methods to collect larval and young-of-year (YOY) *Scaphirhynchus* have been refined during the past decade; therefore, the numbers of larval *Scaphirhynchus* collected within the Mississippi River have increased (Herzog et al. 2005; Hrabik et al. 2007; Phelps et al. 2010). In 1985, a shovelnose sturgeon larva was collected at White Castle (River Mile 193) (Constant et al. 1997). Larval shovelnose sturgeon have also been collected near Vicksburg, Mississippi, (River Mile 435) approximately 374 miles upstream of the proposed MBSD (Constant et al. 1997; Hartfield et al. 2013; Schramm et al. 2017). Kynard et al. (2002) and Braaten et al. (2008) reported longer larval drift times; thus, greater distances were traveled by pallid sturgeon larva when compared to shovelnose sturgeon larva. Pallid sturgeon larvae were determined to travel at approximately the mean river velocity for the first 11 days after hatching and then slightly slower for the next 6 days because of the sturgeon's transition to a benthic life stage. Distances covered during larval drift are affected by water velocity; however, water temperature can affect larval/fry development rates (warmer temperatures increase development rates) which would also affect drift distances. Higher water velocities occur with larger flood events (USACE 2009). Water velocities in the Mississippi River south of Baton Rouge (River Mile 231) have been documented to range from 4.4 feet per second (fps) to 1.5 fps depending on the discharge. South of Baton Rouge the river channel is larger and the slope of the river decreases; thus, velocities are slower than those above Baton Rouge (Wells 1980). Surface water velocities measured north of Baton Rouge range from 2.9 fps to 5.6 fps for discharges of 200,000 cubic feet per second (cfs) to l million cfs, respectively.

Three surface velocity cross-sections taken south of Baton Rouge at discharges of 350,000, 460,000, and 470,000 cfs never had velocities greater than 4 fps, but a surface velocity cross-section taken north of Baton Rouge measured velocities in excess of 5 fps for a discharge of 310,000 cfs (Wells 1980). The MBSD operation plan calls for initial opening of the diversion gates when the Mississippi River gage in Belle Chasse reaches 450,000 cfs and maximum flow (75,000 cfs) through the structure will occur when the Belle Chasse gage exceeds 1,000,000 cfs. The most southern pallid sturgeon spawning sites are unknown; however, potential gravel bar spawning sites occur at various locations between Baton Rouge, Louisiana, and Vicksburg, Mississippi, (River Mile 435) approximately 374 miles upstream of the MBSD. If a mean water velocity of 5.9 fps (4 miles per hour) is assumed to have occurred from Vicksburg to the MBSD, larvae could travel as much as 96 miles per day, barring entrainment into the eddies, the batture, and other areas.

One seven-day and one nine-day post-hatch larval sturgeon were collected near Vicksburg, Mississippi, on May 20, which indicated that hatching occurred on the 13 and 11 of May, respectively. The previously mentioned larval sturgeon captured at White Castle was collected on May 15. Other larval sturgeon recently captured between Greenville and Vicksburg, Mississippi, (approximate Rivers Miles 540 and 440, respectively) would indicate hatching occurred in early to mid-May (Schramm et al. 2017). Although there could be limited spawning as early as late March, most spawning in the LMR occurs during late April through mid-May.

Effects of the action on sub-adult and adult

Hoover et al. (2005) examined swimming performance of juvenile pallid sturgeon (maximum size 6.3 inches) at different velocities. Minimum escape speeds for pallid sturgeon ranged from 1.6 to 1.7 fps and burst speeds were determined to range from 1.7 to 2.95 fps; however, because they frequently failed to exhibit rheotaxis, their ability to avoid entrainment based on swimming performance was determined to be relatively low. Overall, approximately 18 percent were not positively rheotatic; however, Adams et al. (1999) found only 7 percent were non-rheotatic. White and Mefford (2002) examined swimming behavior and performance of shovelnose sturgeon ranging from 25.2 to 31.5 inches in length. Their ability to navigate the length of the test flume was best (60 to 90 percent) over a smooth bottom followed by coarse sand, gravel, and then cobble, but the small sample size and large variability precluded this from being a definitive conclusion. The greatest success at negotiating the flume was determined to occur between the range of 2 and 4 fps; however, success at greater velocities (6 fps) did occur. Approximately 30 percent failed to exhibit rheotactic behavior at velocities below 1.6 fps. Conversely, Adams et al. (1997) found all adult shovelnose to be positively rheotactic. Pallid sturgeon are believed to avoid areas that have very little or no water velocity (DeLonay and Little 2002, cited in Quist 2004; Erickson 1992 cited in Service, no date) and leave areas that no longer have flows (Backes et al. 1992; Constant et al. 1997).

The timing of pallid sturgeon movements and migration in the LMR may differ from that of other rivers and other portions of the Mississippi River (Constant et al. 1997). Migrations and movement in the Atchafalaya River was associated with water temperatures between 14 and 21 degrees Celsius (ºC) (Constant et al. 1997) and spring and early summer seasons (Schramm and Dunn 2008). During winter months, when water temperatures fall below 12ºC, pallid sturgeon have been caught in deeper water and reduced growth and survival of juvenile *Scaphyrynchus spp.* was noted; therefore, pallid sturgeon may be at a lower entrainment risk during winter (DeVries et al. 2015, Kappenman et al. 2009, Friedenberg and Siegrist 2019). This is supported by the observation of few pallid sturgeon entrained through the Bonnet Carré Spillway during the January emergency operation in 2016 (Service 2018).

4.3.3 Summary of Effects of the Action

An estimate for the entrainment risk associated with the MBSD was developed using entrainment risk as a function of the abundance of pallid sturgeon present in the action area and the likelihood of entrainment during operations (Friedenberg and Siegrist 2019). Three potential density scenarios were evaluated based on a conservative estimate of the abundance of pallid sturgeon in the system, to estimate the abundance of pallid sturgeon in the action area (Friedenberg 2018). The three density scenarios are provided in Section 4.2.1 (50% population density below New Orleans, 10% population density below New Orleans, and only juveniles below New Orleans) and abundance estimates are shown in Table 2. Entrainment estimates are based on predicted number of fish present per volume of water which characterizes the greatest potential effect from entrainment losses to the population, essentially overestimating the effect of a level of entrainment on the population.

The combination of population estimate with entrainment risk assumes that fish are evenly distributed and so are proportional to the volume of Mississippi River water diverted. Friedenberg and Siegrist (2019) based volumetric entrainment rates on either Service-derived rates (Service 2018) or a mark-recapture rate (Schultz 2013) predicted or observed in diversions, and then applied the rates to generate annual volumetric estimates (Table 4). The projected mean annual entrainment estimates were applied to simulations of future flows over the next 50 years to estimate predicted mean total entrainment over the MBSD operational period (Table 5). Based on these calculations, annual entrainment of pallid sturgeon through the MBSD could range from 7 to 58 sturgeon per year while the MBSD could entrain between 350 and 2,403 pallid sturgeon over the MBSD operational period of 50 years. Depending on the entrainment scenario, a reduction of 0.07 to 0.43 percent in the annual population growth rates of sturgeon, with the 50 percent densities resulting in the greatest potential effect to population growth and the juvenile only scenario resulting in the least potential effect. Due to insufficient data on pallid sturgeon to determine which scenario best represents expected conditions, the conservative assumption of the 50 percent density scenario represents the maximum number of entrainment of pallid sturgeon through the MBSD per year and total over the 50 year analysis period as well as the population effects from the proposed project. Therefore, entrainment of pallid sturgeon from the MBSD would be 58 individuals per year and 2,403 sturgeon over 50 years, and there would be an estimated 0.43 percent reduction in the annual population growth rate for the species.

Table 4. Projected mean annual pallid sturgeon entrainment through MBSD (LA TIG 2021).

Age Structure	Ages Entrained	Mean Annual Entrainment Estimates	
		FWS 2018 Capture Rate* mean (SD)	Mark-Recapture Rate** mean (SD)
50% Density	Age 1+	58.0 (19.1)	34.8 (11.5)
10% Density	Age 1+	11.6 (3.8)	7.0 (2.3)
Juveniles Only	Age 1-2	20.2 (6.7)	12.1 (4.0)

*USFWS 2018 methods; **Schultz 2013 methods
SD = standard deviation
Sources: Schultz 2013, LWFD 2018, Friedenberg 2019

Table 5. Predicted mean total pallid sturgeon entrainment through the MBSD over 50 years (LA TIG 2021).

Age Structure	Mean Total Entrainment Over 50 Years Estimates	
	FWS 2018 Capture Rate* mean (SD)	Mark-Recapture Rate** mean (SD)
50% Density	2,403 (292)	1,561 (186)
10% Density	515 (62)	350 (47)
Juveniles Only	1,020 (281)	647 (191)

*USFWS 2018 methods; **Schultz 2013 methods
SD = standard deviation
Sources: Schultz 2013, LWFD 2018, Friedenberg 2019

4.4. Cumulative Effects

For purposes of consultation under ESA §7, cumulative effects are those caused by future state, tribal, local, or private actions that are reasonably certain to occur in the Action Area. Future Federal actions that are unrelated to the proposed action are not considered, because they require separate consultation under §7 of the ESA.

We know that the Mid-Breton Sediment Diversion and Maurepas Diversion Projects are reasonably certain to be implemented upstream of the MBSD. However, those projects are federal actions that will require separate consultation under ESA §7. We are not aware of any non-federal actions in the action area that may affect the pallid sturgeon. Therefore, cumulative effects did not alter the conclusion reached in this BO for the action.

4.5. Conclusion

In this section, we summarize and interpret the findings of the previous sections for the pallid sturgeon (status, baseline, effects, and cumulative effects) relative to the purpose of a BO under §7(a)(2) of the ESA, which is to determine whether a Federal action is likely to:

a) jeopardize the continued existence of species listed as endangered or threatened; or

b) result in the destruction or adverse modification of designated critical habitat.

"*Jeopardize the continued existence*" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02).

The proposed project would involve construction, operation, and maintenance of the MBSD to discharge sediment, fresh water, and nutrients from the Mississippi River to an outfall area within the mid-Barataria Basin. Construction activities on the river side would include pile driving as well as the isolation and dewatering (using a cofferdam) of approximately 9.25 acres in within the Mississippi River. Construction activities are estimated to take 3 to 5 years, in which pile driving activities would occur from one to five months in the river. Both vibratory and impact pile driving will be used on the river side; however, when possible vibratory pile driving will be used to minimize impacts to sturgeon. Pallid sturgeon near this area of construction are anticipated to avoid the area during in-water pile driving activities due to increased underwater noise but would likely return to the area once noise returns to ambient levels. Any pallid sturgeon isolated in the cofferdam area may be lost.

Operation of the MBSD poses the risk of entrainment of all life stages of pallid sturgeon present in the area near the structure. Base flow of the MBSD would be 5,000 cfs while maximum flow would be capped at 75,000 cfs when the Mississippi River gage at Belle Chasse reaches 1,000,000 cfs. While the MBSD has a different purpose and design compared to other diversions located north of the proposed MBSD, impacts of entrained pallid sturgeon would be similar. A maximum of 48 sturgeon per year and 2,403 sturgeon over 50 years are estimated to be entrained through the MBSD, and therefore, be lost to the population. The estimated maximum reduction in annual population growth for pallid sturgeon is 0.43 percent. Our analysis indicates that while the proposed MBSD would have a negative effect on pallid sturgeon, such effects to annual population growth would not be appreciable for the survival and recovery of the pallid sturgeon.

After reviewing the current status of the pallid sturgeon, the estimated effects of the construction, operation, and maintenance of the MBSD, and the cumulative effects, it is the Service's biological opinion that the MBSD is not likely to jeopardize the continued existence of the species.

5. INCIDENTAL TAKE STATEMENT

ESA §9(a)(1) and regulations issued under §4(d) prohibit the take of endangered and threatened fish and wildlife species without special exemption. The term "take" in the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (ESA §3). In regulations at 50 CFR §17.3, the Service further defines:

- "harass" as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering;"

- “harm” as “an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering;” and
- “incidental take” as “any taking otherwise prohibited, if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.”

Under the terms of ESA §7(b)(4) and §7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered prohibited, provided that such taking is in compliance with the terms and conditions of an incidental take statement (ITS).

For the exemption in ESA §7(o)(2) to apply to the Action considered in this BO, the USACE and the LA TIG must undertake the non-discretionary measures described in this ITS, and these measures must become binding conditions of any permit, contract, or grant issued for implementing the Action. The USACE has a continuing duty to regulate the activity covered by this ITS. The protective coverage of §7(o)(2) may lapse if the USACE and the LA TIG fails to:

- assume and implement the terms and conditions; or
- require a permittee, contractor, or grantee to adhere to the terms and conditions of the ITS through enforceable terms that are added to the permit, contract, or grant document.

In order to monitor the impact of incidental take, the USACE must report the progress of the Action and its impact on the species to the Service as specified in this ITS.

5.1. Amount or Extent of Take

This section specifies the amount or extent of take of listed wildlife species that the Action is reasonably certain to cause, which we estimated in the “Effects of the Action” section(s) of this BO. We reference, but do not repeat, these analyses here.

The Service estimated incidental loss (by death or serious injury) of 48 pallid sturgeon per year and 2,403 over the 50 years. The pallid sturgeon estimated as incidental loss are those anticipated to be entrained through the MBSD.

5.2. Reasonable and Prudent Measures

The Service believes the following reasonable and prudent measures (RPMs) are necessary or appropriate to minimize the impact of incidental take caused by the Action on listed wildlife species. RPMs are described for each listed wildlife species in the subsections below.

RPM 1. Gate operation that would significantly increase or decrease the velocity through the structure should be implemented over several hours to allow fish sufficient time to migrate back to the river or swim away from the structure.

RPM 2. The CPRA and the USACE will coordinate with the Service to develop a Fish Monitoring and Removal Plan for pallid sturgeon. This plan will need to be completed and Service approved prior to the construction of the cofferdam.

RPM 3. Dredging (cutterhead/suction) in the Mississippi River would be conducted using dredge operational parameters coordinated with the Service.

RPM 4: Ensure that the terms and conditions are accomplished and completed as detailed in this incidental take statement including the completion of reporting requirements.

5.3. Terms and Conditions

In order for the exemption from the take prohibitions of §9(a)(1) and of regulations issued under §4(d) of the ESA to apply to the Action, the USACE and the LA TIG must comply with the terms and conditions (T&Cs) of this statement, provided below, which carry out the RPMs described in the previous section. These T&Cs are mandatory. As necessary and appropriate to fulfill this responsibility, the USACE and the LA TIG must require any permittee, contractor, or grantee to implement these T&Cs through enforceable terms that are added to the permit, contract, or grant document.

T&C 1. RPM 1. The Service's Louisiana Ecological Services Office (337-291-3126) should be notified of any proposed changes to the proposed action described in the biological opinion, so that re-initiation of consultation under Section 7 of the ESA can proceed as quickly and efficiently as possible.

T&C 2. RPM 2. Develop a plan to be implemented for the proposed MBSD that identifies potential avoidance and minimization measures for pallid sturgeon. Live sturgeon captured in the structure or the cofferdam area should be tagged and returned to the river.

T&C 3. RPM 3. Should dredging (cutterhead/suction dredge) activities be necessary in the Mississippi River, the following operational parameters would be included as conditions of the permit and in the design of the project:

1) The cutterhead must remain completely buried in the bottom material during dredging operation. If pumping water through the cutterhead is necessary to dislodge material or to clean the pumps or cutterhead, etc., the pumping rate will be reduced to the lowest rate possible until the cutterhead is at mid-depth, where the pumping rate can then be increased.
2) During dredging, the pumping rates will be reduced to the slowest speed possible while the cutterhead is descending to the channel bottom.

T&C 4. RPM 4. Upon locating a dead, injured, or sick individual of an endangered or threatened species, CPRA must notify the Louisiana Ecological Services Office at Lafayette, Louisiana at (337) 291-3100 and the USACE within 48 hours. Care should be taken in handling sick or injured individuals and in the preservation of specimens in the best possible state for later analysis of cause of death or injury.

T&C 5. RPM 4. A report describing the actions taken to implement the terms and conditions of this ITS shall be submitted to the Project Leader, U.S. Fish and Wildlife Service, 200 Dulles Drive, Lafayette, LA 70506, within 60 days of the completion of project construction. This report shall include the dates of work, assessment, and actions taken to address impacts to the pallid sturgeon, if they occurred.

5.4. Monitoring and Reporting Requirements

In order to monitor the impacts of incidental take, the USACE must report the progress of the Action and its impact on the species to the Service as specified in the ITS (50 CFR §402.14(i)(3)). This section provides the specific instructions for such monitoring and reporting (M&R). As necessary and appropriate to fulfill this responsibility, the USACE must require any permittee, contractor, or grantee to accomplish the monitoring and reporting through enforceable terms that are added to the permit, contract, or grant document. Such enforceable terms must include a requirement to immediately notify the USACE and the Service if the amount or extent of incidental take specified in this ITS is exceeded during Action implementation.

M&R 1- Monitoring of the diversion structure for the entrainment of pallid sturgeon should be conducted, once the diversion is in operation. This monitoring should be conducted yearly, once flows through the MBSD revert to base flow after maximum flow conditions. This report should include the amount of pallid sturgeon captured in the diversion structure throughout the year, time of year they were captured, flow volumes, and how the captures coincides with the flow.

M&R 2- A monitoring report will be submitted to the Service after maximum flow conditions have occurred. This report should include any data sheets, maps, and the findings of the pallid sturgeon monitoring efforts.

6. CONSERVATION RECOMMENDATIONS

§7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by conducting conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary activities that an action agency may undertake to avoid or minimize the adverse effects of a proposed action, implement recovery plans, or develop information that is useful for the conservation of listed species. The Service offers the following recommendations that are relevant to the listed species addressed in this BO and that we believe are consistent with the authorities of the USACE and the LA TIG.

- Support pallid sturgeon monitoring and studies throughout the Lower Mississippi River to aid in the determination of future diversion impacts to the pallid sturgeon population, as well as, to improve our understanding the species.

7. REINITIATION NOTICE

Formal consultation for the Action considered in this BO is concluded. Reinitiating consultation is required if the USACE retains discretionary involvement or control over the Action (or is authorized by law) when:

a. the amount or extent of incidental take is exceeded;
b. new information reveals that the Action may affect listed species or designated critical habitat in a manner or to an extent not considered in this BO;
c. the Action is modified in a manner that causes effects to listed species or designated critical habitat not considered in this BO; or
d. a new species is listed or critical habitat designated that the Action may affect.

In instances where the amount or extent of incidental take is exceeded, the USACE is required to immediately request a reinitiation of formal consultation.

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Evaluation of Potential Impacts of the Lake Maurepas Diversion Project to Gulf and Pallid Sturgeon

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Final report

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Vicksburg, MS 39181-0080

Abstract: The impacts to Gulf and pallid sturgeon from a proposed Mississippi River water diversion into the swamps bordering Lake Maurepas were evaluated. Gulf sturgeon were unlikely to be affected by the diversion due to characteristics of their life history. Adult and subadult pallid sturgeon were relatively abundant in the proposed project area and could be affected by the proposed diversion. A risk assessment was performed. Juvenile pallid sturgeon were judged to have a “low” entrainment risk due to low likelihood of their occurrence in the project area. Risk of entrainment by adults and subadults was judged “medium” due to their relatively low burst swimming speeds compared to intake velocities. Management recommendations were made to reduce or mitigate chance of their entrainment.

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Preface

The work described in this report was funded by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Engineer Division, Mississippi Valley.

This report was prepared by Dr. James P. Kirk, Dr. Jan J. Hoover, and Dr. K. Jack Killgore, Aquatic Ecology and Invasive Species Branch (AEISB), Ecosystem Evaluation and Engineering Division (EEED), Environmental Laboratory (EL), U.S. Army Engineer Research and Development Center (ERDC). Peer review was provided by Kenneth Teague of the EPA and David Walther of the U.S. Fish and Wildlife Service.

Bradley Lewis, Jay Collins, William Lancaster, Steven George, and Catherine Murphy of AEISB participated in field collections as did R. Timothy Ruth of the Louisiana Department of Wildlife and Fisheries (LDWF). The LDWF provided expedited permitting, telemetry-tagged Gulf sturgeon, and field sampling assistance.

ERDC supervision was provided by Dr. Timothy E. Lewis, Chief, AEISB; Dr. David J. Tazik, Chief, EEED; and Dr. Elizabeth C. Fleming, Director, EL.

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1 Introduction

Over the past century, flood control in the Mississippi River has reduced freshwater, nutrients, and sediment inputs that maintained swamps bordering Lake Maurepas, Louisiana. A 1,500 to 2,000 cubic feet per second (cfs) diversion from the Mississippi River is proposed to reverse habitat deterioration and improve overall water quality. The diversion from the Mississippi River would use two box culverts at a point near the Hope Canal, near River Mile (RM) 144 (see Figures 1 and 2). The major benefits of this water diversion would be:

1. Increase accretion in the swamps, thus offsetting subsidence, and ameliorate salt stress to cypress-tupelo swamps along the lake's boundaries and
2. Reverse the trend of swamp conversion to open water or marsh.

Before this project can proceed, however, evaluation must be made of its potential impacts on the endangered pallid sturgeon (*Scaphirhynchus albus*) and the threatened Gulf of Mexico (Gulf) sturgeon (*Acipenser oxyrinchus desotoi*), both of which are thought to occur in the project area.

Figure 1. Location of the study area within the State of Louisiana.

Figure 2. Approximate location of the proposed diversion site and the location where pallid sturgeon were captured.

Gulf sturgeon are diadromous (using both salt and freshwater habitats) and mature between ages 7 to 12 at a fork length (FL) of 1.2 to 1.4 m (Huff 1975). Ranging from Tampa Bay to the Mississippi River (Grunchy and Parker 1980), this fish was listed as threatened in 1991 (USFWS 1991). Exploitation, blockage of migration routes, and declining water quality are thought to be responsible for species decline (Wooley and Crateau 1985; Barkuloo 1988; USFWS and GSMFC 1995). Gulf sturgeon generally spend November through March in saltwater and the rest of the year in freshwater rivers (Wooley and Crateau 1985; Odenkirk 1989; Carr et al. 1996; Foster and Clugston 1997; Fox et al. 2000; Rogillio et al. 2001, 2007; Heise et al. 2004). Gulf sturgeon have been collected in tributary rivers (e.g., the Amite River) flowing into Lake Maurepas. Gulf sturgeon from the Pearl River system in Louisiana-Mississippi may also use Lake Maurepas, and this nearby system has been extensively studied (Davis et al. 1970; Rogillio 1992; Morrow et al. 1996, 1998, 1999; Rogillio et al. 2001, 2007).

The pallid sturgeon was listed as an endangered species in 1990 and occurs in the large rivers in the Mississippi River Basin (Lee et al. 1980; Killgore et al. 2007). The decline of this species is attributed to flood control and navigation projects, pollution, and overexploitation for caviar (Dryer and Sandoval 1993). Populations in the lower Mississippi River are probably stable, but long-term studies are required to fully evaluate population trends and habitat preferences (Killgore et al. 2007). In that regard, the U.S. Army Engineer Research and Development Center (ERDC) is conducting a multi-year study on population status and habitat requirements of pallid sturgeon in the middle and lower Mississippi River. Prior to this study, pallid sturgeon have been documented in the Mississippi River as far south as Donaldsonville, LA, but likely occur below New Orleans albeit at relatively low numbers.

In this study, researchers assessed impacts to Gulf and pallid sturgeon of diverting water from the Mississippi River into swamps around Lake Maurepas. Field studies were conducted with the following objectives:

1. Document habitat characteristics in the proposed diversion site and compare these characteristics to known pallid sturgeon habitat use patterns,
2. Determine relative abundance of both species,
3. Evaluate the impacts to Gulf sturgeon that may periodically be utilizing Lake Maurepas, and
4. Perform a risk assessment of pallid sturgeon entrainment at the proposed water diversion site.

2 Methods

Gulf sturgeon in Lake Maurepas were sampled during November 2005 through June 2006 using 27.4-m experimental monofilament gill nets with stretch mesh panels varying from 102 to 229 mm and 3.1-m otter trawls. Concurrently, mobile sonic telemetry along a systematic grid was used to locate any of approximately 40 Gulf sturgeon telemetry-tagged in the Pearl River system by the Louisiana Department of Wildlife and Fisheries (LDWF) and the ERDC during 2001 through 2006. While sampling, habitat data were collected to describe micro- and macro-habitats. At each sampling site the following water quality parameters were measured: temperature, specific conductance, pH, dissolved oxygen, and turbidity. Likewise, Global Positioning System (GPS) coordinates, distance to shore, depth, bottom slope, water velocities, and substrate were measured.

Pallid sturgeon in the Mississippi River near the proposed diversion site were sampled with trawls and trotlines. Age-0 and juvenile pallid sturgeon were sampled during August 2005 and monthly from April through June 2006 using 3.1- and 4.9-m otter trawls. Replicate trawls approximately 0.6 km in length were made near the diversion site (when river currents were not too high) and at nearby sandbars because age-0 and juvenile sturgeon have been captured at other sandbars in ongoing studies. Habitat data comparable to those described for Gulf sturgeon were recorded at each sampling location.

Abundance was measured in cooler months (December 2005 through April 2006) using trotlines. Once a month, eight trotlines with 60 hooks per line were fished overnight at a variety of sites near the proposed diversion site using night crawlers or crayfish for bait. Sites included: sandy bars above and below the diversion site, in the main channel at the bridge at Gramercy, LA, and near a petroleum loading dock close to the proposed diversion site (Figure 2). Because shovelnose *Scaphirhynchus platorynchus* were also likely to be captured, morphological and meristic data were obtained to separate pallid from shovelnose sturgeon (Murphy et al. 2007). As with trawling sites, water quality and habitat data were collected.

A generic risk assessment for pallid sturgeon entrainment at the diversion site is presented next based on site-specific observations, construction plans, and data from previous studies. Information relevant to entrainment risk of pallid sturgeon is summarized in a format that documents the assessment process. This approach allows re-assessment of risk whenever new information is obtained (e.g., additional data on pallid sturgeon demographics, revised specifications for structure, and studies of pallid sturgeon behavior).

Protocol includes assessment of the probability of pallid sturgeon entrainment adapted from methodology used to assess probability of non-native fish establishment (Courtenay and Williams 2004; Nico et al. 2005). Elements representing a temporal sequence in the movement of the organism are identified, evaluated, and rated to determine overall risk within the pathway (ANSTF 1996). For pallid sturgeon entrainment, elements (Figure 3) are defined below.

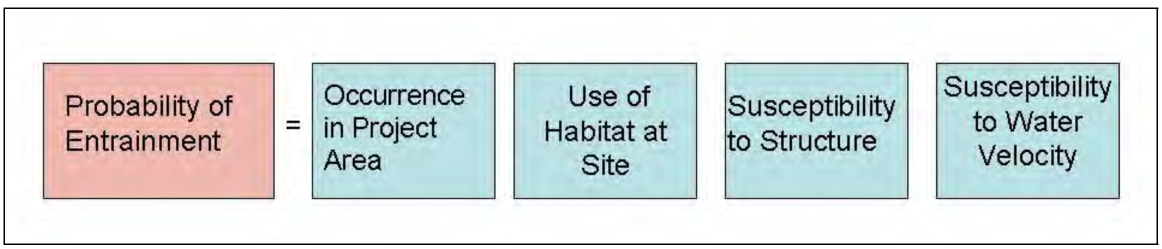

Figure 3. Elements for pallid sturgeon entrainment.

“Occurrence within the project area” is evaluated based on a single characteristic: distribution of the fish within the reach where construction and operation of the project will take place. “Use of habitat at site” is also evaluated on a single characteristic: occurrence of the fish at the location where the structure will be placed and/or in habitat similar to that in which the structure will be constructed. “Susceptibility to structure” is based on multiple characteristics of the completed structure: its suitability as a unique habitat for pallid sturgeon and the creation of flows at the same position in the water column as those occupied by the fish. “Susceptibility to water velocity” is based on swimming performance of the fish in water velocities created by diverted water considering rheotaxis (movement in response to the flow of a current), swim speeds, and station-holding behaviors. Because swimming performance of smaller sturgeon is substantially lower than that of larger sturgeon (Peake et al. 1997), juvenile fish are evaluated separately from subadult and adult fish.

Elements are rated qualitatively on a 3-point scale for risk: low, medium, or high. Probability of entrainment is assigned the value of the element with the lowest risk rating. This estimate of risk is considered conservative since each of the elements must take place for entrainment to occur and since a combined series of probabilities results in a cumulative probability that is in reality lower than any probability of a single event (ANSTF 1996). For each element, ratings of risk were evaluated on a 5-point scale for uncertainty: very certain, reasonably certain, moderately certain, reasonably uncertain, and very uncertain. These evaluations identify elements for which more information is required for greater accuracy in risk assessment. Probability of entrainment was assigned the value with the highest degree of uncertainty as a conservative measure of confidence in the overall risk of entrainment.

3 Results

No Gulf sturgeon were detected (via telemetry) nor captured using trawls or experimental gill nets in Lake Maurepas. Likewise, extensive trawling captured no age-0 or juvenile pallid sturgeon at any location in the Mississippi River near the proposed water diversion site. A total of 10 pallid and 24 shovelnose sturgeon were captured using trotlines from early December of 2005 through April 2006 (see Table 1). These fish were captured at a single location: at the edge of the main channel of the Mississippi River at the Gramercy Bridge (see Figure 2). No pallid or shovelnose sturgeon were captured using similarly set trotlines near the proposed diversion site or from sand bars above and below the diversion site.

The catch per unit effort (CPUE) and pallid to shovelnose sturgeon ratio were compared with previous data for this section of the Mississippi River (Killgore et al. 2007). The established CPUE of pallid sturgeon in the Mississippi River at RM 154 to 507 was 0.31 per trotline, and the pallid to shovelnose ratio was 1:6. Based upon trotlines, the pallid sturgeon CPUE was 0.28 per trotline and not different from the value reported by Killgore et al. (2007). The ratio of pallid to shovelnose sturgeon was 1:2.4.

The habitat near the bridge was at the edge of the main channel in depths of 17.5 to 22.6 m—current velocities ranged from 0.3 to 1.3 m/sec and water temperatures ranged from of 8.2 to 16.6 °C. The sloping bottom was predominately sand with some gravel. The habitat near the proposed diversion site was deep (approximately 10 to 25 m), not in the main channel, and had a bottom comprised of sand and mud.

Table 1. Pallid and shovelnose sturgeon captures in main channel of Mississippi River near Gramercy Bridge, LA, during 2005 and 2006.

Date	Species	Total length, mm	Depth, m	Water Temperature, °C
1 Dec 05	shovelnose	600	17.5	13.6
		621		
	pallid	788		
25 Jan 06	shovelnose	535	22.7	8.4
		514		
		479		
		543		
		563		
	pallid	831		
		823		
		860		
		735		
2 Mar 06	shovelnose	623	20.6	8.2
		600		
		700		
		523		
		547		
		589		
		450		
		430		
		552		
		683		
		593		
		565		
		597		
		561		
		542		
		470		
	pallid	773		
		623		
		709		
13 April 06	shovelnose	545	15.3	16.6
	pallid	762		
		713		

4 Discussion

A risk assessment for entrainment of Gulf sturgeon was not performed, since this species is unlikely to be in this reach of the Mississippi River and thus unlikely to be entrained (Douglas 1974; Ross 2001). Instead, temperature and salinity impacts caused by diverting water from the Mississippi River were evaluated for the Gulf sturgeon in and near Lake Maurepas.

No Gulf sturgeon were captured nor detected using telemetry in Lake Maurepas. However, Gulf sturgeon are likely to use or move through Lake Maurepas from tributary rivers on their annual migration to and from marine habitats (where they feed). In that regard, a review of the literature of Gulf sturgeon movements in Mississippi, Alabama, and Florida is instructive in understanding when Gulf sturgeon are likely to use Lake Maurepas and thus be influenced by project impacts (i.e., decreasing salinity and lower water temperatures).

Movements of Gulf sturgeon out of the Suwannee River in Florida were reported for October to November by Carr et al. (1996) and mid-September through November by Foster and Clugston (1997). Movements out of the Pascagoula River system were reported to be during mid-October through late November (Heise et al. 2004).

Gulf sturgeon in the nearby Pearl River system used winter habitat in the Mississippi Sound between November and March. Starting in April, fish were located at the Rigolets Pass and mouth of the Pearl River. Movements into the Bogue Chitto and Pearl rivers began in April (Rogillio et al. 2007). In the Suwannee River, Gulf sturgeon return ranged from late February through May (Carr et al. 1996; Foster and Clugston 1997) at temperatures of approximately 22 °C. Similar chronologies were found in the Apalachicola River. Wooley and Crateau (1985) found fish moved back into the river during April and May, and Odenkirk (1989) tracked return movements during March and April. Gulf sturgeon returned to the Choctawhatchee River system during March through May (Fox et al. 2000).

Thus, although some Gulf sturgeon may reside in Lake Maurepas – as they are known to do in Lake Pontchartrain – their use of the lake is likely to be during October or November and again during their return from marine habitats in the Mississippi Sound during February through April. Since these fish are moving into or out of saline habitats and are not feeding, changes in temperature or salinity caused by the diversion of water from the Mississippi River seem unlikely to adversely impact their populations.

A risk assessment of pallid sturgeon potentially entrained by all proposed diversion sites from the Mississippi River into the brackish waters in nearby Lake Maurepas was performed. While no direct literature on salt water tolerance of pallid sturgeon was located, it was deemed that diversion from fresh to brackish water could be lethal. Further, if the salinity levels were not lethal, the entrained pallid sturgeon would still be a loss to the Mississippi River population.

Pallid sturgeon probability of entrainment

Entrainment risk was "low" for juveniles due to low likelihood of occurrence in the project area, and "medium" for subadults and adults due to presumed lower limits on swimming capabilities of some individual fish (Table 2). Pallid sturgeon occur throughout the Mississippi River, including reaches above and below the sites of all proposed diversions (Killgore et al. 2007) and thus entrainment risks apply equally to all sites including the one near the Hope Canal. Subadult and adult pallid sturgeon are relatively abundant in the project area (see Table 1), but no small sturgeon (< 623 mm FL) were collected. The occurrence of subadults and adults within the project area can be accepted as "very certain," but the apparent absence of juveniles is less certain. Juvenile pallid sturgeon are rarely collected, even during spatially and temporally extensive surveys of naturally reproducing populations. Low numbers of juveniles is presumably due to specialized habitat requirements and very rapid growth of young fish. Spawning habitat of pallid sturgeon (i.e., gravel beds in swift water) was not apparent in the project area, and it is possible that juveniles do not occur in the area because spawning is taking place elsewhere. Surveys for potential spawning habitat and additional sampling using gear with higher selectivity for juvenile sturgeon (e.g., trawling, small mesh gillnets) during periods of likely occurrence (e.g., late spring, early summer) could confirm or refute their presence in the project area.

Table 2. Risk of entrainment of pallid sturgeon by a water diversion structure at Lake Maurepas.

Element	Characteristics	Juveniles		Subadults & Adults	
		Rating	Uncertainty	Rating	Uncertainty
Occurrence in Project Area	Distribution of sturgeon	Low	Reasonably uncertain	High	Very certain
Use of Habitat at Site	Abundance of sturgeon	Low	Reasonably uncertain	High	Very certain
Susceptibility to Structure	Suitability of habitat for sturgeon Vertical position of withdrawal	High	Moderately certain	High	Reasonably certain
Susceptibility to Velocity	Swimming performance of sturgeon	High	Very certain	Medium	Reasonably certain
Risk	All of the above	Low	Moderately certain	Medium	Reasonably certain

Adult pallid sturgeon were collected at one location, the Gramercy Bridge, within 2,000 m of the proposed diversion structure (Figure 2). Also, it is not uncommon to collect adult pallid sturgeon near steep, vertical banks (sandbar “reefs”) similar to the littoral habitat of the proposed site. Consequently, the probability of use of the site where the structure will be constructed is “high” and “very certain” for subadult and adult fish. Juvenile fish are not documented from the area so use of habitat is presumed “low.” Pending targeted sampling for small fish, this rating is “reasonably uncertain.”

Susceptibility of fish to the proposed culvert is “high” for juveniles and for subadults and adults. Pallid sturgeon in the Mississippi River are frequently found in the vicinity of man-made structures (e.g., dikes). Such structures provide attractive areas of shelter from main channel water velocities. They also provide hard, permanent substrates for benthic invertebrates (e.g., common net spinning caddisflies, Hydropsychidae) and fishes (e.g., chubs, *Macrhybopsis* spp.) eaten by pallid sturgeon (Hoover et al. 2007). The likelihood that pallid sturgeon of any size would exploit a culvert (and any associated embayment) as a refugium and/or feeding ground is “high.” Flows in the culvert will be controlled by vertical lift gates and water diverted through the bottom of the structure (Dr. Patricia Taylor, U.S. Environmental Protection Agency [EPA], personal communication). Consequently, sturgeon attracted to the culvert seeking shelter or food will be placed in direct proximity to potentially entraining flows diverted through the structure. This rating is only "moderately certain" because it is largely conjectural for juveniles (due to limited empirical data). It is "reasonably certain" for subadults and adults since these fish have been frequently confirmed near similar structures.

Susceptibility to water velocities in the culvert is "high" for juveniles, but only "medium" for subadults and adults due to greater swimming capabilities of larger fish. Pallid sturgeon of all sizes are conspicuously rheotactic and exhibit complex station-holding behaviors. Swimming speeds, based on endurance, however, are highly variable among (and within) age classes. Escape speeds (i.e., swimming speeds that can be maintained for up to 1 min) have been measured for juvenile pallid sturgeon 74–205 mm FL and range from 35–75 cm/s (Adams et al. 1999; Hoover et al. 2005). Escape speeds for subadult and adult pallid sturgeon have not been measured but are probably in excess of 120 cm/s (pallid sturgeon were captured in this study in currents as fast as 130 cm/s). This estimate is based on data for shovelnose sturgeon, which have nearly identical swimming endurance to pallid sturgeon (Adams et al. 1997). Shovelnose sturgeon >530 mm SL are capable of swimming at 49–71 cm/s for 60 min (Parsons et al. 2003) and 65–116 cm/s for 15 min (Adams et al. 2003). An extrapolated swim speed of 120–150 cm/s for 1 min would be conservative. Projected flows through the culvert could be 100–150 cm/s (EPA, preliminary communication). If flows approach this range however, entrainment of most juveniles and some of the slower-swimming larger fish would be likely. Rating is "very certain" for juveniles because of data from multiple laboratory studies. Rating is "reasonably certain" for subadults and adults since shovelnose sturgeon data served as surrogates for pallid sturgeon and since trends in swimming performance were extrapolated from observed values of endurance.

Management implications

Risk assessment indicates several critical information needs and possible mitigation actions. Uncertainty in risk ratings for several elements could be reduced with data on pallid sturgeon demographics (i.e., occurrence of juveniles in project area), flow fields around the culvert (i.e., water velocities at varying distances and depths from gate), and frequency of entrainment of riverine species by diversion structures (i.e., sturgeons and suckers that have passed through large culverts). Additional field studies at the site for the planned Lake Maurepas structure and the existing Caernarvon and Davis Pond structures are warranted.

Risk of pallid sturgeon entrainment could be reduced in several ways. Withdrawal of water from near the surface of the river (based upon river stage and season) would make entrainment less likely since pallid sturgeon swim close to the river bottom and rarely approach the water's surface. Also, larger or a greater number of gates to distribute flow (and reduce velocity of exiting water through any single gate) would make it possible for sturgeon to resist flow by creating water velocities lower than escape speeds of most fish. Rough or complex substrates (e.g., scarified concrete, rip rap, etc.) directly in front of the gates (as currently envisioned by the designers) would also enable pallid sturgeon to resist entraining flows by providing low-velocity boundary layers and by enabling alternative low-energy station-holding behaviors such as creeping, hunkering, and tail-bracing to be used by fish (Hoover et al. 2005). Seasonal restrictions on diversion, or "windows," could minimize likelihood of entraining spawning adults (e.g., early spring) or juveniles (e.g., late spring, early summer).

Since some entrainment of pallid sturgeon is possible, mitigation strategies should at least be considered and studied. Culture and release of pallid sturgeon should be a last option for a number of reasons. Brood stock availability, genetic and behavioral considerations, as well as lack of understanding of pallid sturgeon demographics are reasons sufficient to presently recommend against this approach. Thus, mitigation resources would better be used in gaining an enhanced understanding of the pallid sturgeon demographics, swimming capabilities, and the hydraulic characteristics of the diversion structure.

The population status of pallid sturgeon in this reach should be better understood, not only for the evaluation of this project but also future lower Mississippi River water diversion projects. If the local population is robust, then some incidental entrainment losses will likely have very little impact upon the population. If the population is depressed, however, then any losses could be consequential. A local study conducted over several fall and winter periods could determine acceptable levels of entrainment using estimates of abundance, mortality, and recruitment in age-structure population models. A longer study (about 4 years and using multiple sampling gears), could be conducted within a reach perhaps 60 to 80 km above

New Orleans to evaluate the impacts of existing as well as future water diversions to the local pallid sturgeon population.

With water diversion speeds potentially reaching 150 cm/sec, studies of the similar box culvert diversion structure are justified. Fine-scale studies of water velocities in the area near diversion are important because pallid sturgeon have complex swimming behaviors. A good start would be a short but intensive study at the existing Caenarvon and Davis Pond structures to determine fine-scale variation in water velocities in a box culvert as well as velocities in the outlet channel. The results could be paired with laboratory swimming studies of adult pallid and/or shovelnose sturgeons. Taken together, these studies could be used to provide input into biologically sound design criteria as well as to refine risk assessment.

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14. ABSTRACT

The impacts to Gulf and pallid sturgeon from a proposed Mississippi River water diversion into the swamps bordering Lake Maurepas were evaluated. Gulf sturgeon were unlikely to be affected by the diversion due to characteristics of their life history. Adult and subadult pallid sturgeon were relatively abundant in the proposed project area and could be affected by the proposed diversion. A risk assessment was performed. Juvenile pallid sturgeon were judged to have a "low" entrainment risk due to low likelihood of their occurrence in the project area. Risk of entrainment by adults and subadults was judged "medium" due to their relatively low burst swimming speeds compared to intake velocities. Management recommendations were made to reduce or mitigate chance of their entrainment.

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Entrainment Studies of Pallid Sturgeon Associated with Water Diversions in the Lower Mississippi River
DRAFT

November 15, 2013

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PREFACE

This study was funded by the U.S. Army Corps of Engineers New Orleans District (MVN) and Mississippi Valley Division (MVD). MVN project managers were Richard Boe and Thomas Parker. MVD project managers were Dave Vigh and Dr. Barb Kleiss and. Individuals assisting with all or part of this study are listed below.

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EXECUTIVE SUMMARY

Water diversions from the Lower Mississippi River (LMR) are used for flood risk reduction, water supply, and habitat restoration. There was concern that existing and proposed diversions can entrain the federally endangered pallid sturgeon (*Scaphiryhnchus albus*), a species that occurs throughout the LMR. Potential entrainment of pallid sturgeon would be considered a "take" under the Endangered Species Act. Consequently, the New Orleans District and the Mississippi Valley Division funded ERDC-EL to monitor potential entrainment of pallid sturgeon in existing diversions and provide information to evaluate the risk of future entrainment. Objectives were to:

- Document and quantify sturgeon entrainment in existing diversions compared to adjacent river reaches.
- Estimate population size of pallid sturgeon in river reaches associated with diversions.
- Develop population viability models of pallid sturgeon to analyze impacts of entrainment-based "take" by water diversions.

The first task was to determine the spatial distribution and relative abundance of sturgeon in the lower 320 miles of the Mississippi River where all of the diversions either currently exist or are proposed. Four hundred and sixty-nine (469) total sampling gears were deployed at 85 sample stations along the 320 river mile reach with 74.1% of the sampling efforts conducted within the reach associated with existing or planned river diversions. A total of 51 pallid sturgeon, 319 shovelnose sturgeon, and 84 young-of-year sturgeon were collected between 2001 and 2011 below RM 320. The most downstream collection of pallid sturgeon was at RM 95.5. Two juvenile shovelnose sturgeon were collected opposite the Caernarvon Diversion at RM 81, which is the most downstream collection of *Scaphiryhnchus.* These data indicate a low risk of entraining pallid sturgeon below New Orleans because of their rarity or absence in the lower 100 miles of the LMR.

The second task was to estimate pallid sturgeon abundance in the lower reach of the LMR. This information was required to evaluate impacts of potential entrainment to population viability. A long-term (1997-2008) sequential mark-recapture survey of pallid sturgeon in the Lower and Middle Mississippi River failed to recapture any of the 241 individuals marked within the Mississippi River itself. Consequently, we used a hypergeometric probability distribution to estimate population size in light of some chosen probability of no recaptures (i.e., nil-recapture method). After accounting for survival, movement, and habitat use, we estimated that the total abundance of age-3+ pallid sturgeon in the Lower and Middle Mississippi River is at least 3,400-4,100 with probability 0.99; 5,900-7,000 with probability 0.95; and 17,000-20,000 with probability 0.75. Assuming fish were distributed in proportion to survey catch-per-unit-effort, the population estimate in the southernmost reach where existing and planned diversions occur was at least 3.8, 6.5, or 19 fish per river kilometer (rkm) for the 0.99, 0.95, and 0.75 probability respectively. These estimates do not account for juvenile sturgeon less than 3 years of age and there is considerable uncertainty in the analysis. However, this is the first estimate of population size of pallid sturgeon in the LMR and is an essential variable in the analysis of viability for the pallid sturgeon.

Existing diversion outlets were sampled for sturgeon from 2009 – 2011 that included Davis Pond Diversion, Violet Siphon, Caernarvon Diversion, White Ditch Siphon, and Naomi Siphon. Additional sampling occurred in the Bonnet Carré spillway after the 2008 and 2011 openings. The Old River Control Structure was not sampled as part of this study. Multiple gears were used to evaluate species composition entrained through the diversions. In total, 113 species were sampled in one or more of the diversions. Of this total, 35 species were relatively common in the Mississippi River but rare or absent in the marsh habitat below the diversions. Entrainment was highest in diversions during or in periods shortly after there were high volumes of flow through the diversions. There was no significant relationship between entrainment and river stage in most diversions because diversion flows were restricted during high river stages. Highest flows through the diversions occurred in the months following the Deepwater Horizon oil spill when they were opened to near their maximum capacity. During the same period, entrainment was generally high in the larger diversions. Sturgeon were found in samples in the two largest diversions, the Bonnet Carré Spillway and the Davis Pond Diversion. In the former, sturgeon were captured in several lakes after the structure was closed and a high degree of entrainment was found in periods following high flows. Additional sampling of the Bonnet Carré is reported below. In the latter, one pallid sturgeon and three shovelnose sturgeon were taken in each quarter of the latter half of 2009 and the first half of 2010. This component of the overall study indicates that entrainment risk is higher for larger diversions (>10,000 cfs) located above New Orleans.

The Bonnet Carré Spillway was intensively sampled after the 2008 and 2011 openings of the structure to evaluate entrainment of pallid sturgeon from the Mississippi River. Morganza floodway was sampled after the structure was closed in 2011. Pallid sturgeon were collected only in the Bonnet Carré floodway after the structure was closed. Sampling during the openings was restricted due to safety concerns. Higher discharge and longer opening in 2011 resulted in greater number of sturgeon caught. In 2008, a total of 14 pallid sturgeon and 41 shovelnose sturgeon were collected over a 4-week period. In 2011, a total of 20 pallid, 78 shovelnose, and one possible intermediate sturgeon were collected over a 1.5-week period. The majority of these fish were relocated back into the Mississippi River; some were retained for taxonomic studies by USFWS. Field surveys indicated that it was unlikely that pallid sturgeon, an obligate riverine species, would be entrained through Morganza because of the long distance between the main channel of the Mississippi River and the structure. Pallid sturgeon entrained through the Bonnet Carré spillway may move downstream into Lake Pontchartrain, although a telemetry study did not detect movement into the Lake. For those pallid sturgeon remaining in the floodway, a slow decline in discharge after closure draws sturgeon towards the structure where they can be rescued and placed back into the Mississippi River.

An age-based population viability model of pallid sturgeon was developed from the field data reported above that included both demographic and environmental stochasticity. Using abundance estimates, projected numbers of entrained fish was translated into per capita entrainment rates to explore the ecological risk posed by episodic and chronic water diversion actions in the southernmost reach of the LMR. Uncertainty was addressed by testing a range of entrainment rates, abundance levels, and spatial structures. Entrainment during episodic diversions characteristic of the Bonnet Carré spillway reduced median local population size by 0-20% in 60 years. Entrainment in chronic annual water diversions, characteristic of those proposed for wetlands nourishment in Louisiana, reduced median local population size by 2-50%. The effect of combined episodic and cumulative entrainment was multiplicative. If the true abundance of pallid sturgeon adults in the LMR is near 5,000 or more, entrainment is not a central factor in the recovery and maintenance of the population. Only the worst-case scenario of low abundance and high entrainment presented an appreciable risk to the population. At the low abundance level, our estimate of chronic diversion was sufficient to induce an IUCN rating of vulnerable if the LMR pallid population was otherwise stable. However, this scenario is unlikely below New Orleans where pallid sturgeon have not been captured.

Model projections revealed that the greatest gains in certainty would come from a more precise population size estimate. Improved understanding of large-scale movements of age-1+ fish would also greatly improve our ability to manage pallid sturgeon in the free-flowing Mississippi River. Based on the Bonnet Carré experience, it is possible that mitigation efforts, such as monitoring and rescue below small diversion structures, could reduce risks posed by wetlands restoration projects in those reaches where pallid sturgeon are known to occur.

Entrainment Studies of Pallid Sturgeon Associated with Water Diversions in the Lower Mississippi River

Background

The Louisiana Coastal Area (LCA) Program is a systematic approach to restore natural features and ecosystem processes (New Orleans District 2012). As part of the LCA and the Mississippi River and Tributary projects, water diversions are used for flood risk reduction, water supply, and habitat restoration in the Lower Mississippi River (LMR). In 2008, the Bonnet Carré Spillway, which diverts floodwaters from the Mississippi River into a floodway that empties into Lake Pontchartrain to reduce river stages at New Orleans, was open for 27 days. Prior to opening, the federally endangered pallid sturgeon (*Scaphiryhnchus albus*) was captured in the Mississippi River near the Bonnet Carré structure by Louisiana Department of Wildlife and Fisheries (LDWF). Potential entrainment of pallid sturgeon would be considered a "take" under the Endangered Species Act, and therefore, post-closure monitoring of the floodway was warranted. Within a week after the structure was closed in 2008, ERDC and LDWF captured pallid sturgeon in the floodway verifying that entrainment had occurred.

Water diversions from the Mississippi River for marsh habitat restoration will increase as new projects are implemented in the delta. Future floods will necessitate the openings of the Bonnet Carré and Morganza floodways further increasing entrainment risk. Prior to this study, impacts of diversions on imperiled sturgeon populations were unknown. Comprehensive risk assessments for entrainment of sturgeon by water diversions require substantial inputs including field data on local sturgeon populations, life history information, and output from population modeling simulations. These risk assessments, however, can provide probability of entrainment for specific environmental scenarios (e.g., time of year, river stage, and flow fields generated by a structure). Such probabilities can be eliminated or reduced through modified operations of structures (e.g., schedule of operation, rate of diversion, implementation of deterrents). Otherwise, monitoring and rescue programs will be ongoing elements of O&M costs and concerns regarding long-term impacts to endangered sturgeon will go unresolved.

Biological assessments of freshwater diversions on pallid sturgeon are mandated by the Endangered Species Act. Consequently, the New Orleans District funded ERDC-EL to monitor potential entrainment of pallid sturgeon in existing diversions and provide information to evaluate fully the risk of future entrainment. Objectives of this document are to:

- Document and quantify sturgeon entrainment in existing diversions and adjacent river reaches
- Estimate population size of pallid sturgeon in river reaches associated with diversions
- Develop population viability models of pallid sturgeon to analyze impacts of entrainment-based "take" by water diversions

Approach

This document is divided into five chapters that integrate the full study into a comprehensive risk assessment of entraining pallid sturgeon through water diversions in the lower 300 miles of the Mississippi River as illustrated by the Conceptual Model (Figure 1). Chapters address the following questions:

- How many sturgeon occur in this reach of river? (Chapter 1, river sampling; Chapter 2, demographic model of abundance)
- How many sturgeon are entrained through diversions? (Chapter 3, seasonal sampling in existing diversions; Chapter 4, Bonnet Carré /Morganza sampling in 2008 and 2011)
- What are the impacts of entrainment to the population? (Chapter 5, population viability model)

The first chapter summarizes sampling in the lowermost reach of the Mississippi River for pallid sturgeon and includes extant data collected by ERDC over a ten-year period. Chapter 2 presents a demographic model, based on age-structure of populations of sturgeon collected in the river, to evaluate existing status of the pallid sturgeon (e.g., declining, stable, or increasing) within the lower reach of the Mississippi River and provide for the first time an estimate of population size. Chapter 3 describes a comprehensive database of entrained fish collected seasonally in existing diversions by Nicholls State University under contract with ERDC. Chapter 4 summarizes ERDC's efforts to evaluate sturgeon entrainment through the Bonnet Carré Spillway in 2008 and 2011, and Morganza floodway in 2011. Overall, these four chapters provide the baseline to conduct risk analysis. Risk of entrainment and impacts to sturgeon populations were addressed using a Population Viability Model (PVA) in Chapter 5. The PVA quantifies viability as predicted time-to-extinction (or extirpation): greater viability is reflected in longer (or indefinite) time-to-extinction (Akcakaya 2000). PVA has been successfully used to establish causes of extinction (e.g., Turvey and Risley 2006) and to evaluate individual threats to survival (e.g., Brook et al. 2002). PVA was used to compare scenarios of entraining low numbers (e.g., 10) to high numbers (e.g., >>100) of sturgeon, and determine if a threshold is reached that constitutes a jeopardy opinion. Application of these data and models are illustrated in the conceptual model (Figure 1 – Application of Data).

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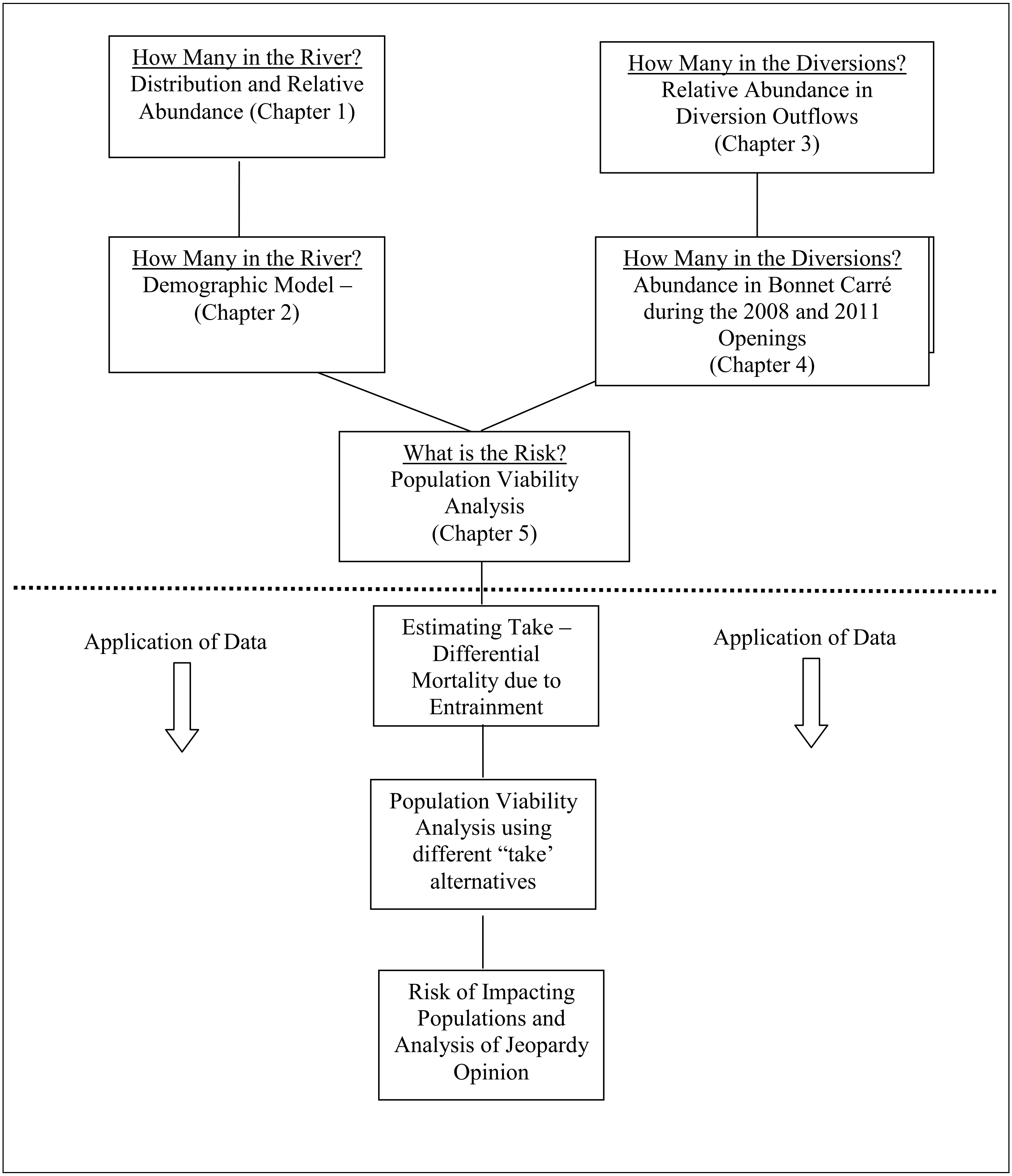

Figure 1. Conceptual Model of Information Acquisition and Application

Chapter 1

Spatial Distribution and Relative Abundance of Sturgeon in the Lower 300 miles of the Mississippi River

by

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Abstract

Field sampling of sturgeon in the lowermost reach of the Mississippi River between river mile (RM) 0 and 320 has been ongoing since 2001. For the Diversion project, additional sampling occurred below New Orleans where the majority of proposed diversions will be located. Three gears were used to sample sturgeon: trotlines, trawl, and gill nets. Four hundred and sixty-nine (469) total sampling gears were deployed at 85 sample stations along the 320 river mile reach with 74.1% of the sampling efforts conducted within the reach associated with existing or planned river diversions. Our sampling documented 61 species of fishes with a total abundance of 13,314 individuals across all samples. A total of 51 pallid sturgeon, 319 shovelnose sturgeon, and 84 young-of-year sturgeon were collected between 2001 and 2010 below RM 320. The most downstream collection of pallid and shovelnose sturgeon was at RM 95.5 and 81, respectively. Consequently, we assume that entrainment risk of pallid sturgeon declines substantially below New Orleans and is unlikely below RM 50.

Introduction

Field sampling of pallid sturgeon, shovelnose sturgeon, and associated species were conducted in the lower reaches of the Mississippi River at sites corresponding to proposed and existing diversions (Table 1.1). Sampling was conducted according to standard protocols established in previous field assessments (Killgore et al. 2007; Miranda and Killgore 2013). The purpose of river sampling was to determine the spatial distribution and most downstream limit of occurrence in the lowermost reach of the Mississippi River. Both shovelnose and pallid sturgeon were considered since the presence of shovelnose sturgeon may imply the presence of the rarer pallid sturgeon. Field collections were used to develop a population model of pallid sturgeon to estimate absolute abundance in the river (see Chapter 2).

Methods

Sampling efforts summarized in this chapter include efforts in the Lower Mississippi River proper between river mile (RM) 0 and 320, all within the operational boundaries of the U.S. Army Corps of Engineers, New Orleans District. Although the primary study reach (i.e., diversion reach) ranges between RM 45 and 160 (Table 1.1, Figure 1.1), the inclusion of comparable upriver sampling efforts was necessary to provide comparisons on relative abundance of both pallid and shovelnose sturgeon within the immediate study zone.

Three gears were used to sample sturgeon. Trotlines (61 m long, 60 dropper lines spaced every 0.9 m tied to 2/0 hooks) were be baited with worms (Canadian night crawlers), fished overnight along the bottom, and retrieved the following morning. Up to eight trotlines were deployed per night at each site, each fishing approximately 16 hours. Trotlines were evenly distributed between littoral and channel border locations. Experimental mesh gill nets (27.4 m by 1.8 m, six mesh panels ranging from 23 to 76 cm) were set in littoral locations and adjacent to diversion inflow areas only. Usually two gill nets were set at each site in the late afternoon and retrieved the following morning, usually over a 16-hour period. A 3.0-m Missouri benthic trawl, based on the design by Herzog et al. (2005), was used to sample smaller benthic fishes. The distance traveled, average speed, and depth range were recorded during each trawling event. Number of trawls per site was dependent on available locations conducive for this type of gear (i.e., relatively un-obstructed river bottom in waters ranging from 1-15 m). Water quality (temperature, dissolved oxygen, pH, conductivity, turbidity) and hydraulic (depth, velocity) variables were measured at each sampling location. GPS coordinates of sampling locations were also recorded. All data were entered into ERDC's Mississippi River long-term database.

All fish captured were identified to species, enumerated, and total length (also fork length for sturgeon) was measured. Additional morphometric measurements and meristic counts were taken on pallid sturgeon to verify species designation *a posteriori* as described by Murphy et al. (2007). Prior to release, shovelnose and pallid sturgeon were externally tagged with t-anchor bar spaghetti tags. In addition, all pallid sturgeon specimens were scanned for the presence of a Passive Integrated Transponder (PIT) tag, and if no tag was detected, a non-encrypted PIT tag was inserted at the base of the dorsal fin. All pallid sturgeon were also scanned for coded wire tags to determine if individuals were of hatchery origin.

Results and Discussion

Four hundred and sixty-nine (469) total sampling gears (e.g., trotline, trawl, gillnet) were deployed at 85 sample stations along the 320 river mile reach (Figure 2.1) with 74.1% of the sampling efforts conducted within the reach associated with existing or planned river diversions. Trotline and trawl were the predominant gear types utilized for all sampling efforts (Figure 3.1; 87.5%) because both are very effective gears for targeting river sturgeon, but each gear type generally targets individuals of different size ranges (Killgore et al. 2007; Phelps et al. 2009). Total sampling efforts included in this summary have been stratified across several years (Figure 4.1) with 57.8 % of the analyzed efforts occurring within the past 5 years, and occurring primarily within the study reach associated with the river diversions. Sampling within the river occurred year-round (Figure 5.1) with 73.1% of all efforts occurring during the cooler months of spring, fall and winter. The depicted monthly pattern is typical and generally reflects gear recruitment by river sturgeon. Our primary gears are very effective in catching sturgeon but catch rates, particularly with trotlines, are temperature dependent (Killgore et al. 2007; Phelps et al. 2009) and are minimally effective during months associated with warmer water temperatures. In contrast, sampling for young-of-year (YOY) with trawls is effective during all months.

The spatial distribution of all sampled gears for the Lower Mississippi River are illustrated in Figure 6.1, which adequately depicts extensive sampling above, below and within the reach containing existing and planned river diversions. Our sampling documented 61 species of fishes with a total abundance of 13,314 individuals across all samples (Table 2.1). A total of 51 pallid sturgeon, 319 shovelnose sturgeon, and 84 young-of-year sturgeon were collected between 2001 and 2010 below RM 320. Seven species composed over 90% of the relative abundance with *Ictalurus furcatus* being the most abundant species and followed in descending order by *Anchoa mitchilli*, *Dorosoma cepedianum*, *Aplodinotus grunniens*, *Ictalurus punctatus*, *Scaphirhynchus platorynchus* and *Mugil cephalus*. *Scaphirhynchus albus* ranked 16th and represented 0.4% of the total relative abundance.

Sturgeon were generally distributed from RM 319 downstream to RM 81 (Figure 7.1) with abundances for each species varying throughout the sampled reach (Figure 8.1). Pallid sturgeon size ranged 405-964 mm FL and shovelnose sturgeon size ranged 231-852 mm FL. Adult pallid and shovelnose sturgeon, as well as YOY, are present within the upper portion (RM 80-160) of the diversion reach, providing evidence of recruitment within this region (Table 2.1, Figure 10.1). Post-larval sturgeon (i.e., YOY) have been documented from RM 128 to 245, and have been represented by numerous specimens (not limited to a single individual in a single effort), over multiple years and during both spring and fall sampling events. Recently spawned sturgeon ranged in size from 17 to 268 mm TL, which is the reported size ranges of pallid and shovelnose sturgeon YOY (Harrison et al. 2014) (Figure 11.1). These data provide additional support for fall spawning in *Scaphirhynchus* species and confirm spawning in the lower extent of the Mississippi River. In addition, the shovelnose sturgeon occurring near the Caernarvon diversion (Figure 10.1) further suggests upriver spawning and/or downstream drift from a favorable upriver site (i.e., Donaldsonville, White Castle). Regardless of the scenario of choice, these data provide support for increased potential of entrainment of small sized sturgeon in nearby diversion areas (e.g., Violet Siphon, Caernarvon).

Killgore et al. (2007) compared CPUE of pallid and shovelnose sturgeon in reaches of the Middle and Lower Mississippi River using only catch from trotlines. In their study (Killgore et al. 2007), effort was considered as an "overnight set" such that a single 100', 60 hook trotline (ca. 16 hour soak period) was treated as a single effort and catch per unit effort (CPUE) of both pallid and shovelnose sturgeon were tabulated based on that set. For this evaluation, we followed the same methodology to compute CPUE and comparisons were restricted to only trotline captures. All but one pallid sturgeon (51 total individuals) and 14 shovelnose sturgeon (319 total) were captured by trotlines. CPUE of both pallid and shovelnose sturgeon varied across the study area with CPUE of shovelnose sturgeon generally exceeding that of pallid sturgeon when compared across stations sampled with trotlines (Figure 12.1). Condensing these data into a river mile category (Table 3.1) illustrates that shovelnose sturgeon were more prevalent in the upstream reach. Although the ratio of pallid to shovelnose sturgeon varied across river mile categories, values for both species were fairly consistent between RM 120-180 with pallid/shovelnose ratios ranging from 1:1 to 1:2.85. Downstream of this area, abundances of both species declined to minimal numbers.

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Table 1.1. List of proposed and existing diversions in the Lower Mississippi River that were sampled by ERDC Fish Ecology Team during the entrainment study.

Water Diversion	River Mile	Status	Mississippi River Sampling	Outflow Channel Sampling	Latitude	Longitude
Convent/Blind River	160.0	Proposed	YES		30.036780	-90.838990
Hope Canal	145.0	Proposed	YES		30.051230	-90.657120
Bonnet Carré	128.0	Existing	YES	YES	30.002430	-90.441470
Davis Pond	119.0	Existing	YES	YES	29.932010	-90.321650
Violet Siphon	83.8	Existing	YES	YES	29.898210	-89.902960
Caernarvon	81.5	Existing	YES	YES	29.862830	-89.912000
White Ditch	64.5	Existing	YES	YES	29.711650	-89.979140
Naomi Siphon	63.9	Existing	YES	YES	29.701360	-89.983520
Myrtle Grove	59.0	Proposed	YES		29.639720	-89.949190
Magnolia (Myrtle Grove No. 2)	45.0	Proposed	YES		29.541650	-89.761730

Table 2.1. Total species occurrence by 20 river mile delineation as documented by ERDC sampling efforts in the Lower Mississippi River during the 2001-2010 sample period. River reaches containing existing or proposed diversion are highlighted with Convent/Blind River (RM 179-160) and White Ditch (RM79-60) noted in red.

Taxa	Common Name	River Mile																	
		301-320	319-300	299-280	279-260	259-240	239-220	219-200	199-180	179-160	159-140	139-120	119-100	99-80	79-60	59-40	39-20	19-0	SUM
Acipenseriformes																			
Acipenseridae																			
Scaphirhynchus albus	Pallid sturgeon	--	9	---		1		---	14	12	11	3		1					**51**
Scaphirhynchus platorynchus	Shovelnose sturgeon	--	201	---	4	7		---	36	31	29	6	2	3					**319**
Scaphirhynchus sp.	YOY sturgeon	--		---		5		---	51	23	2	3							**84**
Polyodontidae																			
Polyodon spathula	Paddlefish	--		---				---		4		37							**41**
Semionotiformes																			
Lepisosteidae																			
Lepisosteus oculatus	Spotted gar	--		---				---				24					9		**33**
Lepisosteus osseus	Longnose gar	--		---				---								1			**1**
Amiiformes																			
Amiidae																			
Amia calva	Bowfin	--		---				---	3					1					**4**
Osteoglossiformes																			
Hiodontidae																			
Hiodon alosoides	Goldeye	--		---	7	3	1	---				1							**12**
Anguilliformes																			
Anquillidae																			
Anguilla rostrata	American eel	--	1	---				---		8	12	16	4	17	1		1		**60**
Ophichthidae																			
Myrophis punctatus	Speckled worm eel	---		---				---								1			**1**
Ophichthus gomesii	Shrimp eel	---		---				---						1					**1**

Clupeiformes																			
Engraulidae																			
Anchoa mitchilli	Bay anchovy	---		---			82	---		16	50			148	43	3040			**3379**
Clupeidae																			
Alosa chrysochloris	Skipjack herring	---		---				---				122		2		1			**125**
Brevoortia patronus	Gulf menhaden	---		---				---						4					**4**
Dorosoma cepedianum	Gizzard shad	---		---	1			---		25		1184	17		23	2	47	4	**1303**
Dorosoma petenense	Threadfin shad	---		---				---	3		24	27	3			2			**59**
Cypriniformes																			
Cyprinidae																			
Ctenopharyngodon idella	Grass carp	---		---				---				2							**2**
Cyprinus carpio	Common carp	---		---				---		2		14				1			**17**
Hypophthalmichthys molitrix	Silver carp	---		---				---				3		1					**4**
Macrhybopsis aestivalis hyostoma	Shoal chub	---		---			4	---	1	9	5			6					**25**
Macrhybopsis storeriana	Silver chub	---	3	---			2	---	1	4	9	147							**166**
Notropis blennius	River shiner	---		---				---				2							**2**
Notropis shumardi	Silverband shiner	---		---				---			6	46							**52**
Notropis wickliffi	Channel shiner	---		---				---				1							**1**
Catostomidae																			
Carpiodes carpio	River carpsucker	---		---				---				7							**7**
Ictiobus bubalus	Smallmouth buffalo	---		---				---	1	2		53	1	3					**60**
Ictiobus cyprinellus	Bigmouth buffalo	---		---				---				4							**4**
Ictiobus niger	Black buffalo	---		---				---	2	1				1					**4**
Siluriformes																			
Ictaluridae																			
Ictalurus furcatus	Blue catfish	---	342	---	344	77	300	---	251	639	438	1277	36	433	157	39	329	73	**4735**
Ictalurus punctatus	Channel catfish	---	18	---				---	33	110	307	224	21	133	3	40	36	1	**926**
Noturus sp.	Unidentified madtom	---		---				---				1							**1**
Pylodictis olivaris	Flathead catfish	---	2	---	1			---	41	26	12	26	4	15	7				**134**

Mugiliformes																			
Mugilidae																			
Mugil cephalus	Striped mullet	---		---				---				10	6				240	1	**257**
Atheriniformes																			
Atherinidae																			
Menidia sp.	Unidentified silverside	---		---				---				10							**10**
Beloniformes																			
Belonidae																			
Strongylura marina	Atlantic needlefish	---		---				---				7							**7**
Cyprinodontiformes																			
Fundulidae																			
Lucania parva	Rainwater killifish	---		---				---				1							**1**
Perciformes																			
Moronidae																			
Morone chrysops	White bass	---		---			3	---			1	9	2				3		**18**
Morone mississippiensis	Yellow bass	---		---				---									1		**1**
Morone saxatilis	Striped bass	---		---				---				7		1			1	4	**13**
Perciformes																			
Centrarchidae																			
Lepomis cyanellus	Green sunfish	---		---				---				6							**6**
Lepomis gulosus	Warmouth	---		---				---				13							**13**
Lepomis humilis	Orangespotted sunfish	---		---				---				5							**5**
Lepomis macrochirus	Bluegill	---		---				---			1	32							**33**
Lepomis marginatus	Dollar sunfish	---		---				---				9							**9**
Lepomis megalotis	Longear	---		---				---				5							**5**
Lepomis microlophus	Redear	---		---				---				1							**1**
Lepoms sp.	Unidentified sunfish	---		---				---			1								**1**
Micropterus salmoides	Largemouth bass	---		---				---		1		58							**59**
Pomoxis annularis	White crappie	---		---				---				28							**28**
Pomoxis nigromaculatus	Black crappie	---		---				---				20					1		**21**

Percidae																			
Sander canadensis	Sauger	---		---				---		2	2	10							**14**
Sciaenidae																			
Aplodinotus grunniens	Freshwater drum	---	1	---	47	18	36	---	11	138	202	616	1	33	3	3	17		**1126**
Cynoscion nebulosus	Spotted seatrout	---		---				---									9		**9**
Pogonias cromis	Black drum	---		---				---									5		**5**
Sciaenops ocellatus	Red drum	---		---				---									2		**2**
Cichlidae																			
Oreochromis sp.	Unidentified tilapia	---		---				---									25		**25**
Gobiidae																			
Gobionellus shufeldti	Freshwater goby	---		---				---						1					**1**
Unidentified goby	unidentified goby	---		---				---						3					**3**
Pleuronectiformes																			
Paralichthyidae																			
Paralichthys lethostigma	Southern flounder	---		---				---						2		1	2		**5**
Achiridae																			
Trinectes maculatus	Hogchoker	---		---				---				5		14	2				**21**
TOTAL			**577**		**404**	**111**	**428**		**448**	**1053**	**1112**	**4082**	**97**	**821**	**239**	**3131**	**728**	**83**	**13314**
NUMBER OF DIVERSIONS										1	1	1	1	2	1	2			
Graptemys pseudogeographica kohnii	Mississippi map turtle									2	2								4
Trachemys scripta elegans	Red-eared slider											1							1
Macrobrachium ohione	Ohio River shrimp								400		1000	2922		3					4325
Orconectes palmeri longimanus	Western painted crayfish											5							5
Procambarus clarkii	Red swamp crayfish											1							1

Table 3.1. Ratio of pallid/shovelnose sturgeon by river mile category based on CPUE from trotlines within each category.

RM	Abundance		Diversions	CPUE		Pallid:Shovelnose	
	Pallid	Shovelnose		Pallid	Shovelnose	proportion	ratio
>320	0	0					
319-300	9	201		0.18	4.02	0.04	1:22.33
299-280	0	0					
279-260	0	0					
259-240	0	0					
239-220	0	0					
219-200	0	0					
199-180	13	37		0.57	1.61	0.35	1:2.85
179-160	12	29	1	0.23	0.56	0.41	1:2.42
159-140	12	29	1	0.29	0.71	0.41	1:2.45
139-120	3	3	1	0.08	0.08	1.00	1:1
119-100	0	2	1		0.20	0.00	
99-80	1	1	2	0.03	0.03	1.00	1:1
79-60	0	0	1				
59-40	0	0	2				
39-20	0	0	0				
19-0	0	0	0				

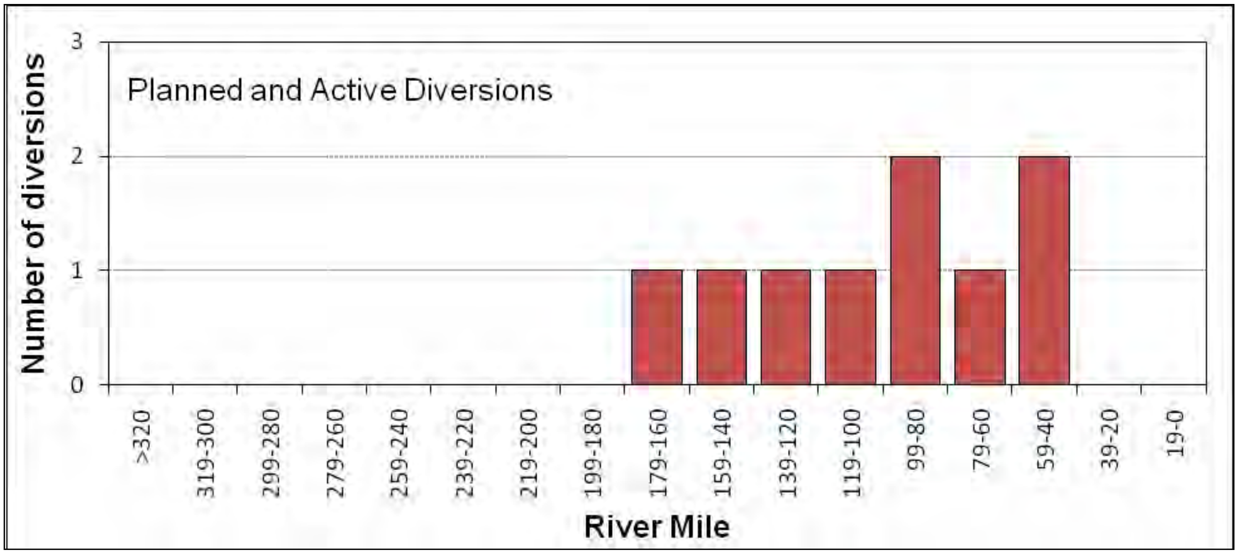

Figure 1.1. Number of planned and active diversions occurring on the Lower Mississippi River within 20 river mile delineations.

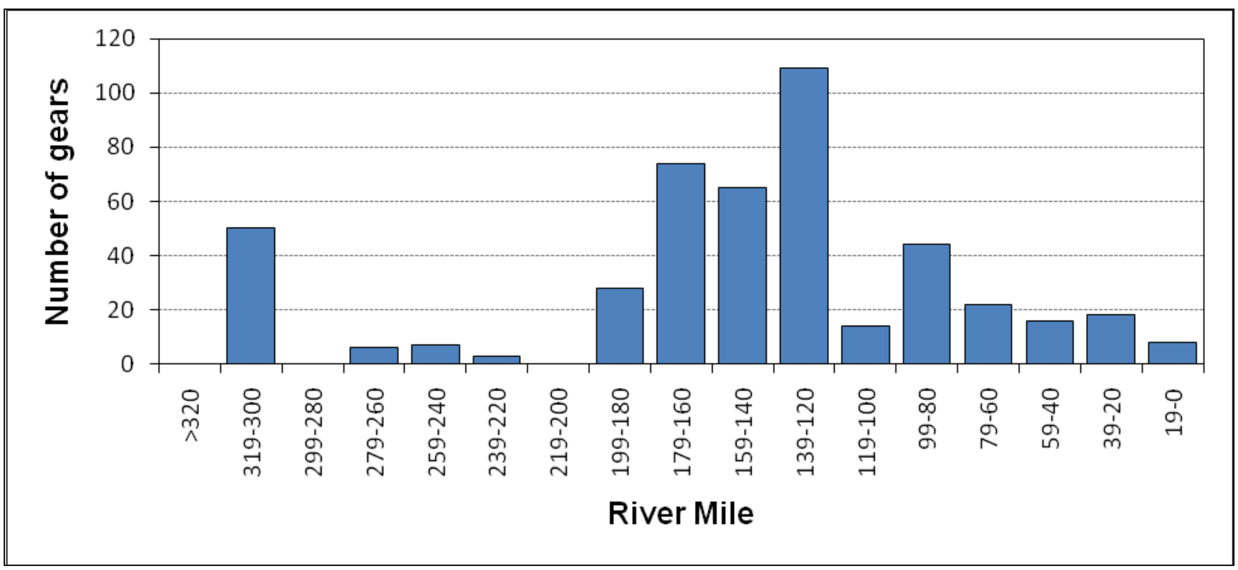

Figure 2.1. Total sampling effort by ERDC Fish Ecology team per river mile category on the Lower Mississippi River (RM 320-0), 2001-2010.

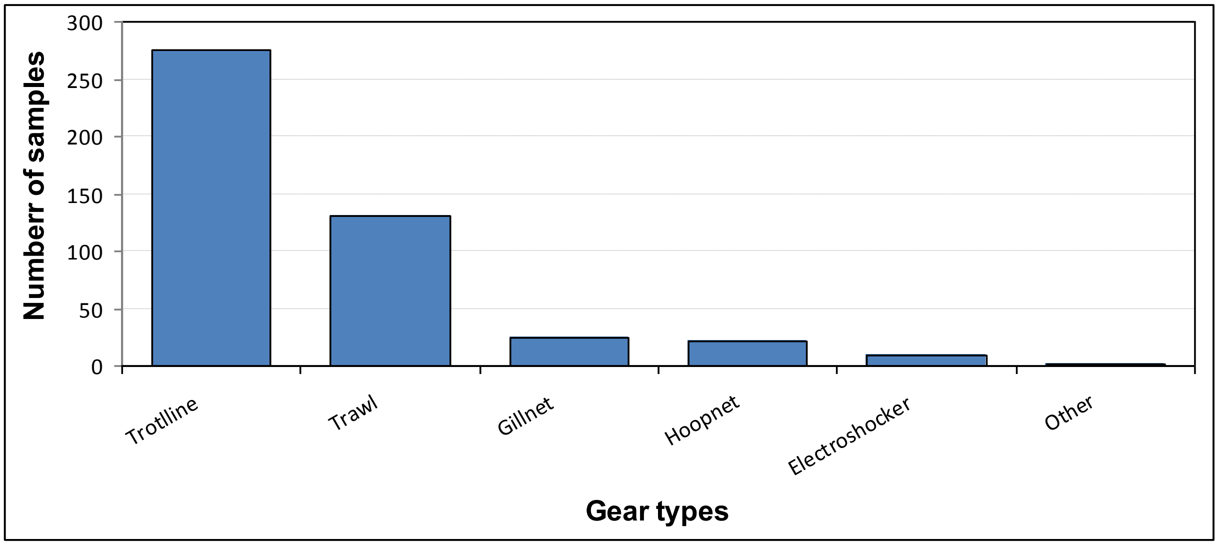

Figure 3.1. Breakdown of gears deployed during fish sampling efforts on the Lower Mississippi River (RM 320-0) (total N = 469), 2001-2010.

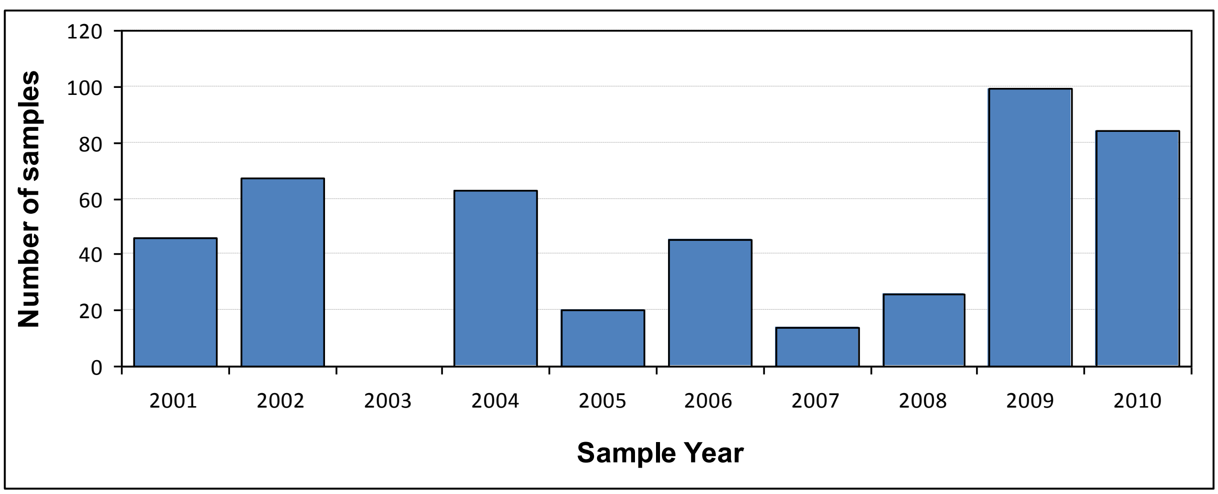

Figure 4.1. Breakdown of sampling effort on the Lower Mississippi River (RM 320-0) by year (total N = 469).

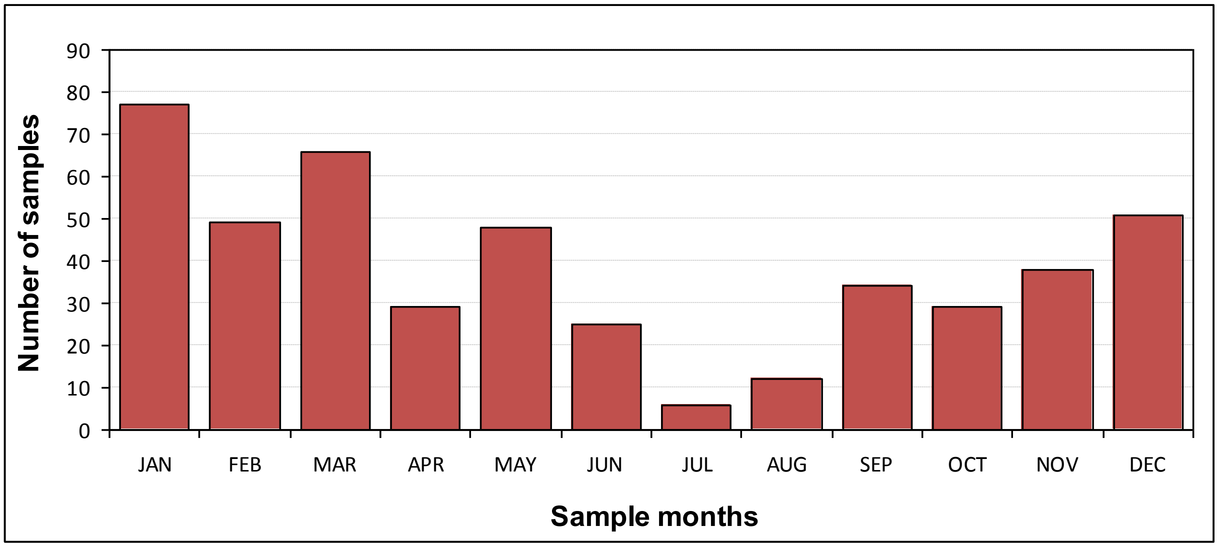

Figure 5.1. Distribution of sampling efforts in Lower Mississippi River (RM 320-0) across months the sample occurred (total N = 469), 2001-2010.

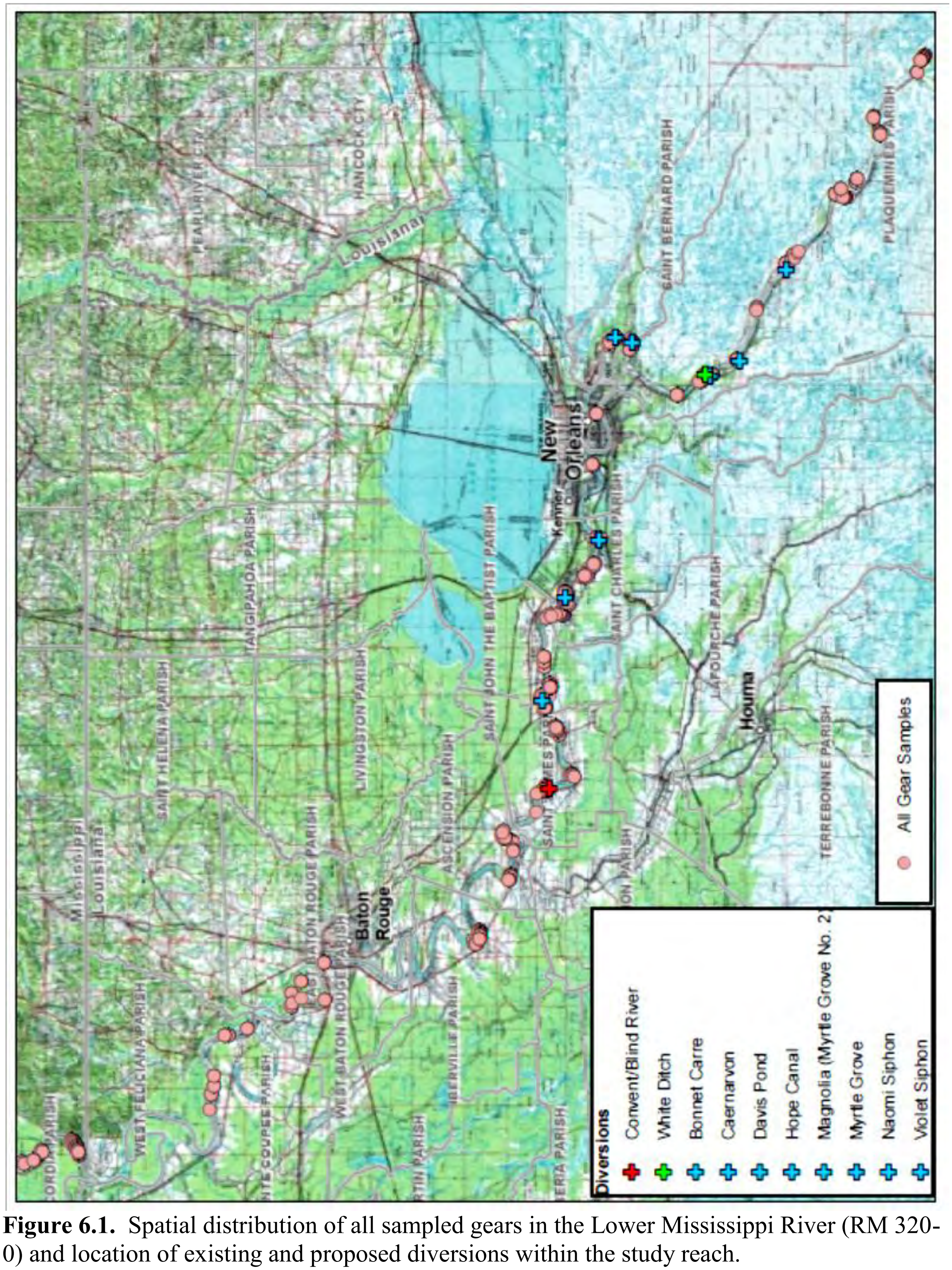

Figure 6.1. Spatial distribution of all sampled gears in the Lower Mississippi River (RM 320-0) and location of existing and proposed diversions within the study reach.

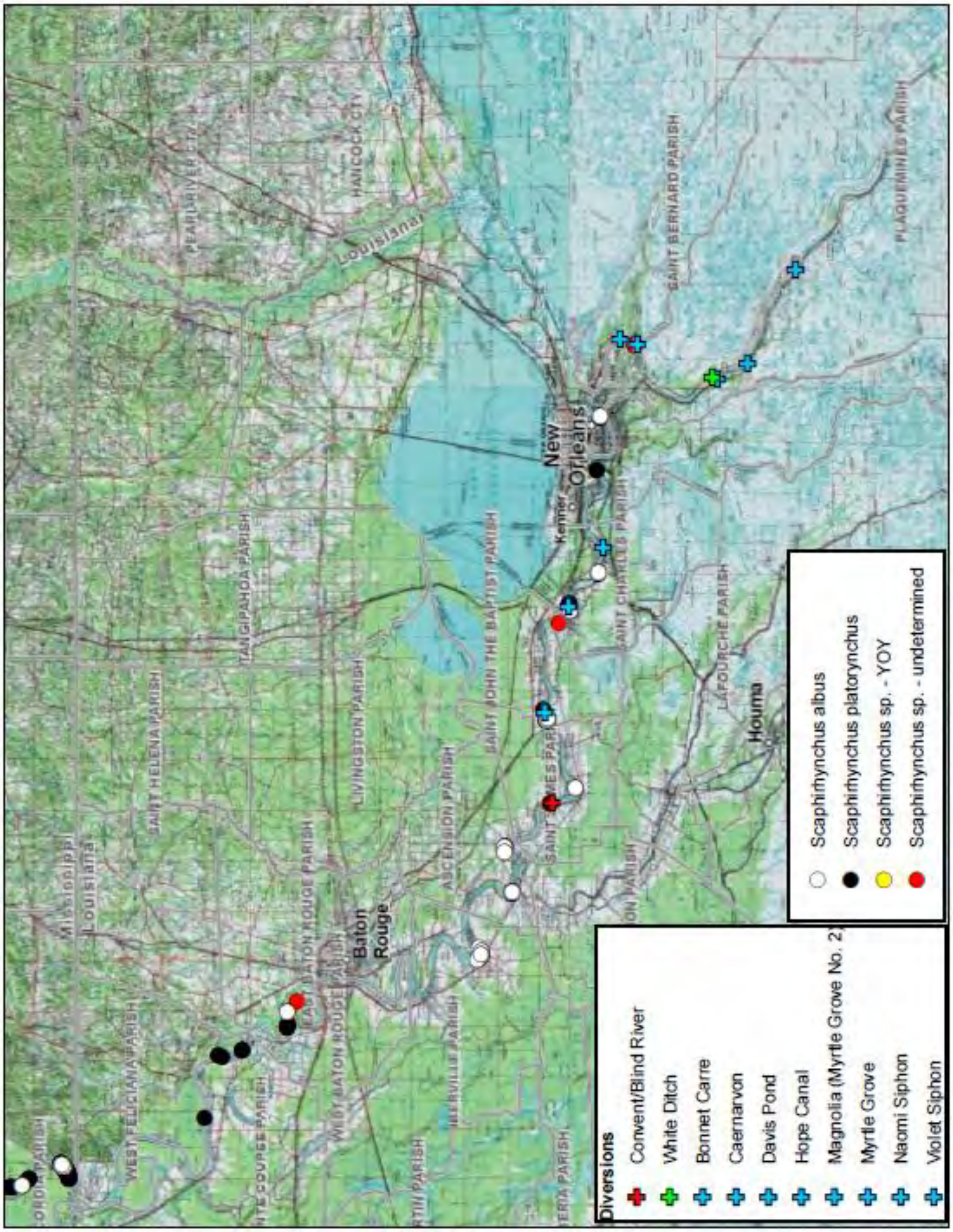

Figure 7.1. Spatial distribution of sturgeon catches along the Lower Mississippi River (RM 320-0).

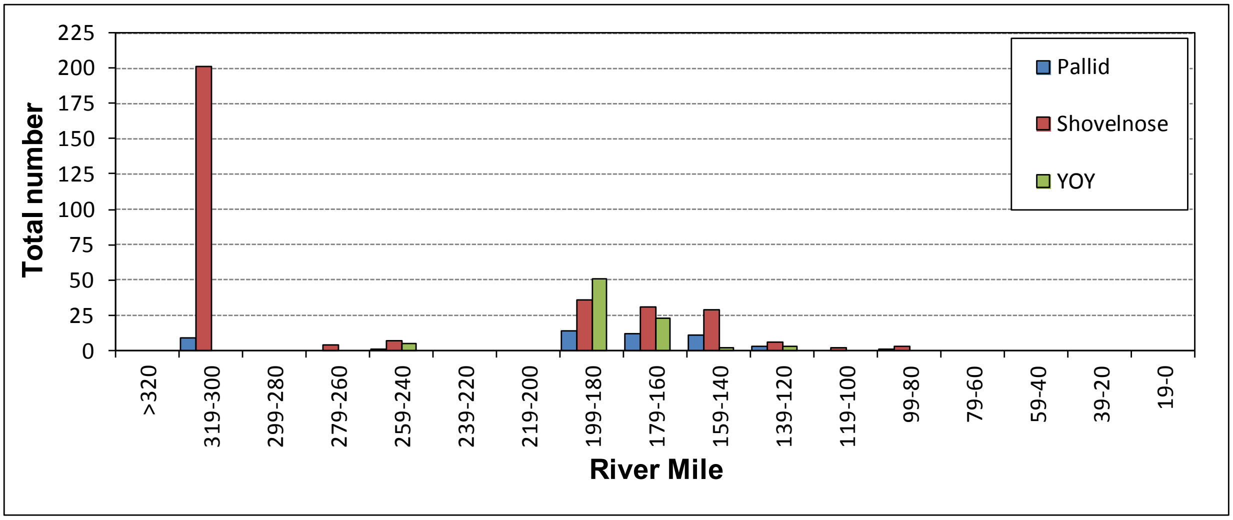

Figure 8.1. Breakdown of all sturgeon catch (all gears combined) by river mile category from 2001-2010.

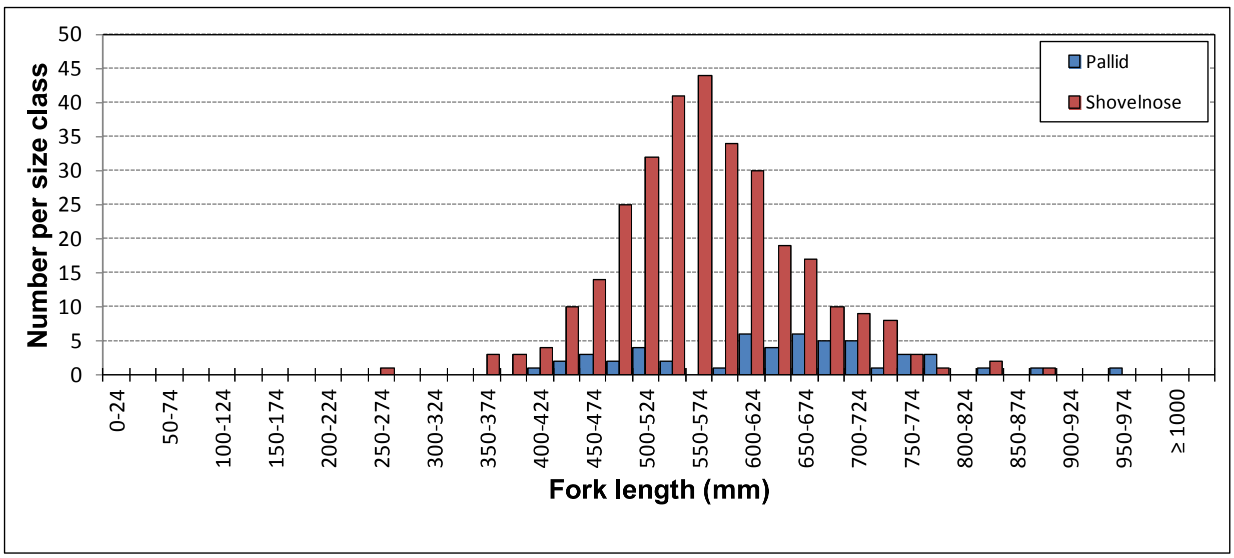

Figure 9.1. Size range and number per size class for pallid and shovelnose sturgeon processed during sampling of Lower Mississippi River (RM 320-0), 2001-2010.

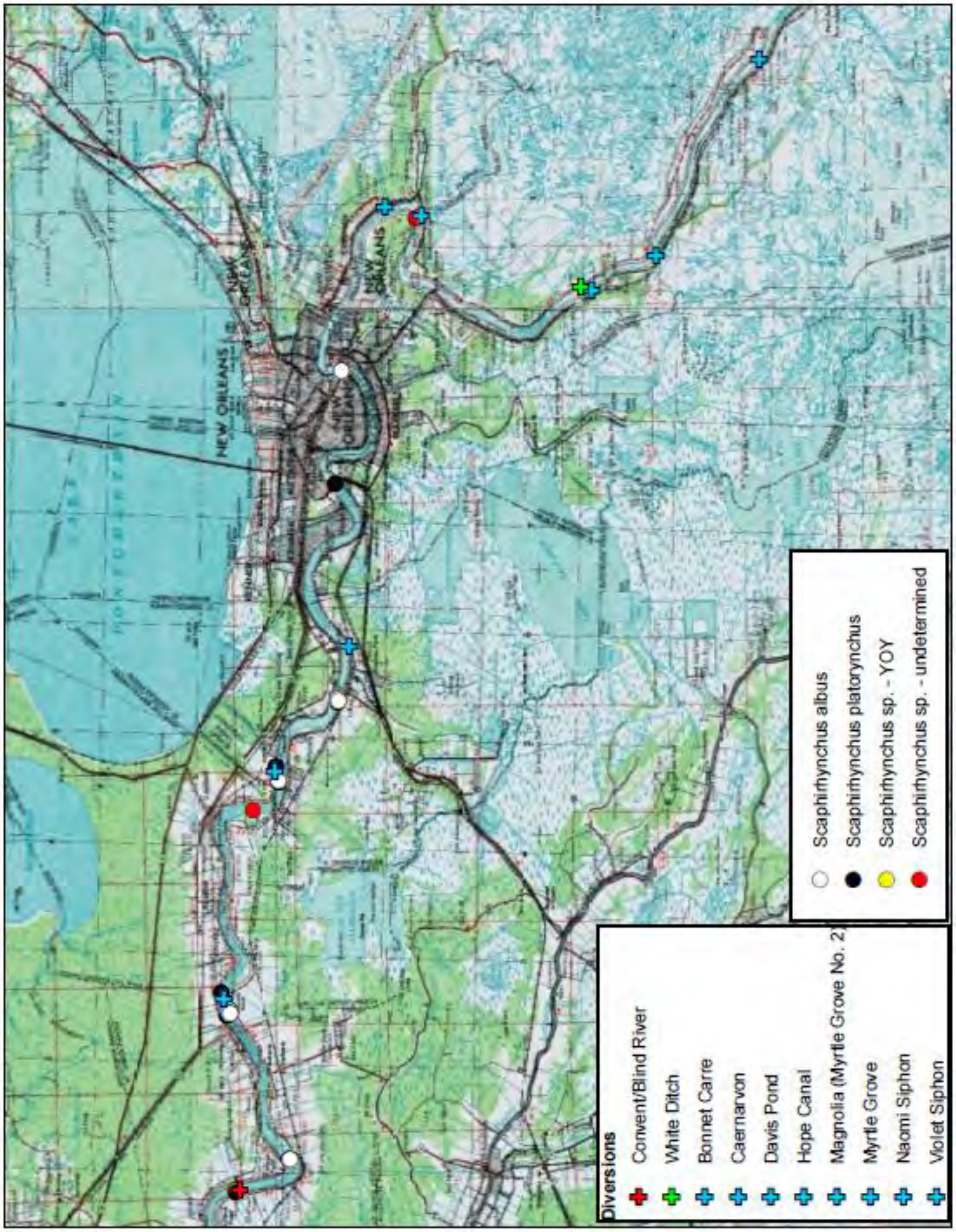

Figure 10.1. Spatial distribution of sturgeon catch within the diversion reach (RM 160-45) of the Lower Mississippi River containing existing and planned diversions.

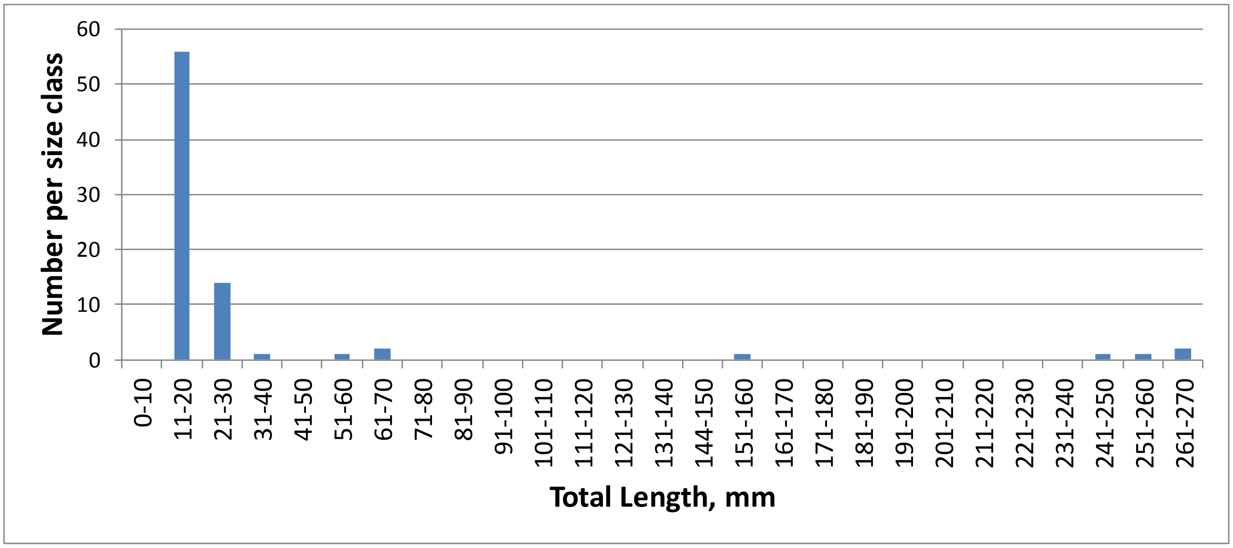

Figure 11.1. Length-frequency histogram for *Scaphirhynchus* young-of-the-year (YOY) processed while sampling the Lower Mississippi River (RM 320-0), 2001-2010.

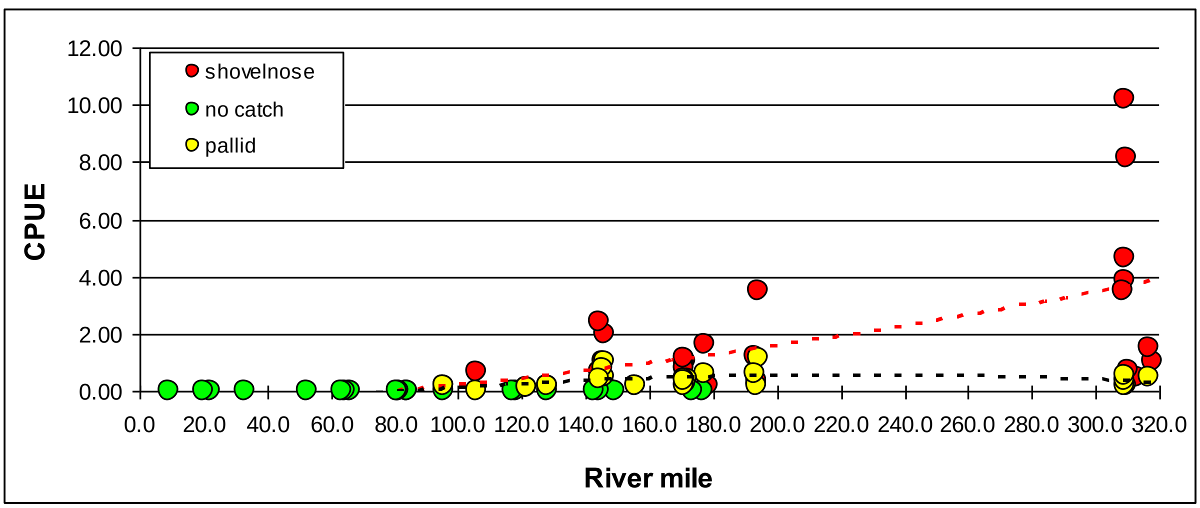

Figure 12.1. Plot of CPUE of pallid and shovelnose sturgeon by river mile for trotlines sampled in the Lower Mississippi River (RM 320-0). Dashed line represents best fit line (2nd order polynomial) through respective data points. Shovelnose sturgeon equation: $y = 3E\text{-}05x^2 - 0.0062x - 0.6581$, $R^2 = 0.3183$; pallid sturgeon equation: $y = -9E\text{-}06x^2 + 0.0042x - 0.1969$, $R^2 = 0.1527$.

Chapter 2

Estimating Pallid Sturgeon (*Scaphirhynchus albus*) Abundance in the Lower and Middle Mississippi River from the Absence of Recaptures

by

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Abstract

Abundance estimates are essential for estimating the viability of populations and the risks posed by alternative management actions. A long-term (1997-2008) sequential mark-recapture survey of pallid sturgeon in the Lower and Middle Mississippi River failed to recapture any of the 241 individuals marked within the Mississippi River itself. We demonstrate that the data are still useful insofar as they suggest lower bounds on abundance consistent with some probability of no recaptures. After accounting for survival, movement, and habitat use, we estimated that the total abundance of age-3+ pallid sturgeon in the Lower and Middle Mississippi River is at least 3,400-4,100 with probability 0.99; 5,900-7,000 with probability 0.95; and 17,000-20,000 with probability 0.75. The latitudinal pattern of reach-level abundance was driven by our assumption about population density along the river. If we assumed fish were distributed in proportion to survey catch-per-unit-effort, then the southernmost reach in the survey, which is thought to lack spawning habitat, hosted at least 3.8, 6.5, or 19 fish per river kilometer (rkm), whereas the remainder of the reaches in the lower and middle Mississippi River hosted at least 1.8-2.3, 3.0-3.9, or 8.7-11.3 fish rkm^{-1}. If we instead assumed a uniform population density over the length of the survey area, the three lower-bound estimates were at least 2.1, 3.7, and 10.7 fish rkm^{-1}. The Lower Mississippi River as a whole comprised over 80% of the Mississippi River population with an average density of 2.0-12.4 age-3+ pallid sturgeon rkm^{-1}. While highly uncertain, our estimates of abundance provide objective initial inputs for what remains an elusive variable in the analysis of viability for the Mississippi River population of pallid sturgeon.

Introduction

Understanding, in absolute terms, the risks facing populations of concern requires an estimate of abundance. As with most of the information we need to know about rare species, however, an abundance estimate may not be available through traditional means, even after extended periods of study. Such is the case with the population of pallid sturgeon, *Scaphirhynchus albus*, in the Mississippi River. The species was listed as endangered in 1990 (55 Federal Register 36641-36647) with presumed low population sizes and recruitment due to overfishing, habitat modifications, pollution, and hybridization (Dryer and Sandvol 1993). The range of the pallid sturgeon includes the Missouri River as well as the Middle and Lower Mississippi River. Pallid sturgeon do not occupy the Upper Mississippi River above the mouth of the Missouri River due to impoundment and are thought to be rare in the lowermost 160 km of the river below New Orleans (Dryer and Sandvol 1993). Pallid sturgeon were historically considered common in the Middle Mississippi River (MMR) between the mouths of the Missouri and Ohio Rivers. Little was known about population density in the Lower Mississippi River (LMR) and the species was thought to be rare there (Duffy et al. 1996). However, the abundance of pallid sturgeon relative to its sister species, *S. platorynchus*, has long been observed to increase southward (Forbes and Richardson 1905; Bailey and Cross 1954), and a more recent study of the LMR indicated higher relative abundances of pallid sturgeon than previously thought (Killgore et al. 2007a).

A long-term survey effort to elucidate abundance and distribution within the Mississippi River captured and marked hundreds of individuals between New Orleans, LA, and the mouth of the Missouri River (Hoover et al. 2007; Killgore et al. 2007a, b)). None of the marked individuals were recaptured in the Mississippi River (Killgore et al. 2007a). The absence of recaptures presents a challenge for traditional mark-recapture methods of abundance estimation but is far from novel. A similar problem arises in risk analysis whenever an event of interest (e.g., an oil spill or pharmaceutical side effect) has not yet been observed (Louis 1981; Hanley and Lippman-Hand 1983; Smith and Winkler 1999; Winkler et al. 2002). The probability of such occurrence is seldom zero. For the mark-recapture problem, Bell (1974a) suggested the use of the hypergeometric probability distribution to estimate population size in light of some chosen probability of no recaptures. Edwards (1974) noted that such an approach can only offer lower bounds on abundance and suggested the use of likelihood ratios for statistical inference. Combined, these methods are easily generalized to sequential mark-recapture studies that might typically be analyzed using the Schnabel estimator (Schnabel 1938; Chapman 1952). The results are highly uncertain and honestly confront the unbounded nature of the problem; the most likely population given no recaptures is always infinite in size. At best, we can only suggest an approximate probability distribution for abundance (Edwards 1992) from which any point estimate is arbitrary.

In this paper we briefly describe our extension of Bell's (1974a) nil-recapture concept to spatially-structured sequential mark-recapture data. We then use the method to find a range of abundance estimates for the pallid sturgeon population in the LMR and MMR under contrasting assumptions about its distribution.

Methods

Survey Overview

A thorough explanation of the survey, study area, and reach delineations can be found in Killgore et al. (2007a). Briefly, the survey dataset covered 12 years (1997 through 2008) of catching and marking pallid sturgeon in the LMR and MMR. The river was divided into six reaches, A-F (Figure 1.2), corresponding to geomorphic differences and river management activities for navigation and flood control. Reach A, the 153 river kilometers (rkm) of river south of New Orleans, yielded no pallid sturgeon and was not considered in this study. Reach B extended 349 rkm from New Orleans to the mouth of the Atchafalaya River, near the southwestern corner of Mississippi. Reach C included the next 433 rkm to the mouth of the Arkansas River. Reach D extended the next 598 rkm to the mouth of the Ohio River, the northern limit of the LMR. Reach E comprised the 314 rkm of the MMR to the mouth of the Missouri River and included the Chain of Rocks, which was separately designated reach F. In the current study, reaches E and F were combined and called reach E+F.

Sampling locations were largely driven by access and the allocation of effort across reaches changed over time with the greatest effort expended in the first half of the survey. All sampling bouts deployed trotlines in a consistent manner throughout the study period. Each trotline was 61 m long, with 60 hooks baited with worms, and deployed for approximately 16 h from late afternoon until the following morning.

Likelihood Function

Each sampling event in the survey consisted of up to eight trotlines and multiple individuals were sometimes caught. Strictly, then, each bout of sampling was conducted without replacement (i.e., the number of fish available to the second hook was one less than the number available to the first hook), indicating the use of a hypergeometric probability distribution to model the likelihood of not catching a marked fish in the sample. In practice, the hypergeometric, binomial, and Poisson distributions gave identical results because the number of fish caught was small relative to estimated total abundance. Hence, we describe the likelihood function generically as proportional to the probability that the number of recaptured fish, *r*, was zero given *c* captures and *m* marked individuals in a population of *N* fish (sensu Edwards 1992) and provide the hypergeometric expression as only one example of specific functions that could be used. That is,

$$L(N|r=0,c,m) \propto \Pr(r=0|c,m,N), \qquad \text{Eq. 1a}$$

$$\Pr(r=0|c,m,N) = \frac{(N-m)!(N-c)!}{N!(N-m-c)!}, \qquad \text{Eq. 1b}$$

where *L* denotes likelihood and Pr denotes probability. Eq. 1b is the hypergeometric probability of no recaptures.

Repeated sampling and marking add three complexities to the inference described in Eqs. 1. First, the number of marked individuals changes in time. Second, an assumption must be made about change in total population size over time. Third, the likelihood of no recaptures must be expressed as the conditional probability of no recaptures in any of the sampling events.

While it is common to make closed-population assumptions [constant population size, no emigration or immigration, no mortality (sensu Gazey and Staley 1986; Yang and Pal 2010)], we assumed the population was open but at birth-death-immigration-emigration equilibrium. Because we were lacking the multiple recapture data necessary for open population estimation methods (Seber 2002), we accounted for immigration, emigration, and survival of marked individuals using an independent demographic model described in the next section (see Estimating Marked Individuals*)*.

We assumed that samples were independent over time. Thus, given no recaptures after repeated sampling and marking events, the likelihood of *N* is proportional to the joint probability of no recaptures in any sample (Schnabel 1938; Otis et al. 1978; Gazey and Staley 1986), computed as the product of Eq. 1b over all samples.

We also assumed that river reaches were independent. Hence, the joint probability that no individuals were recaptured in any of the locations sampled was taken as the product of Eq. 1b over reaches. Modeling spatial structure is appropriate when it is unlikely that the population is well-mixed at the spatial scale of the entire survey (Kareiva 1990). With *T* sample dates and *R* river reaches in the study, the number of individuals caught was recorded in matrix $\boldsymbol{C}$ with *T* rows and *R* columns. In the Mississippi River survey, not all reaches were sampled on the same date because sampling locations were separated by hundreds of kilometers and sampling effort varied geographically over the survey period. If reach *i* was not sampled on date *t*, $\boldsymbol{C}_{ti}$ was given a value of zero, which has no effect on the estimate of abundance. The number of marked individuals projected to occupy each reach was recorded in matrix $\boldsymbol{M}$, which was the same size as $\boldsymbol{C}$. The resulting hyperbolic likelihood function for total abundance, *N,* was

$$L(N|r=0,\boldsymbol{C},\boldsymbol{M}) \propto \prod_{i=1}^{R}\prod_{t=1}^{T}\frac{(N_i-\boldsymbol{M}_{ti})!(N_i-\boldsymbol{C}_{ti})!}{N_i!(N_i-\boldsymbol{M}_{ti}-\boldsymbol{C}_{ti})!} = \prod_{i=1}^{R} L_i, \qquad \text{Eq. 2}$$

where L_i is the likelihood of the reach-level estimate of abundance, N_i.

We explored two possible spatial structures of the population. The first assumed uniform population density along the length of the survey area. The second assumed that spatial variation in population density was described by the reach-specific catch per unit effort (CPUE) observed during the survey. The proportion of the total population expected to occupy each reach, denoted w_i, based on either reach length or reach length and CPUE, was then used to determine the local population sizes for any total abundance, such that $N_i = Nw_i$. We explored two spatial structures because it was not clear whether CPUE measured relative abundance, detectability, or the degree of aggregation at nonrandomly-selected sampling locations.

One cost of including spatial structure was that it required assumptions not only about how to apportion abundance over space but also about the degree of dispersal among locations (Hilborn 1990). Observations of pallid sturgeon movement include individuals with high site fidelity (Bramblett and White 2001) as well as dramatic, long distance relocations (Mayden and Kuhajda 1997; Killgore et al. 2007a). A recent telemetry study in the MMR(Koch et al. 2012) observed a maximum 300 km movement among 84 tagged pallid sturgeon, with seven individuals dispersing out of the reach in a year, yielding a dispersal rate estimate of 0.083 with a 95% confidence interval of (0.024, 0.143). We explored two levels of dispersal rates enclosing the 95% confidence interval for exchange between neighboring reaches: no dispersal and 15% annual dispersal from reach E+F to reach D. In the latter case, dispersal rates between other neighboring reaches were adjusted to maintain either the uniform or CPUE spatial structure by accounting for total relative abundance and relative survival rates (described in more detail in the next section).

We also considered a model in which the entire Mississippi River population of pallid sturgeon was panmictic such that any marked individual could conceivably be caught at any location. While formally free of spatial structure, this model implicitly assumed uniform density and high dispersal rates. Such assumptions lead to the most conservative estimate of abundance.

Estimating Marked Individuals

To employ Eq. 2, it was necessary to project the number of marked fish in each reach on each sampling date (Chapman 1954), producing the matrix, $\boldsymbol{M}$. We did this deterministically by decrementing the cumulative number of fish marked during the survey to account for daily mortality and emigration. Classified by the age-length relationship for LMR pallid sturgeon (Killgore et al. 2007b), the youngest fish caught was age three. The annual survival of adult pallid sturgeon in the LMR has been estimated to be 0.93 by catch curve analysis (Killgore et al. 2007b). This same survival rate was used for age-3+ individuals in a previous population model for pallid sturgeon (Bajer and Wildhaber 2007) and is near the rate of 0.92 estimated by mark-recapture methods for age-1+ hatchery-reared pallid sturgeon in the Missouri River (Steffensen et al. 2010). Survival in the MMR (reach E+F) was set to 0.70 based on an estimate from catch curve analysis (Killgore et al. 2007b). The higher mortality rate in the MMR reflects that the survey was conducted before the moratorium there on commercial fishing for *S. platorynchus*, which impacted pallid sturgeon through the species' similarity of appearance. For the panmictic model, we averaged reach-specific survivals, weighting by reach length, to obtain a river-wide survival rate of 0.887. We further assumed that the population was open; 10% of fish emigrated from the system annually and never returned (sensitivity to emigration rate was also explored).

Dispersal between reaches (when non-zero) was estimated using relative abundance expected from uniform or CPUE patterns of population density, w, and reach-specific survival rates, s, using the formula,

$$d_{ij} = \frac{w_j s_j}{w_i s_i} d_{ji}, \qquad \text{Eq. 3}$$

where d_{ij} is the dispersal rate from reach i to reach j. We solved Eq. 3 for each reach in turn starting with the assumption of 15% dispersal from reach E+F to reach D and working southward. We assumed reaches C and D exchanged individuals with both their upstream and downstream neighbors; in the terminal reaches, B and E+F, all dispersers moved toward the interior of the survey area. Table 1.2 gives the resulting dispersal rates for the two spatial structures we explored.

All rates, including dispersal, were converted to a daily time scale based on 365 days per year and applied to the number of days between sampling events. While all calculations were carried out with double-precision floating point numbers, the number of marked fish was rounded to the nearest integer when entered into the likelihood function. Rounding had the effect of delaying demographic changes in the short term (one fish does not become 0.999 fish the next day). We assumed that survival, emigration, and population size remained constant over the survey period, tagging did not affect survival or detectability, tags were not lost, and populations were well mixed within reaches.

Detectability

It is unlikely that all individuals were detectable during sampling bouts. Hence, the number of marked individuals available to the sampling gear was smaller than the total number projected. Trotlines were deployed along the channel border and near-shore areas but the main channel could not be sampled due to towboat traffic. Pallid sturgeon may spend about 40% of their time in the main channel (Hurley et al. 2004). While this behavior was measured in the MMR and is likely to differ over space, we assumed only 60% of the marked individuals were detectable during any given sampling bout. This assumption had the net effect of reducing total abundance estimates by 40%.

Cumulative Probabilities

The right side of Eq. 2 is a probability mass function. Every point on the function is the probability of no recaptures given ***C*, *M***, *r*, and *N* (Edwards 1974). The function is unbounded, such that the maximum likelihood estimate of *N* is infinity. The most accurate way to communicate the abundance estimate is to report the entire probability mass function. If required, a point estimate or a finite range of abundance can be selected from the mass function, but this selection is necessarily subjective. Bell (1974a; 1974b; 1977) suggested that a practical method for point estimation is to report the abundance for which the probability of no recaptures was 0.5. His reasoning was that such a point estimate is neither so large that recaptures were unlikely nor so small that the absence of recaptures was unlikely. However, Bell's method does not allow the user to assign a probability to the estimate of abundance itself.

Likelihood theory provides an approximate basis for the assignment of probabilities to nil-recapture estimates of abundance. Eq. 2 can be used to generate relative likelihoods for finite abundance estimates. The probability that the true abundance is *at least* as great as the estimate is then approximated by the χ^2 distribution and one degree of freedom (Edwards 1992). Because the maximum likelihood given by Eq. 2 is $L(N = \infty) = 1$, the relative likelihood of any finite abundance estimate is simply $1/L(N)$ and its probability as a lower bound on abundance is χ^2 $[-2\ln L(N), 1]$. We chose to find point estimates of abundance for which the probability of the true abundance exceeding our estimates was 0.99, 0.95, and 0.75. These lower confidence limits correspond approximately to probabilities of no recaptures of 0.036, 0.147, and 0.516, respectively. We chose the least conservative lower bound for its near equivalence to Bell's (1974) suggested target probability of 0.5.

Results

In total, 50, 64, 70, and 57 pallid sturgeon were caught and marked in reaches B, C, D, and E+F, respectively, from 1997 through 2008. Figure 2.2 illustrates the projected number of marked fish in each reach over time with the assumed rates of survival and emigration from the Mississippi River and no dispersal. The projected number of marked individuals was used to parameterize Eq. 2 for the estimation of total and reach-level abundance. Alternate projections with dispersal between neighboring reaches (rates given in Table 1.2) led to an increase in the number of marked pallid sturgeon expected in the largest reach, D, for both uniform and CPUE population structures. Dispersal consistent with the CPUE pattern of population density reduced the projected number of marked fish in reach C.

Abundance estimates were robust to the assumptions made about spatial structure and dispersal. All models led to estimates of similar magnitude. Figure 3.2 shows the probability mass and cumulative probability for total population size given no recaptures derived using the uniform and CPUE assumptions without dispersal, as well as the panmictic assumption. The three relative likelihoods evaluated provided a range of lower bounds on total abundance from roughly 3,400 to 20,000 age-3+ fish across models (Table 2.2). The CPUE-based estimate was 10% higher than that gained from the uniform density assumption. Limited dispersal between neighboring reaches increased uniform abundance estimates by 1% and CPUE abundance estimates by 0-2%. Panmixia decreased the estimate of abundance 7% relative to the uniform model with limited dispersal.

The spatial pattern imposed on reach-level population densities had the greatest effect on abundance in the southernmost reach, B (Figure 4.2). The uniform model led to a spatial structure with 21% of the total population in reach B, yielding a lower 95% (99%-75%) bound on local abundance of 1,300 (750-3,800) age-3+ fish (Figure 4.2b). In contrast, the CPUE model suggested that 33% of the population resides in reach B, with a lower bound on abundance of 2,300 (1,300-6,600) age-3+ fish (Figure 4.2b). Under a panmictic model (no spatial structure), the lower bound on river-wide population density was 3.5 (2.0-10.1) age-3+ fish rkm^{-1}. Under the uniform model, density was similarly at least 3.7 (2.1-10.7) age-3+ fish rkm^{-1} (Figure 4.2a). Under the CPUE model, the density of age-3+ fish varied among reaches. Reach B had the highest density, 6.5 (3.8-18.9) rkm^{-1}, while reach C had the lowest, 3.0 (1.8-8.7) rkm^{-1}. Density in reach D was 3.9 (2.3-11.3) rkm^{-1}. Reach E+F had a population density of 3.4 (2.0-9.8). The river-wide average density with the CPUE spatial structure was at least 4.2 (2.4-11.9) age-3+ pallid sturgeon rkm^{-1}.

Uncertainty in the distribution of the population among reaches had only a small effect on the relative sizes of the LMR and MMR populations. While the lower river accounted for 81% of the survey area's length, the CPUE distribution assigned it 85% of the total abundance. Mean population density in the LMR was 4.3 (2.5-12.4) age-3+ fish rkm^{-1} compared with 3.4 (2.0-9.8) age-3+ fish rkm^{-1} in the MMR.

Abundance estimates were sensitive to the emigration rate used to project the number of marked individuals (Table 3.2). The only recapture of a pallid sturgeon marked during the survey was made by a commercial fisherman in the Obion River, TN (Killgore et al. 2007a), providing evidence that some marked individuals could have permanently emigrated from the study area and would thereby become undetectable. The results in Table 2.2 assumed a 10% annual rate of emigration. Reduction of annual emigration to 0% decreased abundance 13%. Increasing emigration to 20% increased abundance 16%. Sensitivity to annual survival would be identical.

The efficiency of sampling gear varies among age or size classes of fish (Anderson 1995). Killgore et al. (2007a) noted that pallid sturgeon did not fully recruit to trotlines until age 11. We explored the sensitivity of the abundance estimate to the reduced detectability of younger age classes using a panmictic model. Captured, marked fish were initially assigned to age classes based on their length using the von Bertalanffy growth model of Killgore et al. (2007b). Age-specific detectabilities for age classes 3-10 were calculated as the number of fish per age class relative to the number expected by backward-interpolation of survival based on age-11 fish. The abundance, length, and detectability of these fish were then projected using our demographic model in combination with the growth model and age-specific detectability. These projections resulted in a modified number of detectable marked fish per sampling bout. We found that the apparent bias of trotlines toward larger age classes could lead to a 12% overestimate of abundance.

Discussion

The abundance of pallid sturgeon is a critical factor in the estimation of the species' viability. The most conservative of our four spatially structured models, the uniform density estimate without dispersal between reaches, suggested there was a 1-25% chance that the Mississippi River between New Orleans and the mouth of the Missouri River contains fewer than 3,700-18,000 age-3+ pallid sturgeon, respectively. The statistical confidence expressed for these estimates is overstated; abundance was slightly sensitive to unquantified uncertainty about spatial structure and dispersal and moderately sensitive to uncertainty about survival, emigration, and gear bias. Additional uncertainty in the projection of the marked population due to environmental variation and demographic stochasticity could be captured by stochastic simulation. However, our goal was to find a first approximation of abundance consistent with the survey data to guide models and management of the MMR and LMR populations. In this respect, we can generally conclude it is 25 times more likely that total abundance is less than 20,000 age-3+ individuals than that it is less than 4,000 individuals. Our exploration of model sensitivities suggests that the error in these probabilistic estimates is less than one order of magnitude.

Our range of lower bounds is inclusive of independent estimates of pallid sturgeon abundance. An unpublished genetic analysis has estimated an effective population size in the LMR of about 20,000 individuals (Rob Wood, pers. comm.). The effective population size is likely conservative (Hartl and Clark 2007), although its geographic scope is also likely to exceed the LMR due to gene flow. A mark-recapture experiment utilizing a greater diversity of sampling gear and greater effort focused on the MMR estimated 1,600 pallid sturgeon (Garvey et al. 2009), a number close to our 95% lower bound estimate of 1,100-1,200 age-3+ fish for reach E+F and likely to address similar age classes. Our lower bounds also encompass the IUCN Red List species assessment for the entire geographic range (Krentz 2004), 6,000-21,000 individuals, taken from Duffy et al. (1996). Our estimate differs from Duffy et al. (1996) in that the interval 1) describes only the lower bound on abundance, 2) is restricted to the Mississippi River portion of the species range, and 3) explicitly includes only age-3+ individuals. Due to recruitment in the Mississippi River, the total abundance including younger age classes may be substantially higher. We are currently developing a demographic model for the Mississippi River population of pallid sturgeon that will help extrapolate abundance to include age-1 and -2 fish.

Comparison of wild adult pallid sturgeon in one reach of the Lower Missouri River, where natural recruitment is considered rare or absent, appear to exist at a density of 5.4 to 8.9 fish rkm^{-1} (Steffensen et al. 2012), a level that falls between our 95% and 75% lower bounds for the uniform Mississippi River population density of 3.7-10.7 age-3+ fish rkm^{-1}, with the obvious difference that the former counts only adults (fork length > 589 mm).

The nil-recapture estimates may be inflated. Closed population models tend to have overestimation bias (Evans and Bonnet 1994; Fewster and Jupp 2009) and this bias can be large in cases with few or no recaptures, in which case even typical bias corrections are insufficient (Chapman 1952). In addition, the assumption that all detectable fish in a reach are sampled by an overnight trotline is an obvious simplification. Finally, the sensitivity to gear bias demonstrated that our lower bounds could be inflated by 12%.

There is also a chance that the nil-recapture estimates are conservative. We made the broad assumption that 40% of marked fish were undetectable based on a telemetry study of habitat use in the MMR (Hurley et al. 2004). A more recent study (Koch et al. 2012) found a similar 44% chance that individuals were in main channel habitat, out of the reach of sampling gear deployed in the river margins. However, the same reported individual movements ranging from 0.5 to 6.6 km per week, suggesting that pallid sturgeon frequently move throughout the river. Hence, our assumption about detectability may have been too conservative. The 16 h deployment of trotlines in the survey could be sufficient to allow substantial turnover of individuals between main channel and margin habitats. Finally, the sensitivity of our estimates to the emigration rate was substantial. While movement of pallid sturgeon between the Mississippi River and its tributaries has been observed (Killgore et al. 2007a; Koch et al. 2012), the annual emigration rate, whether that rate differs among reaches, and whether those individuals are likely to return is not clear. Our use of 10% emigration was intended to be conservative.

The distribution of the Mississippi River population is of potential importance to its viability because reach B lacks hard substrates (Baker et al. 1991) that are thought to serve as spawning habitat (Dryer and Sandvol 1993). While there was evidence from body condition measured during the survey that adults in the lower LMR make upstream spawning migrations (Hoover et al. 2007), such inferences may be confounded with seasonal variation in sampling effort as well as latitudinal gradients in morphology (Murphy et al. 2007). Large seasonal movements of pallid sturgeon have been observed in other parts of the range (Bramblett and White 2001; Koch et al. 2012). It remains unclear whether reach B represents a rearing habitat for immature individuals, the non-spawning home range of an actively-recruiting population, or a sink population (Holt 1985; Pulliam 1988) sustained by larval drift. Such hypotheses also affect the perceived role of reaches C and D, which may comprise the best remaining habitat for pallid sturgeon due to their relatively low channelization and absence of impoundments or major diversions (Baker et al. 1991). While the combined abundance of fish in reaches C and D was insensitive to our assumptions about spatial structure, the population growth rate necessary for persistence would differ greatly between the uniform and CPUE spatial patterns of abundance if reach B is a sink.

Population estimates for the MMR and LMR reported herein, along with published estimates from the Missouri River (Steffensen et al. 2012), provide the first range-wide perspective on pallid sturgeon populations in the free-flowing Missouri-Mississippi river system. Together, these studies suggest population sizes of adult wild pallid sturgeon ranging from approximtely 2 to 12 fish/km. Hatchery fish in the Missouri River were considerbly more abundant (28.6 to 32.3 fish/km Steffensen et al. 2012) than wild fish in either the Missouri or Mississippi rivers. While establishment of a large and reproductive population is a primary recovery goal (U.S. Fish and Wildlife Service 2013), stocking above the carrying capacity of specific reaches carries the risk of depressing demographic rates due to negative density dependent effects (Braaten et al. 2009). Management activities for pallid sturgeon can now consider population estimates of wild fish as part of recovery plans throughout the range of this species.

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Table 1.2. Proportion of each reach population dispersing to neighboring reaches consistent with either uniform population density or the pattern of catch per unit effort (CPUE) observed during the survey. Assumes dispersal from reach E+F was 0.15 for both spatial structures. We assumed fish in the central reaches, C and D, moved both up- and downstream. We assumed fish in the terminal reaches, B and E+F, moved only toward their neighboring reach.

Reach	Uniform	CPUE
B	0.1	0.05
C	0.16	0.18
D	0.12	0.1
E+F	0.15	0.15

Table 2.2. Lower-bound estimates of the abundance of age-3+ pallid sturgeon in the middle and lower Mississippi River. Five model variations and their averages are shown.

	Abundance[a]		
Model[b]	P ≈ 0.99	P ≈ 0.95	P ≈ 0.75
panmictic	3,400	5,900	17,000
uniform	3,600	6,300	18,000
uniform, dispersal	3,700	6,400	18,000
CPUE	4,000	7,000	20,000
CPUE, dispersal	4,100	7,000	20,000
average of models	3,800	6,500	19,000

[a]Column headings give the approximate probability that the true abundance is not less than the estimates. Abundance rounded to nearest 100.

[b]Model variations described in Methods.

Table 3.2. Sensitivity of pallid sturgeon abundance estimates to the assumption of annual emigration rate. Estimates assume uniform population density and no dispersal among reaches.

	Abundance[a]		
Emigration	$P \approx 0.01$	$P \approx 0.05$	$P \approx 0.25$
0%	4,200	7,300	21,100
10%	3,600	6,300	18,000
20%	3,200	5,400	15,700

[a]As in Table 2.2.

Figure 1.2. A map of the survey area illustrating the locations of reaches A-F on the lower and middle Mississippi River. Reproduced from Killgore et al. (2007).

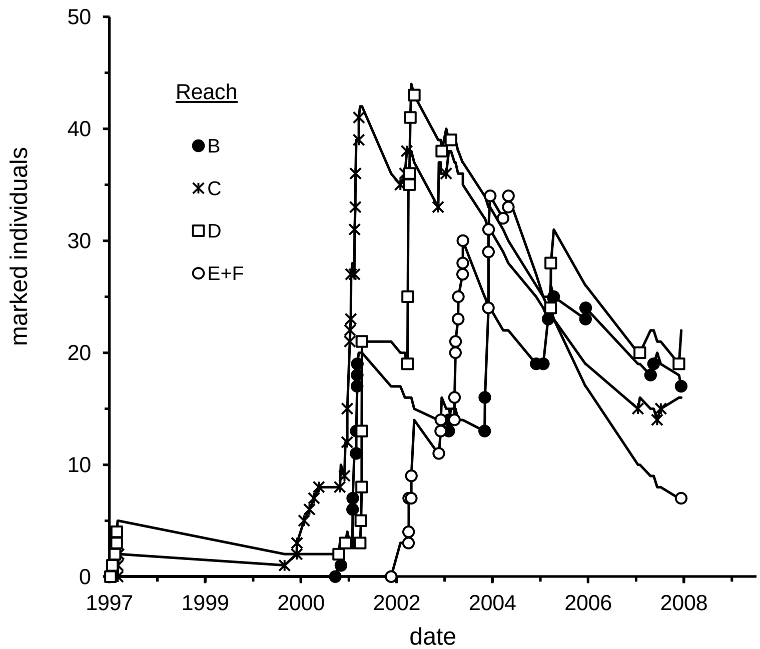

Figure 2.2. Projected numbers of marked pallid sturgeon in four reaches of the middle and lower Mississippi River from 1997 through 2008. Symbols indicate dates on which individuals were caught and marked during the survey period (with the exception of the final symbol for reach E+F, which was added to help identify the curve). Details of projections are given in Methods. The total number of individuals caught and marked was 50, 64, 70, and 57 in reach B, C, D, and E+F, respectively.

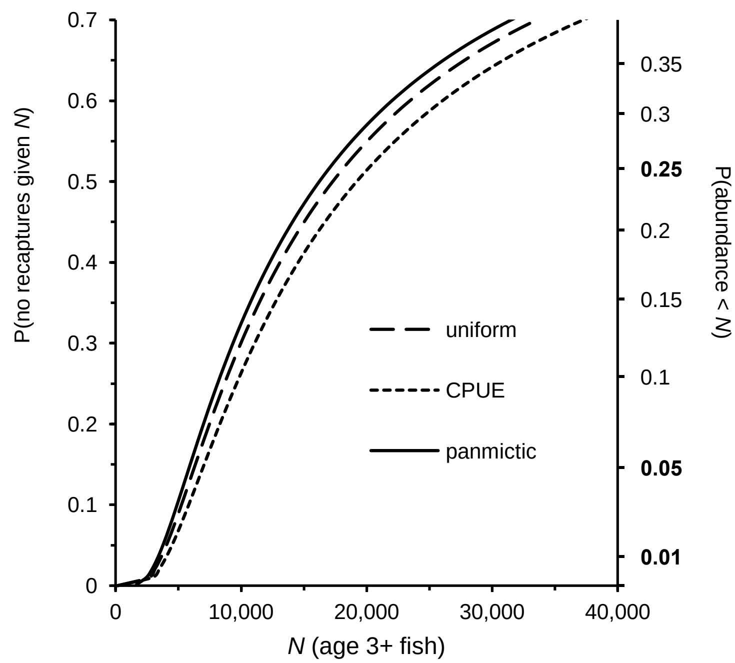

Figure 3.2. The probability of not recapturing any marked individuals during the 1997-2008 Mississippi River survey as a function of hypothetical total population size (left axis) and the associated cumulative probability based on the likelihood ratio test (right axis). The three curves demonstrate the effect of spatial structure model on the estimate. For uniform and CPUE models, curves indicate the estimate assuming no dispersal between reaches. Curves derived assuming dispersal are omitted for clarity.

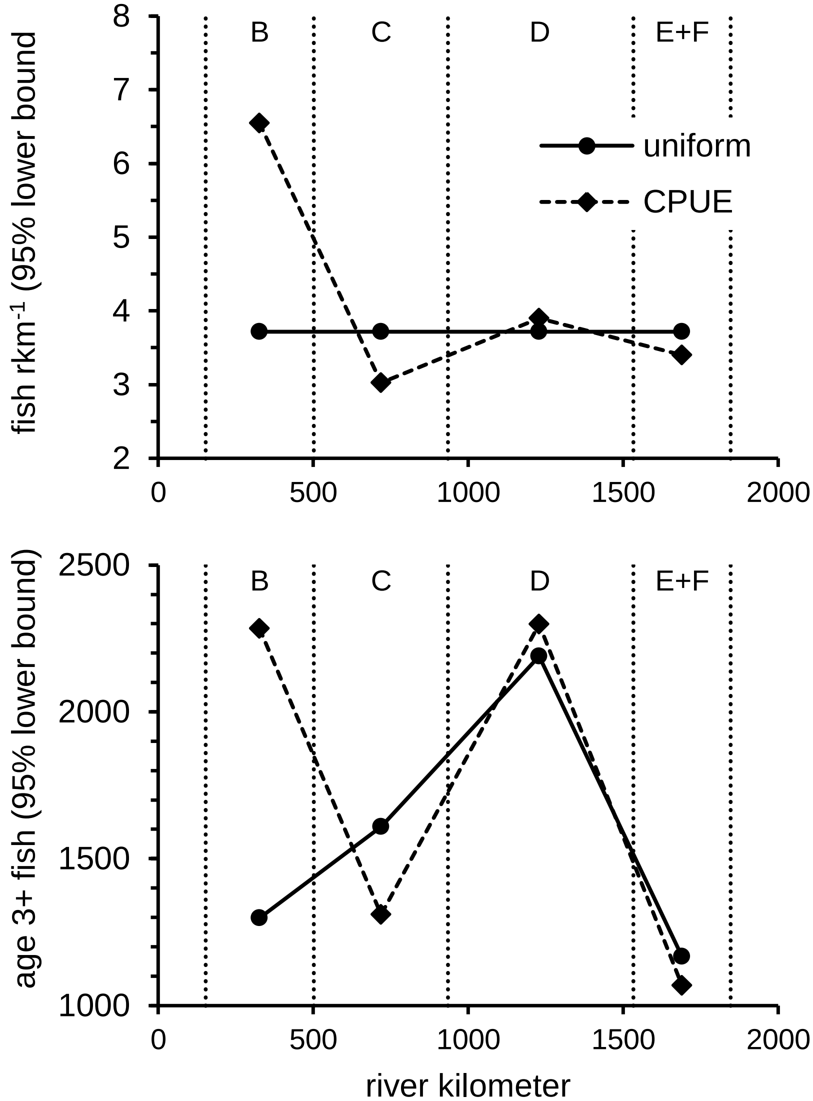

Figure 4.2. Spatial structure of pallid sturgeon population density in the lower and middle Mississippi River. The two series in each panel reflect different spatial structure models. Top panel: the 95% lower bound on population density. Bottom panel: the 95% lower bound on abundance.

Chapter 3

Fish Entrainment by Freshwater Diversions of the Lower Mississippi River.

by

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Abstract

Freshwater diversions in the Lower Mississippi River will likely entrain riverine species and introduce them into new habitats where they may flourish or fail to persist. The pallid sturgeon is endangered and may be entrained in diversions. This study used a variety of collection methods to document the degree to which species are being entrained by six freshwater diversions located in south Louisiana, Bonnet Carré Spillway, Davis Pond Diversion, Violet Siphon, Caernarvon Diversion, White Ditch Siphon, and Naomi Siphon. Special effort was devoted to documenting the occurrence of pallid and shovelnose sturgeon. The amount of entrainment was quantified by identifying 35 species that are relatively common in the river but rare or absent in the marshes below the diversion outflows. In total, 113 species were sampled in one or more of the diversions. Entrainment was highest in diversions during or in periods shortly after there were high volumes of flow through the diversions. There was little relationship between entrainment and river stage in most diversions likely because diversion flows were greatly restricted during high river stages. Highest flows were seen in the months following the Deepwater Horizon oil spill when the diversions were opened to near their maximum capacity. During the same period, entrainment was generally high in the larger diversions. Sturgeon were found in samples in the two largest diversions, the Bonnet Carré Spillway and the Davis Pond Diversion. In the former, the occurrence of sturgeon and a high degree of entrainment was found in periods following high flows. In the latter, one pallid sturgeon and three shovelnose sturgeon were taken in each quarter of the latter half of 2009 and the first half of 2010.

Introduction

Freshwater diversions of the Mississippi River have been constructed for habitat restoration, reduction of saltwater intrusion, sediment introduction and land building, and flood control (Rasi and Steller 1999; USACE 2013a, b). Land loss due to subsidence and sea level rise is motivating plans for more and larger freshwater diversions in southern Louisiana (CPRA 2012). The impact that diversions have on fish species and communities has not been documented but should be considered in the placement and design of diversions, especially where federally listed species may be impacted.

Although most of the freshwater diversions are not intended to modify fish habitat or change the abundance of any fish species, they have changed the habitat downstream from the diversion and this has been documented to have negative impacts on some species and positive impacts on others (Sable and Villarubia 2011). It should be expected that species that prefer low-flow backwater habitats and those that prefer brackish water will likely be displaced and move downstream or into backwaters out of the main flow of water from the river. Introduction of river water will likely improve and expand habitat for many other species, especially those that prefer cooler, flowing, or well-oxygenated waters. Such species may move from areas downstream into waters closer to the diversion or they may be entrained by the diversion and then reside in the diversion channel. Freshwater diversions will potentially negatively impact riverine species that specialize on the high-flow and open-water habitats of the river because many will be entrained by the diversions and either concentrated in the relatively narrow channel downstream from diversions or move further downstream into slower and shallower water bodies where they will likely experience reduced food and oxygen availability.

The purpose of this project was to document the fish species that are found in freshwater diversions of the Lower Mississippi River (LMR). Special effort was devoted to documenting the occurrence of the endangered pallid sturgeon (*Scaphirhynchus albus*) and its congener, the shovelnose sturgeon (*S. platorynchus)*, by diversions. In addition, because many species common in the Mississippi River are uncommon in habitats away from the river (Troxler 2011), the relative potential of each of the diversions to entrain riverine fish species can be estimated. This potential to entrain some riverine species may relate more broadly to the overall entrainment potential of the diversions.

Study Sites

Six freshwater diversions were sampled in the course of this study, the Bonnet Carré Spillway, the Davis Pond Diversion, the Violet Siphon, the Caernarvon Diversion, the White Ditch Siphon, and the Naomi Siphon (Figure 1.3). These diversions differ widely in physical structure, capacity, operation, and potential for entrainment of riverine fishes.

The Bonnet Carré Spillway, located on the east bank of the Mississippi River at river mile (RM) 133, was constructed in response to the Great Mississippi Flood of 1927 and was completed in 1931. Its purpose is to divert water during flood stages to reduce risk of flooding of New Orleans and nearby communities. The spillway structure consists of 2.1 km of concrete weir, partitioned as 350 bays with removable wooden "pins." When river levels rise above the level of the concrete weir water can flow through gaps between the pins. The gaps vary in size but are usually less than 5 cm. Leakage flow is commonly seen in late winter and spring when river levels tend to rise. When river levels approach flood stage, flow through the structure can be increased by removing the pins. The design capacity of the structure is 7100 m^3/s (250,000 cfs). Water flow downstream of the structure is constrained by earthen guide levees that direct water for a distance of 9.5 km into Lake Pontchartrain. The structure has been opened to varying degrees since its construction but has been opened on average about every eight years (USACE 2012). Its last opening was in May 2011. The potential of the Bonnet Carré Spillway to entrain fish is expected to be high when the structure is open. During normal high-water leakage, the potential for entrainment of fish is moderate since only relatively small individuals can pass through the gaps between the pins and the overall volume of flow is low.

The Davis Pond Diversion is located at RM 119 on the west bank of the Mississippi River. The diversion, which is under the management of Office of Coastal Protection and Restoration Authority (OCPRA) New Orleans division, was completed in 2001 and began operating in the summer of the following year. The diversion consists of four 4.3 by 4.3-m concrete box culverts with a maximum discharge of 301.57 m^3s^{-1} (10,650 cfs) and is projected to benefit 13,354 hectares of wetlands and 314,441 hectares of marshes and bays over a 50 year period (USACE 2013b). The main channel of this diversion empties into a ponding area and then into Lake Cataouatche and then farther south into Lake Salvador. The potential for this structure to entrain fish when it is open is expected to be high.

The Violet Siphon Diversion is located on the east bank of the Mississippi River at RM 83.8 and is intended to offset increasing salinity in nearby wetlands through freshwater input from the Mississippi River. The Violet Siphon is operated and maintained by the OCPRA New Orleans division, and consists of two siphon pipes with a maximum capacity of 14.16 m^3s^{-1} (500 cfs). This structure was completed in 1979 and has been operated intermittently since (Rasi and Steller 1999). The Violet Siphon channel flows eastward into the Mississippi River Gulf Outlet and Lake Borgne. Because the capacity of this diversion is low, it is also expected to have low fish entrainment.

The Caernarvon Diversion is located at RM 81.5 and was constructed in 1991 with the intention to restore marsh habitat through freshwater input (USACE 2013a). The OCPRA is in charge of the operation and maintenance of Caernarvon Diversion. The structure contains five 4.6 x 4.6-m box culverts along the inflow and outflow channels and has a maximum discharge rate of 226.53 m^3s^{-1} (8,000 cfs; USACE 2013a). Mississippi River water flows through the Caernarvon Diversion into a lake referred to as Big Mar then farther southeastward through marshland and empties into the Breton Sound. The drainage area of this diversion is 15,556 acres and is projected to benefit 802 acres of wetlands by the year 2013. As with the Davis Pond Diversion, it is expected that this diversion will have a high potential to entrain fish when it is open.

The White Ditch Siphon (also known as White's Ditch Siphon) is located at RM 64.5 on the east side of the river (CPRA 2012). The main channel of this diversion flows through private land and therefore operation of this diversion is almost entirely governed by the landowner. The diversion was built in 1960s to enhance muskrat habitat. Two 127-cm siphon pipes deliver as much as 250 cfs of fresh water eastward towards the Breton Sound. Because the capacity of this diversion is low, its potential for fish entrainment is expected to be low.

The Naomi Siphon Diversion is located at RM 63.9 on the west bank of the river. It has a maximum discharge of 59.47 m3s-1 (2,100 cfs) and was completed in 1992 (CPRA 2012). Eight 1.83-m diameter siphon pipes deliver water from the Mississippi River westward toward a lake called The Pen, and then through marsh and bayous in Barataria Bay, influencing 10,765.9 hectares of wetlands. The Naomi Siphon is managed by the Plaquemines Parish government. Because this siphon has a much higher capacity than the other two, it is expected to have higher fish entrainment.

Methods

Fish were sampled by five methods, including: trawling, gillnetting, electrofishing, seining, and trotlining. Trawl sampling was conducted by deploying a 3-m wide otter trawling fitted with a 3-mm mesh cod end bag. The trawl was pulled off the bow of the boat by propelling the boat in reverse. Trawls were pulled downstream in flowing water, just slightly faster than the current. A hand-held GPS was used to record the beginning and ending coordinates of each trawl pull. If there was sufficient clearance, the trawl was pulled for approximately 300 m. If the trawl could not be pulled for 300 m, it was pulled to the maximum extent possible with beginning and ending coordinates recorded. The fish taken in each trawl were identified to species and counted. When fish could not be identified in the field, specimens were taken to the Marine Biology laboratory at Nicholls State University and identified. Trawl data are expressed as total numbers of each species taken by trawl and mean catch per km (CPUE). In larger diversions, like Davis Pond and Caernarvon, multiple trawls were taken in different reaches of the outfall on each day of sampling. In smaller diversions, like White Ditch and Naomi, fewer trawl samples were taken on each day so as not to sample one area multiple times. Where possible, one or more trawl samples were taken near the outfall, and one or more samples were taken downstream from the outfall.

Gillnet sampling was conducted by deploying one or two 60-m experimental gillnets that each consisted of 8 equal length panels of mesh of sizes 2.5 cm, 5 cm, 7.5 cm, and 10 cm. Gillnets were deployed in various locations within each diversion but eddies and deeper holes were targeted when possible. Gillnet deployments were for various lengths of time but a minimum of 2 hours was targeted. When gillnets were retrieved all fish captured were identified to species and counted. Gillnet sample data are expressed as total numbers of each species taken and mean catch per hour (CPUE).

Electrofishing was conducted using a Smith-Root GPP 5.0 using a prod-pole anode. A pulsating current of 4-8 amperes was applied using a foot-pedal switch. A counter recorded the total time current was applied. Each electrofishing station consisted of 500 seconds application of current as the boat was moved along the shoreline. Three people were required for electrofishing, a boat driver, a netter, and a shocker. An attempt was made to net all fish stunned by the current. Netted fish were placed into a livewell and when a station was completed, each was identified to species and counted. Electrofishing sample data are expressed as total number of fish and the mean number of fish captured per 500-second electrofishing station (CPUE).

Seine samples were taken where the shoreline was relatively unobstructed. This was only true in the Bonnet Carré Spillway. The seine used was 18 m long, 2 m high, with 9 mm mesh. In most cases the seine was deployed by boat approximately 30 m from shore. Bridle lines on either end of the seine were used to bring the seine to shore. Data was recorded only from seine pulls that retained their contents through the length of the pull.

Trotline samples were taken with four trotlines each with 60 hooks spaced at 2 m intervals and baited with earthworms. The lines were weighted to keep them on the bottom.

Trotlines were deployed in the late afternoon and retrieved the next morning. Trotline samples were only taken in the Davis Pond Diversion and the Caernarvon Diversion.

Because fish entrainment is likely to be influenced by the velocity and volume of water taken from the river into the diversion, flow rate was measured once every sample day just below the surface and just above the bottom of the water column by a Flo-Mate flow meter (Frederick, MD). Average daily discharge of the Davis Pond Diversion and the Caernarvon Diversion are available from the USGS National Water Information System (http://waterdata.usgs.gov/la/nwis/uv) and are used for comparison. The other diversions either have no monitoring of discharge (Violet, White Ditch) or the monitoring equipment was not functioning during much of the period of this study (Naomi). Entrainment may also be influenced by river stage. River stage data is available from National Weather Service River Forecast Center (http://www.srh.noaa.gov/lmrfc/). For this report, river stage as recorded in New Orleans at the Carrolton gauge at noon on each day was used.

Entrainment estimates were made by comparing species that are only commonly found in riverine habitats to the total sample, or total number of species in the sample. The total number of individuals that were deemed likely to have been entrained divided by the total catch (each expressed as CPUE) gave the percentage of the catch that was entrained. The total number species that were likely to have been entrained divided by the total number of species sampled gives the percentage of entrained species in samples. Preston (1948) argued and showed with a series of data sets of animal communities that rarer species are only likely to be taken in large samples. Thus, an estimate of the taxonomic breadth of entrainment by diversions could be reflected in the ratio of number of entrained species to the total catch per unit effort. This is the entrained species per unit catch.

Results

Fishing Effort

Table 1.3 details fishing effort by method during each quarter from July 2009 through September 2011. One-hundred-thirty days were spent in the field. Gillnet sets averaged over three per day, as did trawling stations. Electrofishing stations averaged almost two per day. On average, in each quarter, there were over 14 days of effort. Figure 2.3 displays the sampling dates of each diversion over the course of the study.

Table 2.3 details fishing effort at the Bonnet Carré Spillway in each quarter. There was substantial sampling effort in the spillway at the beginning of this study because of the possibility of sturgeon remaining resident in the spillway following the 2008 opening. Sampling was also concentrated at the end of this study following the opening in the spring of 2011. In 2009, because there were large pools on the river side of the spillway, some effort was devoted to sampling in those pools because of the possibility that sturgeon may have been trapped there.

Table 3.3 details fishing effort in the Davis Pond Diversion. More days were spent sampling in Davis Pond than in any other diversion. It is larger than all diversions except the

Bonnet Carré Spillway and it flowed to various degrees throughout the period of this study. Much of the effort was devoted to trawl sampling.

Table 4.3 details sampling effort in the Violet Siphon. Sampling was restricted during late 2009 and early 2010 because of low flow and maintenance dredging in the Violet Siphon. Debris in the outflow channel just below the siphon outfall also made trawling near the diversion impossible. Electrofishing and gillnet samples were taken both near and away from the siphon's outfall.

Table 5.3 details sampling effort in the Caernarvon Diversion. Caernarvon was sampled almost as often as Davis Pond. Fewer trawl samples were taken in Caernarvon because of the narrow outflow channel and large amount of debris on the sides of the channel. A single trotline sample was taken in early 2010.

Table 6.3 details sampling effort in the White Ditch Siphon. Only 5 days of sampling were conducted in White Ditch. White Ditch is privately owned and a legal agreement with the landowner had to be reached before sampling could begin. Operation of the White Ditch Siphon is controlled by the landowner. During most of this study the siphon was not operating. The channel downstream of the siphon is small and shallow. Gillnetting was only practical in the outfall pool and trawling was difficult in general. A single day was spent sampling in August 2010 when the siphon was not operating. At that point, it was deemed unproductive to sample if the siphon was not flowing. The siphon did not operate for the remainder of the study.

Table 7.3 details sampling effort in the Naomi Siphon. The Naomi Siphon was initially chosen as an alternative to the White Ditch Siphon because of difficulties with sampling and the intermittent nature of the operation of the White Ditch Siphon. The Naomi Siphon was sampled regularly during 2010 and early 2011. The small size of channel downstream of the siphon limited trawl sampling effort. In May 2011, the siphon was stopped in preparation for maintenance dredging.

Diversion Flows and River Stage

Figure 3.3a shows the river stage at New Orleans, taken at the Carrolton gauge at noon on each of the days samples were taken in one of the diversions. River stage was highest in spring and early summer of 2011 at the time that the Bonnet Carré Spillway was opened. River stage was high enough to allow some water to leak at the Bonnet Carré Spillway intermittently from late 2009 until summer of 2010. The lowest river stage was seen in late 2010 and early 2011. Figure 3.3b and 3.3c show the average daily discharge of the Davis Pond Diversion and Caernarvon Diversion on each of the dates sampling was conducted. Maximum discharge was seen during the spring and summer of 2010. The high flow in each diversion during this period was a response to the Deepwater Horizon oil spill. During this time of high diversion discharge, the Mississippi River stage was moderate and falling. Otherwise, at the highest river stages the Davis Pond Diversion and Caernarvon Diversion were operated with relatively low discharge on most dates. Figure 3.3d shows the surface current at midday at each of the diversions sampled on the day they were sampled. The periods of high and low discharge in the Davis Pond Diversion and Caernarvon Diversion roughly correspond to field measurements of surface flow. Data on discharge at the other diversions is not available, but measured flow rates at the other diversions, although lower, are roughly correlated with those seen in the Davis Pond Diversion and Caernarvon Diversion and appear to reflect river stage only weakly.

Species Sampled

Over the course of this study, 92,301 fish representing 113 species were sampled (Table 8.3). Many of the species in the samples are found generally throughout south Louisiana. A considerable number of species in the samples are euryhaline species of marine or brackish water origin. At least 35 of the species are likely to have been entrained into the diversion as water flowed from the river. These species are listed in boldface in Table 8.3 and will be referred to henceforth as species likely to have been entrained. All of the species indicated are seldom found in habitats downstream from the diversions (Troxler 2011) and most are relatively common in the river or in flowing water elsewhere in Louisiana. The two sturgeon species, *Scaphirhynchus albus, and S. platorynchus*, are riverine species as is the paddlefish, *Polyodon spathula*. Two gar species, *Lepisosteus osseus*, and *Lepisosteus platostomus* are rarely found in non-riverine habitats in south Louisiana. The two *Hiodon* species are also riverine species. Some minnow species (Family Cyprinidae) are common in non-riverine habitats but those in boldface in Table 8.3 (*Cyprinella lutrensis, Cyprinella venusta, Hybognathus hayi, Hybognathus nuchalis, Hybopsis amnis, Lythrurus fumeus, Macrhybopsis aestivalis, Macrhybopsis storeriana, Notropis atherinoides, Notropis shumardi, Notropis volucellus, Opsopoeodus emiliae,* and *Pimephales vigilax*) are uncommon in non-riverine habitats in south Louisiana (Troxler 2011). Likewise, some sucker species (Family Catostomidae) are common in non-riverine habitats but those in boldface in Table 8.3 (*Carpiodes carpio, Carpiodes cyprinus, Carpiodes vellifer, Cycleptus elongatus, Ictiobus bubalus, Ictiobus cyprinellus, Ictiobus niger,* and *Minytrema melanops*) are uncommon in non-riverine habitats in south Louisiana. Members of the family Moronidae can be found in a range of habitats in south Louisiana but the majority of striped bass (*Morone saxatilis*) taken in this study were large and taken just below the outfall of the diversions. Thus, striped bass are considered species indicative of entrainment. Most sunfish species (Family Centrarchidae) can be found throughout south Louisiana but the spotted bass (*Micropterus punctulatus*) prefers flowing water and likely came into the diversions by entrainment. Members of the perch family (Family Percidae) that were sampled in this study (*Etheostoma asprigene, Percina caprodes, Percina maculata,* and *Sander canadensis*) are rarely taken away from the river in south Louisiana. Sleepers (Family Eleotridae) are common in south Louisiana, but the bigmouth sleeper, *Gobiomorus dormitor*, is only common in south Louisiana in the Mississippi River in Plaquemines Parish. In addition to the species listed in boldface in Table 8.3, there are many other species that are much more common in the Mississippi River than in non-riverine habitats in south Louisiana including *Atractosteus spatula, Hypophthalmichthys molitrix, Hypophthalmichthys nobilis, Ictalurus furcatus, Ictalurus punctatus, Pylodictis olivaris* and *Aplodinotus grunniens.* Several of these species were abundant in our samples, but because each could have entered the diversion from downstream areas, these species are less suitable and were not used as indicators of entrainment.

In the Bonnet Carré Spillway, 11,808 fish representing 72 species were sampled (Table 9.3). Twenty-five of the 35 species likely to have been entrained were found in the Bonnet Carré Spillway. Three of the 35 species that are likely to have been entrained were only taken at the Bonnet Carré Spillway (*Hiodon tergisus, Percina caprodes,* and *Percina maculata*). Three additional species were only taken at the Bonnet Carré Spillway, *Hypophthalmichthys nobilis, Erimyzon oblongus,* and *Herichthys cyanoguttatum.* Of the methods used, seine sampling produced the most species rich samples (60), followed by electrofishing (49) and gillnetting (42). Both sturgeon species were taken in our samples. All but one of the sturgeon sampled were taken by gillnet. The other was taken by seine.

In the Davis Pond Diversion, 26,969 fish representing 77 species were sampled (Table 10.3). Twenty-seven of the 35 species likely to have been entrained were found in the Davis Pond Diversion. Three of the 35 species likely to have been entrained were only taken at the Davis Pond Diversion (*Macrhybopsis aestivalis, Minytrema melanops,* and *Gobiomorus dormitor*). Two additional species were only taken at the Davis Pond Diversion, *Lepomis marginatus,* and *Lutjanus griseus.* Sixty-nine species were sampled by electrofishing, 42 by trawling, and 28 by gillnetting. Only three species were sampled by trotlining. Four sturgeon were taken, three *S. platorynchus*, and one *S. albus*. One of each sturgeon species was taken in trawl samples and the other two sturgeon were taken in gillnets.

In the Violet Siphon, 16,873 fish representing 61 species were sampled (Table 11.3). Six of the 35 species likely to have been entrained were found in the Violet Siphon. None of the species likely to have been entrained were taken only at the Violet Siphon. Six species were only taken at the Violet Siphon, *Bagre marinus, Oligoplites saurus, Bairdiella chrysoura, Pogonias cromis, Gobionellus oceanicus,* and *Citharichthys spilopterus*. All of these species are euryhaline marine species. Fifty-three species were taken by electrofishing, 43 by trawling and 28 by gillnetting.

In the Caernarvon Diversion, 26,001 fish representing 67 species were sampled (Table 12.3). Eighteen of the 35 species likely to have been entrained were found in the Caernarvon Diversion. One of the species likely to have been entrained was taken only at the Caernarvon Diversion, *Etheostoma asprigene*. Two species were only taken at the Caernarvon Diversion, *Ameiurus nebulosus* and *Caranx hippos.* Sixty species were taken by electrofishing, 34 by trawling and 34 by gillnetting. Only 3 species were taken in trotline samples.

In the White Ditch Siphon, 3,481 fish representing 47 species were sampled (Table 13.3). Five of the 35 species likely to have been entrained were found in the White Ditch Siphon. None of the species likely to have been entrained were only taken at the White Ditch Siphon. Two species were only taken at the White Ditch Siphon, *Ctenogobius boleosoma* and *Gobiosoma bosc.* Both of these are euryhaline marine species. Forty-one species were taken by electrofishing, 23 by trawling and 20 by gillnetting.

In the Naomi Siphon, 7,169 fish representing 58 species were sampled (Table 14.3). Twelve of the 35 species likely to have been entrained were found in the Naomi Siphon. None of the species likely to have been entrained were taken only at the Naomi Siphon. One species was only taken at the Naomi Siphon, *Megalops atlanticus*. Fifty-three species were taken by electrofishing, 31 by trawling and 29 by gillnetting.

Overall CPUE and Entrainment Estimates

Table 15.3 compares the CPUE and entrainment estimates for each of the diversions. Entrainment is expressed as the percentage of the total catch that consisted of individuals of species that were likely entrained, the percentage of species captured that were likely to have been entrained and the number of entrained species per unit catch. High CPUE percent catch entrainment is due to large numbers of individuals of species that were likely to have been entrained and could consist of relatively few or many species having been entrained. Entrainment could be selective of a few species or relatively broad due entrainment of a large number of species. In trawl samples, high percent catch entrainment is seen in Davis Pond samples due to a relatively large number of individuals of a wide variety of species while high percent catch entrainment is seen in Naomi samples due to a relatively large number individuals of a few species. Caernarvon Diversion trawl samples had relatively low percent catch entrainment in spite of having a relatively large number of species entrained. High percentage entrainment due to many individuals of a relatively large number of species can be seen in Bonnet Carré gillnet and electrofishing samples while high percentage entrainment due to large numbers of a relatively few species can be seen in Naomi gillnet and electrofishing samples. High total numbers of entrained species can be due to broad entrainment of many species or due to higher fish densities, and thus larger samples, which would be expected to have a higher proportion of rare species. The last column of Table 15.3 presents the entrained species per unit catch. High values of entrained species per unit catch are likely to due to relatively unselective and broad entrainment of species. There is a consistent pattern in entrained species per unit catch among diversions and sampling methods. The highest values of species entrainment are for either the Bonnet Carré Spillway or the Davis Pond Diversion in all samples. The lowest values are for the Violet Siphon or the White Ditch Siphon in all samples.

Species richness in trawl samples within each diversion ranged from a high of 43 in the Violet Siphon to a low 23 in the White Ditch Siphon (Table 15.3). Species richness in the Davis Pond Diversion was a close second (42) while the other diversions ranged from 30 to 34 species. The proportion of those species that were likely to have been entrained was very different however. Thirty-five percent of the species taken in the Davis Pond Diversion were among those deemed likely to have been entrained. Among the species taken in the White Ditch Siphon and Violet Siphon, less than 5% were likely to have been entrained. The Naomi Siphon was higher at 12% while the Caernarvon Diversion and the Bonnet Carré Spillway each had approximately 20% entrained species.

In samples taken by gillnet, species richness ranged from 42 in the Bonnet Carré Spillway to 20 in the White Ditch Siphon (Table 15.3). In the other diversions, species richness ranged from 28 to 34. The White Ditch Siphon and Violet Siphon samples had 15% or fewer species that were likely to have been entrained while the samples from the Bonnet Carré Spillway and Davis Pond Diversion had 32% or more species that were likely to have been entrained.

In samples taken by electrofishing, species richness ranged from 69 in the Davis Pond Diversion to 41in the White Ditch Siphon (Table 15.3). The other diversions in order of decreasing species richness were Caernarvon (60), Naomi Siphon (53), Violet Siphon (50), and Bonnet Carré Spillway (48). The Davis Pond Diversion also had the highest percentage of species that were likely to have been entrained (35%), followed by Caernarvon (28%), Bonnet Carré (27%), Naomi (17%), Violet (10%), and White Ditch (10%).

The percentage of the fish fauna that was likely to have been entrained was consistently smallest in the two smallest siphons (Table 15.3). This was not due to low overall species richness in these siphons. The Violet Siphon had the highest species richness in trawl samples and had intermediate richness in gillnet and electrofishing samples. The percentage of the fish fauna that was likely to have been entrained was consistently more than 32% in Davis Pond for all sampling methods. The other diversions varied in position. The Bonnet Carré Spillway had a relatively high percentage of entrained species in gillnet samples (33%) but a moderate percentage in trawl samples (20%).

Trawl Catch Per Unit Effort and Entrainment Estimates by Quarter

Eighteen of the 35 species likely to have been entrained were taken by trawling in one or more diversions. Except for the first trawl sample of the Bonnet Carré Spillway, where most of the catch was *Aplodinotus grunniens* and *Ictalurus punctatus*, the most productive trawling in terms of species richness (24 spp.) and overall abundance (Table 16.3) was taken the last quarter of sampling. Only six species of those most likely to have been entrained were taken in the Bonnet Carré Spillway by trawling. Five of the six were taken in the last two quarters of sampling after the 2011 opening of the Bonnet Carré Spillway. The highest number of entrained species per unit catch (0.06) was also seen in the second quarter of 2011.

The Davis Pond Diversion had the highest catch per unit effort (CPUE) in the first quarter of sampling in 2010 (1266, Table 17.3). More than half that catch was *Ictalurus furcatus* and *Aplodinotus grunniens*. The highest species richness (23) was seen in the first quarter of 2010, the third quarter of 2010, and the second quarter of 2011. All of these periods were times of moderate to high river stage and low to moderate diversion discharge (Figure 3.3). The highest number of entrained species (11) was also found in the first quarter of 2010 when entrained species represented 47% of the catch. The lowest CPUE and highest number of entrained species per unit catch were seen in the second quarter of 2010, when flow rates were high in the diversion. The single *Scaphirhynchus albus* caught in the Davis Pond Diversion was caught by trawling in the last quarter of 2009 when the river stage was relatively high (13.28 ft), the diversion's discharge and surface flow were moderate (3325 cfs, 0.32 m/s, Figure 3.3). The single *S. platorynchus* caught by trawling in the Davis Pond Diversion was taken in the first quarter of 2010 when the river stage was moderate (9.9 ft), the Davis Pond discharge and surface current were low (1230 cfs, 0.17 m/s).

Trawling in the Violet Siphon yielded relatively high CPUE (over 700 in 3 of the 6 quarters sampled) with *Ictalurus furcatus* making up a majority of many catches (Table 18.3). The highest CPUE (740) was found in the first quarter of 2011. That quarter had the highest species richness (36) and many euryhaline marine species were sampled. During this period, river stage and flow were low. Just two of the likely entrained species were caught by trawling in the Violet Siphon, *Ictiobus bubalus* in the first quarter of 2011 and *Polyodon spathula* in the second quarter of 2011.

Trawling in the Caernarvon Diversion yielded the highest CPUE in the fourth quarter of 2010 (1082). The same quarter had the highest species richness (25) when many euryhaline species were taken and three of the species likely to have been entrained (Table 19.3). In that quarter, the river stage and flows within the diversion were low. One to four of the likely entrained species were taken by trawl in each quarter. As in the Davis Pond Diversion, the highest number entrained species per unit catch was seen in the second quarter of 2010 when flow rates in the diversion were high (Figure 3.3).

Trawl sampling in the White Ditch Siphon yielded mean CPUEs between 131 and 152 in each quarter (Table 20.3). The highest species richness was found in the third quarter of 2010 (17). During that quarter and the previous quarter, the river stage was moderate and flow rates in the diversion were approximately 0.3 m/s. In those two periods, one likely entrained species, *Ictiobus bubalus,* was taken.

The fourth quarter of 2010 yielded the highest CPUE by trawling in the Naomi Siphon (656; Table 21.3). The same quarter had the highest species richness (26) and the highest number of likely entrained species (3). There was no water flowing in the siphon during this time. The lowest CPUE (77) and the lowest species richness was found in the second quarter of 2010 when flow rates in the diversion were at their highest (0.3 to 0.45 m/s). Two or three of the species likely to have been entrained were taken in each quarter.

Gillnet Catch Per Unit Effort and Entrainment Estimates by Quarter

Seventeen of the 35 species likely to have been entrained were taken by gillnetting in one or more diversions. In the Bonnet Carré Spillway, overall CPUE was highest in the second quarter of 2011 (30.2) as was species richness (33) (Table 22.3). The same quarter yielded the highest number of species likely to have been entrained (10). Included in those samples were one of each of the sturgeon species. In the succeeding quarter, another *S. platorynchus* was taken. The lowest CPUE (5.7) was found in the third quarter of 2010 when only 4 species likely to have been entrained were taken. The number of entrained species per unit catch was relatively high in all quarters.

In the Davis Pond Diversion, overall CPUE was highest in the third quarter of 2009 (12.0) (Table 23.3). Species richness was highest in the second quarter of 2010 (20). The highest number of species likely to have been entrained (6) was also seen in the second quarter of 2010, when flow rates in the diversion were high. In the second and third quarter of 2011, when discharge and water flow in the diversion were low only two species likely to have been entrained were taken.

In the Violet Siphon, CPUE was highest in the fourth quarter of 2009 (10.2) (Table 24.3). The highest species richness (18) was found in the third quarter of 2009, which was also when all four of the species likely to have been entrained there were taken. Euryhaline marine species were taken in most quarters.

In the Caernarvon Diversion, seven species likely to have been entrained were taken. CPUE was highest in the first quarter of 2011 (21.9) when the river stage and diversion discharge were both low (Table 25.3). Species richness was highest in the fourth quarter of 2009 (20) when five of the seven species likely to have been entrained were taken. At that time, the river stage was relatively high while diversion discharge and surface flow was low.

In the White Ditch Siphon, only three species likely to have been entrained were taken. They were all *Ictiobus* species (Table 26.3). All three species were all taken in the second quarter of 2010. CPUE did not vary greatly among quarters (8.7 to 12.8) and species richness did not vary greatly either (11 to 14).

In the Naomi Siphon, seven species likely to have been entrained were taken by gillnet. The highest CPUE was in the first quarter of 2010 (14.9; Table 27.3). Highest species richness (22) was found in the first quarter of 2011. Five species likely to have been entrained were taken in the first quarter of 2010, and in the first and second quarter of 2011. In each of those periods flow in the Naomi Siphon was low to moderate (0 to .3 m/s).

Electrofishing Catch Per Unit Effort and Entrainment Estimates by Quarter

Twenty-eight of the 35 species likely to have been entrained were taken by electrofishing in one or more diversions. In the Bonnet Carré Spillway, 13 of the species likely to have been entrained were taken by electrofishing (Table 15.3). The highest CPUE (339) was during the third quarter of 2010 (Table 28.3). The highest species richness (37) was found in the third quarter of 2009 and the highest number of species likely to have been entrained were taken in the third and fourth quarter of 2009. Low CPUE, low species richness, high percent catch entrained, and high entrained species per unit catch was found in late 2009 and early 2010 when the Bonnet Carré Spillway leaked sporadically for several months.

Twenty-four of the species likely to have been entrained were taken in electrofishing samples at the Davis Pond Diversion (Table 15.3). The highest CPUE (322.9), species richness (44) and number of species likely to have been entrained (11) were taken in the third quarter of 2009 (Table 29.3). The same number of species likely to have been entrained were taken in the third quarter of 2010. The former period was during a period of relatively low discharge and the latter was during a period of high discharge. During the latter period, CPUE was lower and this produced the largest value of entrained species per unit catch. Minnow species made up many of the likely entrained species and none of those minnows occurred consistently among quarters.

In the Violet Siphon, only five of the species likely to have been entrained were taken. Only one or two of those species were taken in any quarter (Table 30.3). CPUE was at or close to 200 in several quarters. Species richness was highest (37) the third quarter of 2009. Relatively high species richness was seen the second and third quarters of 2011 where euryhaline marine species were commonly taken.

Seventeen of the species likely to have been entrained were taken in the Caernarvon Diversion. The largest CPUE (755), species richness (42), and number of species likely to have been entrained were found in the third quarter of 2009 (Table 31.3). High numbers of entrained species were also found in the second and third quarters of 2010, and the third quarter of 2011. This is similar to what was seen in the Davis Pond Diversion and as in Davis Pond an assortment of minnows was found in those quarters. The highest number of entrained species per unit catch was found in the second quarter of 2010 when the diversion discharge and flow rates were high.

In the White Ditch Siphon, only four species likely to have been entrained were taken and at most two were taken in any quarter (Table 32.3). These were the two *Ictiobus* species and two *Hybognathus* species. The highest CPUE (686) and species richness (33) were seen in the second quarter of 2010. The high CPUE was due to a very large number of *Dormitator maculatus*. The high species richness was due to a large number of euryhaline marine species in the samples.

In the Naomi Siphon, eight of the species likely to have been entrained were taken (Table 33.3). Seven of those were taken in the third quarter of 2010 when surface flow was relatively high (0.3 to 0.4 m/s). During the same quarter, the highest value of entrained species per unit catch in the Naomi Siphon was seen. In all but the first quarter of 2010, species richness ranged from 30 to 37. The highest CPUE (206) was seen the first quarter of 2011 when flow rates varied between 0 and 0.3 m/s.

Discussion

Guillory (1982) documented that 121 species of fish can be found in the LMR in Louisiana near St. Francisville. He used a variety of collection methods, published literature and observations of fishermen's catches to compile this estimate. In this study, 113 species were sampled. Three recently introduced freshwater species, *Hypophthalmichthys molitrix, H. molitrix,* and *Herichthys cyanoguttatum* were not reported by Guillory but were taken in this study. In addition, many euryhaline marine species were not taken by Guillory but were taken in this study. Byrne (2013) used the samples taken by electrofishing in the Davis Pond Diversion, the Violet Siphon, the Caernarvon Diversion, and the Naomi Siphon, in which 87 total species were taken, and five different mathematical techniques to estimate that the total number of species available for sampling by electrofishing in those diversions is between 92 and 101. Thus, it is likely that different sampling methods and increased sampling would increase the list of species that are entrained by or enter the freshwater diversions sampled in this study by 10% or more.

There was not a consistent relationship between the number of species found in the diversions and the capacity of the diversions among the different sampling techniques. The Violet Siphon had the largest number of species represented in trawl samples (43) in spite of having a small capacity (Table 15.3). The Davis Pond Diversion had the largest number of species taken by electrofishing (69), followed by Caernarvon (60), the Violet Siphon (50), and the Bonnet Carré Spillway (49). In gillnet samples, the Bonnet Carré Spillway had the largest number of species (42) followed by the Caernarvon Diversion (34). When all species taken by all sampling methods are combined the Davis Pond Diversion had the largest number species (77), followed by the Bonnet Carré Spillway (72). The remaining diversions had overall species richness correlated with their capacity.

Broad entrainment, in terms of species per unit catch, was seen in the Bonnet Carré Spillway throughout late 2009 and early 2010 in gillnet and electrofishing samples. During this period the Mississippi River stage was high (Figure 3.3a) and leakage at the spillway was intermittent. Broad entrainment was evident in trawl samples in the second quarter of 2011, just after the closing of the spillway. The only sturgeon taken in the Bonnet Carré Spillway during this study were taken in the second and third quarters of 2011. It is not surprising that the Bonnet Carré Spillway entrains species broadly when the river is high enough to allow water to leak or flow over the weirs. High volume and high velocity flow over the spillway weir will likely convey any fish in the water column.

Entrainment was greatest in the Davis Pond Diversion, Caernarvon Diversion, and Naomi Siphon in trawl and electrofishing samples during second and third quarters of 2010 when flow within these diversions were high. The same pattern was seen the White Ditch Siphon for gillnet and electrofishing samples. Entrainment was greatest in gillnet samples in the Davis Pond Diversion and Caernarvon Diversion early in 2010 when the river stage was high but flow within the diversions were relatively low. Thus, both river stage and flow within the diversions each may have positive effects on entrainment.

In general, there was low entrainment in both the Violet Siphon and White Ditch Siphon. The low volume of water flowing through these structures likely allows many species to avoid being entrained. The contrast of these two siphons with the Naomi Siphon suggests it is siphon size, and not the presence of siphons that result in differences in entrainment.

There appears to be little relationship between river stage and entrainment except in the Bonnet Carré Spillway. High river stage is required for flow in the Bonnet Carré Spillway and when it was flowing, there was broad entrainment. In the other diversions, flow was usually restricted during high river stage. This probably reduced the likelihood of species entering the diversions from the river. There was an almost inverse relationship between river stage and the volume of flow in the other diversions. Entrainment was clearly associated with the high flow through the diversions in the second and third quarters of 2010, when the river stage was moderate and falling. Thus, there may be potential for higher entrainment if the volume of flow through the diversions is allowed to be high when the river stage is high.

Studies that have examined the relationship between environmental variability and fish community structure have generally found that variable flow regimes result in lower community diversity and stability (Bain et al. 1988; Koel and Sparks 2002). None of the diversions in this study have had stable or natural flow regimes (Figure 3.3). In spite of this environmental variability, the fish communities sampled have remained diverse with 47 to 77 species taken in the diversions over the course of the study (Table 8.3). Thirty-one species were found in every one of the diversion in at least one of the samples. These included two gar species, American eel, bay anchovy, three clupeids, three catostomids, three ictalurids, striped mullet, inland silverside, western mosquitofish, white bass, nine centrarchids, freshwater drum, fat sleeper, freshwater goby, and hogchoker and many of these were taken in most samples. This consistency probably reflects continual entrainment of some of these species from larger and stable riverine populations and likely does not reflect self-perpetuating populations of each species in the outfall area of each diversion. Others in the list are likely to have moved into the diversion from stable populations downstream. Euryhaline marine species could enter the diversion through entrainment but for many, access is likely easier from areas downstream of the diversion.

The focus of this study was to attempt to document entrainment of the pallid sturgeon (*Scaphirhynchus albus)* by freshwater diversions. Two pallid sturgeon were captured: one in the Bonnet Carré Spillway and one in the Davis Pond Diversion. Shovelnose sturgeon (*S. platorynchus*) were also taken in the same two diversions: fifteen were taken in the Bonnet Carré Spillway and three in the Davis Pond Diversion. Sampling effort was highest at the Davis Pond Diversion (35 days) but nearly as high at the Caernarvon Diversion (29) days where no sturgeon were taken, in spite of similar flow regimes throughout this study. Sampling effort was highest in the Bonnet Carré Spillway when it was leaking or had recently had significant flow. Thus, is it is not surprising the overall entrainment (Table 15.3) and sturgeon entrainment was relatively high there. Overall entrainment of riverine fishes by the Davis Pond Diversion was as high or higher than that of the Bonnet Carré Spillway even though sampling was conducted in all quarters, during high and low river stages and high and low diversion discharge. The relative ability of diversions to entrain sturgeon specifically cannot be estimated due to the lack of sturgeon in most of the diversions. However, it is clear that smaller diversions have an overall lower degree of entrainment of species that are exclusively riverine and are probably less likely to entrain sturgeon.

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Table 1.3. Total sampling effort by period, days sampling and method. Gillnet effort is gillnet sets which averaged 4.2 hours. Trawl effort is number of trawl pulls, which averaged .29 km in length. Seine effort is the number of seine samples taken. Electrofish effort is the number of electrofishing stations sampled. Each electrofishing station consisted of 500 seconds of charge applied to the water. Trotline effort is the number of trotline sets. Each trotline set consisted of 4 lines with 60 baited hooks each left overnight.

Total Sampling Effort

		Methods				
Period	**Days**	**Gillnet**	**Trawl**	**Seine**	**Electrofish**	**Trotline**
Jul-Sep-09	24	60	11	4	35	0
Oct-Dec-09	12	35	14	3	23	0
Jan-Mar-10	11	29	20	3	12	2
Apr-Jun-10	18	40	42	6	33	1
Jul-Sep-10	15	30	46	1	32	0
Oct-Dec-10	15	30	61	0	28	0
Jan-Mar-11	12	24	53	0	23	1
Apr-Jun-11	16	35	56	3	28	0
Jul-Aug-11	7	25	35	0	11	0
Total	130	308	338	20	225	4

Table 2.3. Bonnet Carré Spillway Sampling Effort. Sampling effort began July 10 2009 and ended August 16 2011.

Bonnet Carré Spillway Sampling Effort

		Methods				
Period	**Days**	**Gillnet**	**Trawl**	**Seine**	**Electrofish**	**Trotline**
Jul-Sep-09	6	16	0	4	6	0
Oct-Dec-09	3	9	1	3	6	0
Jan-Mar-10	1	2	1	3	1	0
Apr-Jun-10	3	10	4	6	3	0
Jul-Sep-10	1	2	0	1	2	0
Oct-Dec-10	0	0	0	0	0	0
Jan-Mar-11	0	0	0	0	0	0
Apr-Jun-11	4	11	8	3	3	0
Jul-Aug-11	6	23	29	0	9	0
Total	24	73	43	20	30	0

Table 3.3. Davis Pond Diversion Sampling Effort. Sampling effort began July 9 2009 and ended August 13 2011.

Davis Pond Diversion Sampling Effort

		Methods				
Period	**Days**	**Gillnet**	**Trawl**	**Seine**	**Electrofish**	**Trotline**
Jul-Sep-09	6	16	4	0	10	0
Oct-Dec-09	3	8	6	0	4	0
Jan-Mar-10	5	12	14	0	4	1
Apr-Jun-10	5	10	21	0	7	1
Jul-Sep-10	3	6	13	0	8	0
Oct-Dec-10	5	10	26	0	12	0
Jan-Mar-11	4	8	23	0	8	1
Apr-Jun-11	3	6	18	0	6	0
Jul-Aug-11	1	2	6	0	2	0
Total	35	78	131	0	61	3

Table 4.3. Violet Siphon Sampling Effort. Sampling effort began July 6 2009 and ended June 9 2011.

Violet Siphon Sampling Effort

		Methods				
Period	**Days**	**Gillnet**	**Trawl**	**Seine**	**Electrofish**	**Trotline**
Jul-Sep-09	5	13	2	0	9	0
Oct-Dec-09	1	4	0	0	4	0
Jan-Mar-10	1	1	0	0	1	0
Apr-Jun-10	3	8	4	0	8	0
Jul-Sep-10	3	6	11	0	5	0
Oct-Dec-10	3	6	13	0	3	0
Jan-Mar-11	3	6	12	0	7	0
Apr-Jun-11	3	6	12	0	6	0
Jul-Aug-11	0	0	0	0	0	0
Total	22	50	54	0	43	0

Table 5.3. Caernarvon Diversion Sampling Effort. Sampling effort began July 1 2009 and ended June 14 2011.

Caernarvon Diversion Sampling Effort						
		Methods				
Period	Days	Gillnet	Trawl	Seine	Electrofish	Trotline
Jul-Sep-09	7	15	5	0	10	0
Oct-Dec-09	3	8	5	0	4	0
Jan-Mar-10	2	6	3	0	3	1
Apr-Jun-10	3	4	6	0	7	0
Jul-Sep-10	3	6	8	0	6	0
Oct-Dec-10	4	8	15	0	6	0
Jan-Mar-11	3	6	13	0	3	0
Apr-Jun-11	4	8	12	0	7	0
Jul-Aug-11	0	0	0	0	0	0
Total	29	61	67	0	46	1

Table 6.3. White Ditch Siphon Sampling Effort. Sampling effort from October 22 2009 through August 11, 2010.

White Ditch Sampling Effort						
		Methods				
Period	Days	Gillnet	Trawl	Seine	Electrofish	Trotline
Jul-Sep-09	0	0	0	0	0	0
Oct-Dec-09	1	4	1	0	2	0
Jan-Mar-10	0	0	0	0	0	0
Apr-Jun-10	2	4	4	0	3	0
Jul-Sep-10	2	4	6	0	3	0
Oct-Dec-10	0	0	0	0	0	0
Jan-Mar-11	0	0	0	0	0	0
Apr-Jun-11	0	0	0	0	0	0
Jul-Aug-11	0	0	0	0	0	0
Total	5	12	11	0	8	0

Table 7.3. Naomi Siphon Sampling Effort. Sampling effort from January 1 2010 through May 31 2011.

Naomi Siphon Sampling Effort

		Methods				
Period	**Days**	**Gillnet**	**Trawl**	**Seine**	**Electrofish**	**Trotline**
Jul-Sep-09	0	0	0	0	0	0
Oct-Dec-09	0	0	0	0	0	0
Jan-Mar-10	2	8	2	0	3	0
Apr-Jun-10	2	4	3	0	5	0
Jul-Sep-10	3	6	8	0	8	0
Oct-Dec-10	3	6	7	0	7	0
Jan-Mar-11	2	4	5	0	5	0
Apr-Jun-11	2	4	6	0	6	0
Jul-Aug-11	0	0	0	0	0	0
Total	14	32	31	0	34	0

Table 8.3. Species Sampled at Freshwater Diversions of the Lower Mississippi. Species are listed in systematic order following Nelson (2006). Species in boldface are most likely to have been entrained in water that flowed into the diversion. Species marked with a dagger (†) are euryhaline marine species.

Species	Common Name	Bonnet Carré Spillway	Davis Pond Diversion	Violet Siphon	Caernarvon Diversion	White Ditch Siphon	Naomi Siphon	Total
Dasyatis sabina†	Atlantic stingray		4	1	4	1		10
Scaphirhynchus albus	pallid sturgeon	1	1					2
Scaphirhynchus platorynchus	shovelnose sturgeon	15	3					18
Polyodon spathula	paddlefish	23	38	1	6		7	75
Atractosteus spatula	alligator gar	2	1	29	16	7	30	85
Lepisosteus oculatus	spotted gar	84	279	452	244	136	583	1778
Lepisosteus osseus	longnose gar	18	125	3	93		84	323
Lepisosteus platostomus	shortnose gar	67	10		6		2	85
Amia calva	bowfin	1	13				23	37
Hiodon alosoides	goldeye	21	22		1		2	46
Hiodon tergisus	mooneye	1						1
Anguilla rostrata	American eel	11	71	25	44	1	9	161
Elops saurus†	ladyfish	5	35	93	164	29	1	327
Megalops atlanticus†	tarpon						2	2
Anchoa mitchilli†	bay anchovy	106	387	835	6456	217	124	8125
Alosa chrysochloris†	skipjack herring	639	36	339	104	14		1132
Brevoortia patronus†	Gulf menhaden	445	97	2257	1100	267	79	4245
Dorosoma cepedianum	gizzard shad	1760	1422	630	998	139	388	5337
Dorosoma petenense	threadfin shad	2316	490	65	223	40	179	3313
Ctenopharyngodon idella	grass carp		2				4	6
Cyprinella lutrensis	red shiner		1		1			2
Cyprinella venusta	blacktail shiner		2		1			3
Cyprinus carpio	carp	84	114	6	21		22	247

Hybognathus hayi	cypress minnow		1			1		2
Hybognathus nuchalis	silvery minnow	1	11		8	11	1	32
Hybopsis amnis	pallid shiner	1	2					3
Hypophthalmichthys molitrix	silver carp	91	21	4	23		9	148
Hypophthalmichthys nobilis	bighead carp	3						3
Lythrurus fumeus	ribbon shiner	4	6	1	8			19
Macrhybopsis aestivalis	speckled chub		3					3
Macrhybopsis storeriana	silver chub	4	87		1		1	93
Notemigonus crysoleucas	golden shiner	1	3		1		8	13
Notropis atherinoides	emerald shiner	1	16		13			30
Notropis shumardi	silverband shiner	1			4			5
Notropis volucellus	mimic shiner	5	2					7
Opsopoeodus emiliae	pugnose minnow	7	1		4		4	16
Pimephales vigilax	bullhead minnow	4						4
Carpiodes carpio	river carpsucker	107	4					111
Carpiodes cyprinus	quillback	10	1					11
Carpiodes vellifer	highfin carpsucker	1						1
Cycleptus elongatus	blue sucker		1				1	2
Erimyzon oblongus	creek chubsucker	1						1
Ictiobus bubalus	smallmouth buffalo	281	772	10	206	27	307	1603
Ictiobus cyprinellus	bigmouth buffalo	67	46	18	42	11	154	338
Ictiobus niger	black buffalo	40	10	6	16	1	80	153
Minytrema melanops	spotted sucker		1					1
Ameiurus melas	black bullhead			2	1			3
Ameiurus natalis	yellow bullhead		2		10	1	3	16
Ameiurus nebulosus	brown bullhead				1			1
Ictalurus furcatus	blue catfish	759	10554	5085	6051	331	794	23574
Ictalurus punctatus	channel catfish	426	1030	208	1297	28	93	3082
Pylodictis olivaris	flathead catfish	85	174	17	42	6	18	342
Bagre marinus†	gafftopsail catfish			9				9
Aphredoderus sayanus	pirate perch	9	21					30
Mugil cephalus†	striped mullet	427	1093	1557	529	64	891	4561

Mugil curema†	white mullet		29		3			32
Membras martinica†	rough silverside	41	1		51			93
Menidia beryllina	inland silverside	131	133	120	109	49	6	548
Strongylura marina†	Atlantic needlefish	5	2	10	53	1		71
Fundulus chrysotus	golden topminnow		1	1			4	6
Fundulus grandis†	Gulf killifish			103		1	2	106
Lucania parva	rainwater killifish			514		3	4	521
Gambusia affinis	western mosquitofish	151	53	492	3	63	43	805
Heterandria formosa	least killifish	2		1		1	2	6
Poecilia latipinna	sailfin molly		3	99			17	119
Cyprinodon variegatus†	sheepshead minnow	1		220				221
Morone chrysops	white bass	113	333	42	152	3	53	696
Morone mississippiensis	yellow bass	65	77	6	60		17	225
Morone saxatilis	striped bass	3	19		19		1	42
Morone saxatilis x M. chrysops	hybrid striped bass		2		1		2	5
Chaenobryttus gulosus	warmouth sunfish	112	1022	188	92	4	107	1525
Lepomis cyanellus	green sunfish	30	335	18	33	1	3	420
Lepomis humilis	orangespotted sunfish	441	19	1	3		3	467
Lepomis macrochirus	bluegill sunfish	881	1761	769	1034	105	965	5515
Lepomis marginatus	dollar sunfish		13					13
Lepomis megalotis	longear sunfish	436	745	27	51	2	67	1328
Lepomis microlophus	redear sunfish	41	37	50	1208	46	397	1779
Lepomis miniatus	redspotted sunfish	25	154	58	727	68	331	1363
Lepomis symmetricus	bantam sunfish	6	1	1			1	9
Micropterus punctulatus	spotted bass		4		13			17
Micropterus salmoides	largemouth bass	640	1367	119	1263	19	358	3766
Pomoxis annularis	white crappie	159	65	2	36	2	39	303
Pomoxis nigromaculatus	black crappie	286	701	85	239	17	357	1685
Etheostoma asprigene	mud darter				1			1
Percina caprodes	logperch	3						3
Percina maculata	blackside darter	1						1
Sander canadensis	sauger	4	12		1			17

Caranx hippos†	crevalle jack				4			4
Oligoplites saurus†	leatherjacket			7				7
Lutjanus griseus†	gray snapper		1					1
Aplodinotus grunniens	freshwater drum	260	2453	381	2394	69	122	5679
Bairdiella chrysoura†	silver perch			1				1
Cynoscion arenarius†	sand seatrout			76	5	19		100
Leiostomus xanthurus†	spot			32	1			33
Micropogonias undulatus†	Atlantic croaker	14		1521	6	57		1598
Pogonias cromis†	black drum			1				1
Sciaenops ocellatus†	red drum			3		2		5
Herichthys cyanoguttatum	Rio Grande cichlid	1						1
Dormitator maculatus†	fat sleeper	1	280	180	489	1605	324	2879
Eleotris pisonis†	spinycheek sleeper		15	3	1	2	1	22
Gobiomorus dormitor	bigmouth sleeper		1					1
Ctenogobius boleosoma†	darter goby					1		1
Ctenogobius shufeldti	freshwater goby	2	16	58	51	1	30	158
Gobionellus oceanicus†	highfin goby			3				3
Gobiosoma bosc†	naked goby					1		1
Citharichthys spilopterus†	bay whiff			3				3
Paralichthys lethostigma†	southern flounder	1		13	5	1	6	26
Trinectes maculatus†	hogchoker	17	299	12	154	6	4	492
	Total sampled	11808	26969	16873	26001	3481	7169	92301
	Total species	72	77	61	67	47	58	108

Table 9.3. Species sampled at the Bonnet Carré Spillway with each sampling method. Species are listed in systematic order following Nelson (2006).

		Sampling Method				
Species	**Common Name**	**Gillnet**	**Trawl**	**Seine**	**Electrofish**	**Total**
Scaphirhynchus albus	pallid sturgeon	1				1
Scaphirhynchus platorynchus	shovelnose sturgeon	14		1		15
Polyodon spathula	paddlefish	5	3	14	1	23
Atractosteus spatula	alligator gar	1		1		2
Lepisosteus oculatus	spotted gar	43	2	10	29	84
Lepisosteus platostomus	shortnose gar	56		3	8	67
Lepisosteus osseus	longnose gar	11	2	2	3	18
Amia calva	bowfin	1				1
Hiodon tergisus	mooneye	1				1
Hiodon alosoides	goldeye	20		1		21
Anguilla rostrata	American eel	1	3	1	6	11
Elops saurus	ladyfish	1		2	2	5
Anchoa mitchilli	bay anchovy		32	34	40	106
Alosa chrysochloris	skipjack herring	579		11	49	639
Brevoortia patronus	Gulf menhaden	31	7	220	187	445
Dorosoma cepedianum	gizzard shad	855	7	363	535	1760
Dorosoma petenense	threadfin shad	62	27	1389	838	2316
Cyprinus carpio	carp	61	6	7	10	84
Hybognathus nuchalis	silvery minnow			1		1
Macrhybopsis storeriana	silver chub		1	3		4
Lythrurus fumeus	ribbon shiner				4	4
Notemigonus crysoleucas	golden shiner				1	1
Hybopsis amnis	pallid shiner			1		1
Notropis atherinoides	emerald shiner			1		1
Notropis shumardi	silverband shiner			1		1
Notropis volucellus	mimic shiner			5		5

Opsopoeodus emiliae	pugnose minnow		2	1	4	7
Pimephales vigilax	bullhead minnow			2	2	4
Hypophthalmichthys molitrix	silver carp	12		24	55	91
Hypophthalmichthys nobilis	bighead carp	1		2		3
Ictiobus bubalus	smallmouth buffalo	90	10	76	105	281
Ictiobus cyprinellus	bigmouth buffalo	43		5	19	67
Ictiobus niger	black buffalo	19		13	8	40
Carpiodes carpio	river carpsucker	47	5	28	27	107
Carpiodes vellifer	highfin carpsucker	1				1
Carpiodes cyprinus	quillback	6		1	3	10
Erimyzon oblongus	creek chubsucker			1		1
Ictalurus furcatus	blue catfish	416	283	26	34	759
Ictalurus punctatus	channel catfish	118	164	138	6	426
Pylodictis olivaris	flathead catfish	47	31	3	4	85
Aphredoderus sayanus	pirate perch			9		9
Mugil cephalus	striped mullet	73	1	53	300	427
Membras martinica	rough silverside			41		41
Menidia beryllina	inland silverside			31	100	131
Strongylura marina	Atlantic needlefish			2	3	5
Gambusia affinis	western mosquitofish			4	147	151
Heterandria formosa	least killifish			2		2
Cyprinodon variegatus	sheepshead minnow				1	1
Morone chrysops	white bass	12	16	70	15	113
Morone mississippiensis	yellow bass	31	18	13	3	65
Morone saxatilis	striped bass	1		1	1	3
Lepomis cyanellus	green sunfish			10	20	30
Chaenobryttus gulosus	warmouth sunfish	10	7	58	37	112
Lepomis humilis	orangespotted sunfish	3	26	341	71	441
Lepomis macrochirus	bluegill sunfish	17	96	215	553	881
Lepomis megalotis	longear sunfish	9	42	111	274	436
Lepomis microlophus	redear sunfish	5	1	1	34	41
Lepomis miniatus	redspotted sunfish			6	19	25

Lepomis symmetricus	bantam sunfish				6	6
Micropterus salmoides	largemouth bass	38		409	193	640
Pomoxis annularis	white crappie	10	47	96	6	159
Pomoxis nigromaculatus	black crappie	20	117	135	14	286
Percina caprodes	logperch			3		3
Sander canadensis	sauger			4		4
Percina maculata	blackside darter				1	1
Aplodinotus grunniens	freshwater drum	40	93	102	25	260
Micropogonias undulatus	Atlantic croaker	1	13			14
Herichthys cyanoguttatus	Rio Grande cichlid				1	1
Dormitator maculatus	fat sleeper			1		1
Ctenogobius shufeldti	freshwater goby		1	1		2
Paralichthys lethostigma	southern flounder				1	1
Trinectes maculatus	hogchoker		14	2	1	17

Table 10.3. Species sampled at the Davis Pond Diversion with each sampling method. Species are listed in systematic order following Nelson (2006).

		Sampling Method				
Species	**Common Name**	**Gillnet**	**Trawl**	**Electrofish**	**Trotlines**	**Total**
Dasyatis sabina	Atlantic stingray	1	3			4
Scaphirhynchus albus	pallid sturgeon		1			1
Scaphirhynchus platorynchus	shovelnose sturgeon	2	1			3
Polyodon spathula	paddlefish		37	1		38
Atractosteus spatula	alligator gar	1				1
Lepisosteus oculatus	spotted gar	37	153	89		279
Lepisosteus osseus	longnose gar	53	44	28		125
Lepisosteus platostomus	shortnose gar		1	9		10
Amia calva	bowfin	2		11		13
Hiodon alosoides	goldeye	6	2	14		22
Anguilla rostrata	American eel			71		71
Elops saurus	ladyfish			35		35
Anchoa mitchilli	bay anchovy		19	368		387
Alosa chrysochloris	skipjack herring	22	1	13		36
Brevoortia patronus	Gulf menhaden		4	93		97
Dorosoma cepedianum	gizzard shad	245	728	449		1422
Dorosoma petenense	threadfin shad	11	17	462		490
Ctenopharyngodon idella	grass carp			2		2
Cyprinella lutrensis	red shiner			1		1
Cyprinella venusta	blacktail shiner			2		2
Cyprinus carpio	common carp	13	10	91		114
Hybognathus hayi	cypress minnow			1		1
Hybognathus nuchalis	silvery minnow			11		11
Hybopsis amnis	pallid shiner			2		2
Hypophthalmichthys molitrix	silver carp	9	2	10		21
Lythrurus fumeus	ribbon shiner			6		6
Macrhybopsis aestivalis	speckled chub		3			3
Macrhybopsis storeriana	silver chub		83	4		87
Notemigonus crysoleucas	golden shiner			3		3
Notropis atherinoides	emerald shiner		2	14		16
Notropis volucellus	mimic shiner			2		2
Opsopoeodus emiliae	pugnose minnow			1		1
Carpiodes carpio	river carpsucker		2	2		4
Carpiodes cyprinus	quillback			1		1
Cycleptus elongates	blue sucker			1		1
Ictiobus bubalus	smallmouth buffalo	65	643	64		772
Ictiobus cyprinellus	bigmouth buffalo	17	8	21		46
Ictiobus niger	black buffalo	2	4	4		10

Minytrema melanops	spotted sucker	1				1
Ameiurus natalis	yellow bullhead		1	1		2
Ictalurus furcatus	blue catfish	1333	8594	543	84	10554
Ictalurus punctatus	channel catfish	177	679	144	30	1030
Pylodictis olivaris	flathead catfish	54	56	64		174
Aphredoderus sayanus	pirate perch		20	1		21
Mugil cephalus	striped mullet	8		1085		1093
Mugil curema	white mullet			29		29
Membras martinica	rough silverside			1		1
Menidia beryllina	inland silverside			133		133
Strongylura marina	Atlantic needlefish			2		2
Fundulus chrysotus	golden topminnow			1		1
Gambusia affinis	western mosquitofish			53		53
Poecilia latipinna	sailfin molly			3		3
Morone chrysops	white bass	71	40	222		333
Morone mississippiensis	yellow bass	7	48	22		77
Morone saxatilis	striped bass	3	2	14		19
Morone saxatilis x M. chrysops	hybrid striped bass	2				2
Chaenobryttus gulosus	warmouth sunfish	1	49	972		1022
Lepomis cyanellus	green sunfish			335		335
Lepomis humilis	orangespotted sunfish		1	18		19
Lepomis macrochirus	bluegill sunfish		78	1683		1761
Lepomis marginatus	dollar sunfish			13		13
Lepomis megalotis	longear sunfish		7	738		745
Lepomis microlophus	redear sunfish			37		37
Lepomis miniatus	redspotted sunfish			154		154
Lepomis symmetricus	bantam sunfish			1		1
Micropterus punctulatus	spotted bass			4		4
Micropterus salmoides	largemouth bass		1	1366		1367
Pomoxis annularis	white crappie		29	36		65
Pomoxis nigromaculatus	black crappie	17	283	401		701
Sander canadensis	sauger	4	5	3		12
Lutjanus griseus	gray snapper			1		1
Aplodinotus grunniens	freshwater drum	199	2209	41	4	2453
Dormitator maculatus	fat sleeper		1	279		280
Eleotris pisonis	spinycheek sleeper			15		15
Gobiomorus dormitor	bigmouth sleeper			1		1
Ctenogobius shufeldti	freshwater goby		6	10		16
Trinectes maculatus	hogchoker		299			299

Table 11.3. Species sampled at the Violet Siphon with each sampling method. Species are listed in systematic order following Nelson (2006).

		Sampling Method			
Species	**Common Name**	**Gillnet**	**Trawl**	**Electrofish**	**Total**
Dasyatis sabina	Atlantic stingray	1			1
Polyodon spathula	paddlefish		1		1
Atractosteus spatula	alligator gar	20	6	3	29
Lepisosteus oculatus	spotted gar	203	140	109	452
Lepisosteus osseus	longnose gar	2		1	3
Anguilla rostrata	American eel			25	25
Elops saurus	ladyfish	11	5	77	93
Anchoa mitchilli	bay anchovy		230	605	835
Alosa chrysochloris	skipjack herring	241	59	39	339
Brevoortia patronus	Gulf menhaden	29	85	2143	2257
Dorosoma cepedianum	gizzard shad	264	89	277	630
Dorosoma petenense	threadfin shad	43	9	13	65
Cyprinus carpio	carp	6			6
Hypophthalmichthys molitrix	silver carp		3	1	4
Lythrurus fumeus	ribbon shiner			1	1
Ictiobus bubalus	smallmouth buffalo	4	2	4	10
Ictiobus cyprinellus	bigmouth buffalo	5		13	18
Ictiobus niger	black buffalo	4		2	6
Ameiurus melas	black bullhead		2		2
Ictalurus furcatus	blue catfish	56	5008	21	5085
Ictalurus punctatus	channel catfish	24	166	18	208
Pylodictis olivaris	flathead catfish	4	13		17
Bagre marinus	gafftopsail catfish	7	2		9
Mugil cephalus	striped mullet	7	407	1143	1557
Menidia beryllina	inland silverside		19	101	120
Strongylura marina	Atlantic needlefish			10	10
Fundulus chrysotus	golden topminnow			1	1
Fundulus grandis	Gulf killifish		15	88	103
Lucania parva	rainwater killifish		360	154	514
Gambusia affinis	western mosquitofish		1	491	492
Heterandria formosa	least killifish		1		1
Poecilia latipinna	sailfin molly		9	90	99
Cyprinodon variegatus	sheepshead minnow		140	80	220
Morone chrysops	white bass	35	4	3	42
Morone mississippiensis	yellow bass	3	3		6
Chaenobryttus gulosus	warmouth sunfish	1	74	113	188
Lepomis cyanellus	green sunfish		2	16	18
Lepomis humilis	orangespotted sunfish			1	1
Lepomis macrochirus	bluegill sunfish	11	541	217	769
Lepomis megalotis	longear sunfish			27	27

Lepomis microlophus	redear sunfish		45	5	50
Lepomis miniatus	redspotted sunfish		57	1	58
Lepomis symmetricus	bantam sunfish		1		1
Micropterus salmoides	largemouth bass	15	2	102	119
Pomoxis annularis	white crappie		2		2
Pomoxis nigromaculatus	black crappie	2	61	22	85
Oligoplites saurus	leatherjacket			7	7
Aplodinotus grunniens	freshwater drum	13	344	24	381

Table 12.3. Species sampled at the Caernarvon Diversion with each sampling method. Species are listed in systematic order following Nelson (2006).

		Sampling Method				
Species	**Common Name**	**Gillnet**	**Trawl**	**Electrofish**	**Trotlines**	**Total**
Dasyatis sabina	Atlantic stingray	3	1			4
Polyodon spathula	paddlefish		6			6
Atractosteus spatula	alligator gar	13	2	1		16
Lepisosteus oculatus	spotted gar	76	77	91		244
Lepisosteus osseus	longnose gar	36	29	28		93
Lepisosteus platostomus	shortnose gar	2	1	3		6
Hiodon alosoides	goldeye	1				1
Anguilla rostrata	American eel			44		44
Elops saurus	ladyfish	1		163		164
Anchoa mitchilli	bay anchovy		5	6451		6456
Alosa chrysochloris	skipjack herring	61		43		104
Brevoortia patronus	Gulf menhaden		13	1087		1100
Dorosoma cepedianum	gizzard shad	181	57	760		998
Dorosoma petenense	threadfin shad	1	4	218		223
Cyprinella lutrensis	red shiner			1		1
Cyprinella venusta	blacktail shiner			1		1
Cyprinus carpio	carp	2	5	14		21
Hybognathus nuchalis	silvery minnow			8		8
Hypophthalmichthys molitrix	silver carp	15		8		23
Lythrurus fumeus	ribbon shiner			8		8
Macrhybopsis storeriana	silver chub			1		1
Notemigonus crysoleucas	golden shiner			1		1
Notropis atherinoides	emerald shiner			13		13
Notropis shumardi	silverband shiner			4		4
Opsopoeodus emiliae	pugnose minnow			4		4
Ictiobus bubalus	smallmouth buffalo	81	89	36		206
Ictiobus cyprinellus	bigmouth buffalo	29	3	10		42
Ictiobus niger	black buffalo	13	1	2		16
Ameiurus melas	black bullhead			1		1
Ameiurus natalis	yellow bullhead			10		10
Ameiurus nebulosus	brown bullhead	1				1
Ictalurus furcatus	blue catfish	1318	4489	230	14	6051
Ictalurus punctatus	channel catfish	163	949	153	32	1297
Pylodictis olivaris	flathead catfish	9	21	12		42
Mugil cephalus	striped mullet	6		523		529
Mugil curema	white mullet			3		3
Membras martinica	rough silverside			51		51
Menidia beryllina	inland silverside			109		109
Strongylura marina	Atlantic needlefish	1		52		53
Gambusia affinis	western mosquitofish			3		3

Morone chrysops	white bass	70	9	73		152
Morone mississippiensis	yellow bass	19	26	14	1	60
Morone saxatilis	striped bass	6	1	12		19
Morone saxatilis x M. chrysops	hybrid striped bass	1				1
Chaenobryttus gulosus	warmouth sunfish	1	2	89		92
Lepomis cyanellus	green sunfish		1	32		33
Lepomis humilis	orangespotted sunfish			3		3
Lepomis macrochirus	bluegill sunfish	12	297	725		1034
Lepomis megalotis	longear sunfish			51		51
Lepomis microlophus	redear sunfish	21	251	936		1208
Lepomis miniatus	redspotted sunfish	1	5	721		727
Micropterus punctulatus	spotted bass			13		13
Micropterus salmoides	largemouth bass	8	6	1249		1263
Pomoxis annularis	white crappie		16	20		36
Pomoxis nigromaculatus	black crappie	12	102	125		239
Etheostoma asprigene	mud darter			1		1
Sander canadensis	sauger			1		1
Caranx hippos	crevalle jack			4		4
Aplodinotus grunniens	freshwater drum	420	1919	55		2394
Cynoscion arenarius	sand seatrout		5			5
Leiostomus xanthurus	spot	1				1
Micropogonias undulatus	Atlantic croaker		3	3		6
Dormitator maculatus	fat sleeper		5	484		489
Eleotris pisonis	spinycheek sleeper			1		1
Ctenogobius shufeldti	freshwater goby		5	46		51
Paralichthys lethostigma	southern flounder	4		1		5
Trinectes maculatus	hogchoker		148	6		154

Table 13.3. Species sampled at the White Ditch Siphon with each sampling method. Species are listed in systematic order following Nelson (2006).

Species	Common Name	Sampling Method Gillnet	Trawl	Electrofish	Total
Dasyatis sabina	Atlantic stingray		1		1
Atractosteus spatula	alligator gar	4		3	7
Lepisosteus oculatus	spotted gar	82	3	51	136
Anguilla rostrata	American eel			1	1
Elops saurus	ladyfish	1	4	24	29
Anchoa mitchilli	bay anchovy		199	18	217
Alosa chrysochloris	skipjack herring	14			14
Brevoortia patronus	Gulf menhaden		32	235	267
Dorosoma cepedianum	gizzard shad	18		121	139
Dorosoma petenense	threadfin shad		3	37	40
Hybognathus hayi	cypress minnow			1	1
Hybognathus nuchalis	silvery minnow			11	11
Ictiobus bubalus	smallmouth buffalo	15	9	3	27
Ictiobus cyprinellus	bigmouth buffalo	8		3	11
Ictiobus niger	black buffalo	1			1
Ameiurus natalis	yellow bullhead			1	1
Ictalurus furcatus	blue catfish	189	110	32	331
Ictalurus punctatus	channel catfish	11	8	9	28
Pylodictis olivaris	flathead catfish	5		1	6
Mugil cephalus	striped mullet	4	3	57	64
Menidia beryllina	inland silverside			49	49
Strongylura marina	Atlantic needlefish			1	1
Fundulus grandis	Gulf killifish			1	1
Lucania parva	rainwater killifish			3	3
Gambusia affinis	western mosquitofish			63	63
Heterandria formosa	least killifish			1	1
Morone chrysops	white bass		1	2	3
Chaenobryttus gulosus	warmouth sunfish		1	3	4
Lepomis cyanellus	green sunfish			1	1
Lepomis macrochirus	bluegill sunfish		12	93	105
Lepomis megalotis	longear sunfish			2	2
Lepomis microlophus	redear sunfish	1	2	43	46
Lepomis miniatus	redspotted sunfish			68	68
Micropterus salmoides	largemouth bass	1		18	19
Pomoxis annularis	white crappie	1	1		2
Pomoxis nigromaculatus	black crappie	3	4	10	17
Aplodinotus grunniens	freshwater drum	29	36	4	69
Cynoscion arenarius	sand seatrout		12	7	19
Micropogonias undulatus	Atlantic croaker	4	17	36	57

Sciaenops ocellatus	red drum	1		1	2
Dormitator maculatus	fat sleeper		6	1599	1605
Eleotris pisonis	spinycheek sleeper		1	1	2
Ctenogobius boleosoma	darter goby			1	1
Ctenogobius shufeldti	freshwater goby		1		1
Gobiosoma bosc	naked goby			1	1
Paralichthys lethostigma	southern flounder	1			1
Trinectes maculatus	hogchoker		5	1	6

Table 14.3. Species sampled at the Naomi Siphon with each sampling method. Species are listed in systematic order following Nelson (2006).

		Sampling Method			
Species	**Common Name**	**Gillnet**	**Trawl**	**Electrofish**	**Total**
Polyodon spathula	paddlefish	7			7
Atractosteus spatula	alligator gar	20	5	5	30
Lepisosteus oculatus	spotted gar	249	67	267	583
Lepisosteus osseus	longnose gar	33	26	25	84
Lepisosteus platostomus	shortnose gar	1		1	2
Amia calva	bowfin	2		21	23
Hiodon alosoides	goldeye			2	2
Anguilla rostrata	American eel			9	9
Elops saurus	ladyfish			1	1
Megalops atlanticus	tarpon	2			2
Anchoa mitchilli	bay anchovy		53	71	124
Brevoortia patronus	Gulf menhaden		1	78	79
Dorosoma cepedianum	gizzard shad	208	48	132	388
Dorosoma petenense	threadfin shad	1	143	35	179
Ctenopharyngodon idella	grass carp	1		3	4
Cyprinus carpio	carp	4	3	15	22
Hybognathus nuchalis	silvery minnow			1	1
Hypophthalmichthys molitrix	silver carp	5		4	9
Macrhybopsis storeriana	silver chub		1		1
Notemigonus crysoleucas	golden shiner			8	8
Opsopoeodus emiliae	pugnose minnow			4	4
Cycleptus elongatus	blue sucker	1			1
Ictiobus bubalus	smallmouth buffalo	79	85	143	307
Ictiobus cyprinellus	bigmouth buffalo	82		72	154
Ictiobus niger	black buffalo	41	3	36	80
Ameiurus natalis	yellow bullhead		1	2	3
Ictalurus furcatus	blue catfish	105	547	142	794
Ictalurus punctatus	channel catfish	18	53	22	93
Pylodictis olivaris	flathead catfish	5	3	10	18
Mugil cephalus	striped mullet	118	221	552	891
Menidia beryllina	inland silverside			6	6
Fundulus chrysotus	golden topminnow			4	4
Fundulus grandis	Gulf killifish			2	2
Lucania parva	rainwater killifish			4	4
Gambusia affinis	western mosquitofish		2	41	43
Heterandria formosa	least killifish			2	2
Poecilia latipinna	sailfin molly			17	17
Morone chrysops	white bass	38	6	9	53
Morone mississippiensis	yellow bass	5	2	10	17

Morone saxatilis	striped bass			1	1
Morone saxatilis xM. chrysops	hybrid striped bass		2		2
Chaenobryttus gulosus	warmouth sunfish		31	76	107
Lepomis cyanellus	green sunfish			3	3
Lepomis humilis	orangespotted sunfish			3	3
Lepomis macrochirus	bluegill sunfish	15	353	597	965
Lepomis megalotis	longear sunfish		7	60	67
Lepomis microlophus	redear sunfish	7	68	322	397
Lepomis miniatus	redspotted sunfish			331	331
Lepomis symmetricus	bantam sunfish			1	1
Micropterus salmoides	largemouth bass	8	2	348	358
Pomoxis annularis	white crappie	2	22	15	39
Pomoxis nigromaculatus	black crappie	28	124	205	357
Aplodinotus grunniens	freshwater drum	15	100	7	122
Dormitator maculatus	fat sleeper		8	316	324
Eleotris pisonis	spinycheek sleeper			1	1
Ctenogobius shufeldti	freshwater goby		15	15	30
Paralichthys lethostigma	southern flounder	5		1	6
Trinectes maculatus	hogchoker		2	2	4

Table 15.3. Overall CPUE, and entrainment estimates for each method at each Diversion. CPUE for trawling is catch per km. CPUE for gillnetting is catch per hour. CPUE for electrofishing is catch per 500 second electrofishing station. Entrained CPUE is the catch of species most likely to have been entrained. Percent catch entrained is the ratio of entrained CPUE to total CPUE multiplied by 100. Percent entrained species is the percentage of species taken that were likely to have been entrained. Entrained species per unit catch is the ratio of total entrained species to total CPUE.

Method/ Diversion	Total CPUE	Entrained CPUE	Percent Catch Entrained	Total Species	Total Entrained	Percent Entrained Species	Entrained Species per Unit Catch
Trawl							
Bonnet Carré	106.8	2.3	2.14	30	6	20.0	0.056
Davis Pond	352.3	20.8	5.91	42	15	35.7	0.043
Violet	590.8	0.2	0.03	43	2	4.7	0.003
Caernarvon	410.0	6.2	1.52	34	7	20.6	0.017
White Ditch	137.1	2.6	1.91	23	1	4.3	0.007
Naomi	331.4	19.0	5.74	31	4	12.9	0.012
Gillnet							
Bonnet Carré	11.8	1.3	11.2	42	14	33.3	1.19
Davis Pond	5.8	0.4	6.5	28	9	32.1	1.55
Violet	5.9	0.1	1.5	28	4	14.3	0.68
Caernarvon	9.0	0.6	6.5	34	7	20.6	0.78
White Ditch	8.5	0.5	6.1	20	3	15.0	0.35
Naomi	8.1	1.8	22.1	29	7	24.1	0.87
Electrofish							
Bonnet Carré	126.9	6.2	4.89	49	13	26.5	0.102
Davis Pond	169.0	3.5	2.05	69	24	34.8	0.142
Violet	146.8	0.5	0.33	50	5	10.0	0.034
Caernarvon	322.0	3.2	0.99	60	17	28.3	0.053
White Ditch	327.1	2.3	0.69	41	4	9.8	0.012
Naomi	123.5	8.5	6.86	52	8	15.4	0.065

Table 16.3. CPUE of species sampled by trawling at the Bonnet Carré Spillway. CPUE is the mean number (± standard error) of fish taken per km of trawl. N is the number of trawls. Species are listed in systematic order following Nelson (2006).

Period	**Oct-Dec 2009**	**Jan-Mar 2010**	**Apr-Jun 2010**	**Apr-Jun 2011**	**Jul-Aug 2011**
N	1	1	4	8	29
Mean CPUE	758.6	7.1	64.6	46.7	104.6
Entrained CPUE	37.8	0.0	2.6	2.9	0.5
Percent Catch Entrained	4.98	0.00	4.07	6.11	0.46
Total Species	11	2	12	18	24
Total Entrained	2	0	2	3	3
Percent Entrained Species	18.2	0.0	16.7	16.7	12.5
Entrained Species per Unit Catch	0.003	0.00	0.03	0.06	0.03
Species					
Polyodon spathula	0	0	0	1.39±1.39	0
Lepisosteus oculatus	0	0	0	0	0.28±0.28
Lepisosteus osseus	0	0	1.62±1.62	0	0.15±0.15
Anguilla rostrata	3.15	0	0	0	0.26±0.18
Anchoa mitchilli	0	0	0	0.57±0.57	3.97±2.86
Brevoortia patronus	0	0	0	0.44±0.44	0.73±0.51
Dorosoma cepedianum	0	3.57	0	0.93±0.61	0.83±0.66
Dorosoma petenense	0	0	6.12±4.77	0	2.94±0.94
Cyprinus carpio	0	0	0	1.38±0.95	0.45±0.34
Macrhybopsis storeriana	0	0	0	0	0.18±0.18
Opsopoeodus emiliae	0	0	0	1.02±1.02	0
Carpiodes carpio	12.59	0	1±1	0	0
Ictiobus bubalus	25.18	0	0	0.44±0.44	0.15±0.15
Ictalurus furcatus	6.3	3.57	0	10.91±2.95	40.93±10.98
Ictalurus punctatus	412.33	0	1.62±1.62	4.1±2.11	3.58±1.21
Pylodictis olivaris	0	0	0	0.51±0.51	4.9±1.81
Mugil cephalus	0	0	0	0.42±0.42	0

Morone chrysops	0	0	2.11±2.11	0	2.35±1.51
Morone mississippiensis	0	0	1.62±1.62	0.51±0.51	2.53±0.99
Chaenobryttus gulosus	0	0	0	0	0.94±0.4
Lepomis humilis	3.15	0	1.62±1.62	5.04±2.13	2.2±0.91
Lepomis macrochirus	47.21	0	4.86±4.86	7.37±2.92	7.96±4.17
Lepomis megalotis	3.15	0	0	1.43±0.71	4.78±3.03
Lepomis microlophus	3.15	0	0	0	0
Pomoxis annularis	0	0	2.63±1.6	1.88±0.72	6.03±1.61
Pomoxis nigromaculatus	3.15	0	37.13±27.16	5.86±1.86	13.04±2.4
Aplodinotus grunniens	239.21	0	0	0	2.78±1.06
Micropogonias undulatus	0	0	0	0	1.66±1.21
Ctenogobius shufeldti	0	0	2.11±2.11	0	0
Trinectes maculatus	0	0	2.1±1.22	2.51±1.15	0.93±0.43

Table 17.3. CPUE of species sampled by trawling at the Davis Pond Diversion. CPUE is the mean number (± standard error) of fish taken per km of trawl. N is the number of trawls. Species are listed in systematic order following Nelson (2006).

Period	**Jul-Sep 2009**	**Oct-Dec 2009**	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**	**Jul-Aug 2011**
N	4	6	14	21	13	26	23	18	6
Mean CPUE	197.3	40.1	1266.0	14.1	718.9	269.2	224.7	400.6	24.1
Entrained CPUE	7.7	3.9	118.2	1.3	1.4	17.0	21.5	2.5	0.6
Percent Catch Entrained	3.88	9.60	9.33	9.41	0.20	6.32	9.59	0.62	2.53
Total Species	6	10	23	13	13	23	19	23	3
Total Entrained	2	2	11	3	2	5	5	4	1
Percent Entrained Species	33.3	20.0	47.8	23.1	15.4	21.7	26.3	17.4	33.3
Entrained Species per Unit Catch	0.01	0.05	0.009	0.21	0.003	0.02	0.02	0.01	0.04
Species									
Dasyatis Sabina	0	1.63±1.63	0	0	0	0	0	0	0
Scaphirhynchus albus	0	0.48±0.48	0	0	0	0	0	0	0
Scaphirhynchus platorynchus	0	0	0.19±0.19	0	0	0	0	0	0
Polyodon spathula	6.97±6.08	3.37±2.17	4.95±2.36	0.13±0.13	0	0	0	0	0
Lepisosteus oculatus	0	0.4±0.4	26.05±12.08	0	0.86±0.46	0.87±0.44	0	6.34±2.49	0
Lepisosteus osseus	0	0	0.5±0.34	1.09±0.36	0.99±0.63	3.09±1.22	0	1.76±0.82	0.61±0.61
Lepisosteus platostomus	0	0	0.22±0.22	0	0	0	0	0	0
Hiodon alosoides	0	0	0	0	0.41±0.31	0	0	0	0
Anchoa mitchilli	0	1.32±1.32	0	0	0	2.56±1.96	0	0	0
Alosa chrysochloris	0	0	0	0	0	0	0	0.2±0.2	0
Brevoortia patronus	0	0	0	0	0	0.62±0.5	0	0	0
Dorosoma cepedianum	0	0	52.16±28.76	0.15±0.15	0	37.03±22.42	34.96±17.04	0.41±0.28	0
Dorosoma petenense	0	0	0.19±0.19	0.13±0.13	0.11±0.11	0.14±0.14	0	2.64±2.44	0
Cyprinus carpio	0	0	0	0.15±0.15	0	0	0.49±0.36	1.27±0.62	0
Hypophthalmichthys molitrix	0	0	0	0.17±0.17	0	0	0	0.18±0.18	0
Macrhybopsis aestivalis	0	0	0	0	0	0	0.17±0.17	0.39±0.27	0
Macrhybopsis storeriana	0	0	1.14±0.54	0	0	8.52±3.64	1.74±0.91	0	0

Notropis atherinoides	0	0	0.19±0.19	0	0	0.12±0.12	0	0	0
Carpiodes carpio	0	0	0.44±0.44	0	0	0	0	0	0
Ictiobus bubalus	0	0	107.72±61.55	0	0	5.16±2.04	19.14±8.06	0.18±0.18	0
Ictiobus cyprinellus	0.7±0.7	0	1.38±0.72	0.1±0.1	0	0	0	0	0
Ictiobus niger	0	0	0.47±0.32	0	0	0	0.33±0.23	0	0
Ameiurus natalis	0	0	0	0.13±0.13	0	0	0	0	0
Ictalurus furcatus	98.38±43.35	25.57±1.86	783.69±244.9	9.87±2.04	635.96±325.53	91.5±22.41	28.05±8.1	322.85±82.09	21.01±7.2
Ictalurus punctatus	0	2.63±2.63	59.01±20.46	0.21±0.21	0.82±0.38	12.87±4.18	41.99±15.55	7.77±2.26	0
Pylodictis olivaris	0	1.09±0.71	4.3±1.32	1.25±0.42	0.2±0.2	0.58±0.36	0.98±0.49	1.82±0.78	2.47±0.78
Aphredoderus sayanus	0	0	0	0	0	0	0	4.05±2.34	0
Morone chrysops	0.7±0.7	0	2.7±2.42	0	0	1.43±0.65	2.45±1.49	0.29±0.29	0
Morone mississippiensis	0	0	0.22±0.22	0	0	2.3±1.42	3.32±2.02	1.62±0.78	0
Morone saxatilis	0	0	0	0	0	0.11±0.11	0	0.14±0.14	0
Chaenobryttus gulosus	0	0	0	0	3.91±2.08	0.29±0.29	0.17±0.17	4.11±2	0
Lepomis humilis	0	0	0	0	0.29±0.29	0	0	0	0
Lepomis macrochirus	0	0	0	0	1.33±0.95	3.05±0.97	4.26±1.99	3.8±3.03	0
Lepomis megalotis	0	0	0	0	0	1.04±0.68	0.16±0.16	0	0
Micropterus salmoides	0	0	0	0	0	0.15±0.15	0	0	0
Pomoxis annularis	0	0	0.66±0.66	0	0	2.64±1.39	0.33±0.23	1.1±0.44	0
Pomoxis nigromaculatus	0	0	5.82±5.27	0.1±0.1	7.74±4.31	9.88±3.22	7.63±2.74	15.88±8.87	0
Sander canadensis	0	0	0.96±0.43	0	0	0	0.17±0.17	0	0
Aplodinotus grunniens	89.75±62.57	3.2±1.62	212.81±71.88	0	64.07±35.73	57.81±28.84	77.24±36.27	6.18±1.55	0
Dormitator maculatus	0.84±0.84	0	0	0	0	0	0	0	0
Ctenogobius shufeldti	0	0	0	0	0	0	0	1.2±0.51	0
Trinectes maculatus	0	0.44±0.44	0.22±0.22	0.58±0.27	2.15±1.73	27.4±14.79	1.17±0.66	16.4±12.28	0

Table 18.3. CPUE of species sampled by trawling at the Violet Siphon. CPUE is the mean number (± standard error) of fish taken per km of trawl. N is the number of trawls. Species are listed in systematic order following Nelson (2006).

Period	**Jul-Sep 2009**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**
Species **N**	2	4	11	13	12	12
Mean CPUE	53.6	131.5	714.9	366.6	740.4	708.0
Entrained CPUE	0.0	0.0	0.0	0.0	0.5	0.3
Percent Catch Entrained	0.00	0.00	0.00	0.00	0.07	0.05
Total Species	6	10	16	22	36	16
Total Entrained	0	0	0	0	1	1
Percent Entrained Species	0.0	0.0	0.0	0.0	2.8	6.3
Entrained Species per Unit Catch	0.00	0.00	0.00	0.00	0.001	0.001
Species						
Polyodon spathula	0	0	0	0	0	0.34±0.34
Atractosteus spatula	0	0	0	0.24±0.24	1.29±1.02	0
Lepisosteus oculatus	0	0	0	5.49±4.21	32.44±18.33	0.31±0.31
Elops saurus	1.78±1.78	0	1.07±1.07	0	0.31±0.31	0
Anchoa mitchilli	14.08±10.83	28.49±10.93	22.27±6.7	15.79±4.14	0.83±0.44	12.42±5.42
Alosa chrysochloris	0	0	0	0	12.78±12.47	0
Brevoortia patronus	0	0	9.77±6.17	14.48±10.75	0.29±0.29	0
Dorosoma cepedianum	0	0	3.69±2.28	1.88±1.12	15.4±5.56	2.8±1.04
Dorosoma petenense	0	0	0.33±0.33	1.03±0.61	0.51±0.35	0.55±0.37
Hypophthalmichthys molitrix	0	1.74±1.74	0	0	0.32±0.32	0
Ictiobus bubalus	0	0	0	0	0.5±0.35	0
Ameiurus melas	0	0	0	0	0.27±0.27	0.31±0.31
Ictalurus furcatus	0	25.46±13.75	663.85±504.5	142.83±48.82	287.42±159.06	216.44±61.53
Ictalurus punctatus	0	0.93±0.93	0.89±0.89	6.54±3.78	23.28±13.39	8.06±4.54
Pylodictis olivaris	0	0.66±0.66	0	3.65±3.35	0	0
Bagre marinus	1.63±1.63	0	0.36±0.36	0	0	0
Mugil cephalus	0	0	2.4±1.46	0	120.91±74.96	0

Menidia beryllina	0	0	0	0	5.33±3.02	0
Fundulus grandis	0	1.32±1.32	0	0	3.51±3.19	0
Lucania parva	0	0	0	0	80.55±65.78	0
Gambusia affinis	0	0	0	0	0.22±0.22	0
Heterandria formosa	0	0	0	0	0.31±0.31	0
Poecilia latipinna	0	0	0	0.3±0.3	2.29±1.87	0
Cyprinodon variegatus	0	0	0	0	32.86±21.65	0
Morone chrysops	0	0	0.24±0.24	0.17±0.17	0.48±0.33	0
Morone mississippiensis	0	0	0	0.24±0.24	0.62±0.62	0
Chaenobryttus gulosus	0	0	0	16.01±11.33	4.51±1.84	0.32±0.32
Lepomis cyanellus	0	0	0	0	0.51±0.35	0
Lepomis macrochirus	0	0	0	120.29±57.96	36.83±14.12	0
Lepomis microlophus	0	0	0	5.03±3.57	7.19±3.11	0
Lepomis miniatus	0	0	0	14.84±9.68	1.71±0.91	0
Lepomis symmetricus	0	0	0	0	0.22±0.22	0
Micropterus salmoides	0	0	0	0	0.56±0.38	0
Pomoxis annularis	0	0	0.27±0.27	0.31±0.31	0	0
Pomoxis nigromaculatus	0	0	0.45±0.45	10.3±5.41	5.04±2.39	1.2±0.51
Aplodinotus grunniens	0	0	5.46±2.9	6.14±3.79	55.2±27.63	16.5±7.8
Cynoscion arenarius	32.73±9.97	34.75±22.53	2.01±0.87	0	0	0.26±0.26
Leiostomus xanthurus	0	0.81±0.81	0	0.45±0.32	0.67±0.46	5.63±3.14
Micropogonias undulatus	1.63±1.63	36.36±6.78	1.18±0.62	0	0.58±0.58	436.31±119.73
Pogonias cromis	0	0	0	0.29±0.29	0	0
Dormitator maculatus	0	0	0.69±0.46	0.28±0.28	0	0
Ctenogobius shufeldti	0	0.93±0.93	0	0	3.77±2.08	4.34±2
Trinectes maculatus	1.78±1.78	0	0	0	0.86±0.6	2.2±2.2

Table 19.3. CPUE of species sampled by trawling at the Caernarvon Diversion. CPUE is the mean number (± standard error) of fish taken per km of trawl. N is the number of trawls. Species are listed in systematic order following Nelson (2006).

Period	**Jul-Sep 2009**	**Oct-Dec 2009**	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**
N	5	5	3	6	8	15	13	12
Mean CPUE	298.3	486.7	53.2	16.3	353.3	1082.1	219.9	195.0
Entrained CPUE	1.1	12.5	3.5	0.9	0.8	15.4	7.8	4.5
Percent Catch Entrained	0.35	2.58	6.59	5.45	0.24	1.42	3.57	2.31
Total Species	7	13	7	7	14	25	20	16
Total Entrained	1	3	2	2	2	3	4	3
Percent Entrained Species	14.3	23.1	28.6	28.6	14.3	12.0	20.0	18.8
Entrained Species per Unit Catch	0.003	0.01	0.04	0.12	0.01	0.00	0.02	0.02
Species								
Dasyatis sabina	0	0	0	0	0	0.23±0.23	0	0
Polyodon spathula	1.05±0.67	0.55±0.55	0	0.33±0.33	0.56±0.56	0	0	0
Atractosteus spatula	0	0	0	0	0	0.42±0.29	0	0
Lepisosteus oculatus	0	22.55±9.11	0	0	0	5.8±3.09	6.92±1.95	0
Lepisosteus osseus	0	5.1±3.37	1.98±1.14	0	0	1.77±0.79	2.17±1.23	1.74±0.78
Lepisosteus platostomus	0	0	0	0	0	0.22±0.22	0	0
Anchoa mitchilli	0	0	0	0	0.28±0.28	0.59±0.41	0	0.24±0.24
Brevoortia patronus	0	0	0	0	0.67±0.45	2.32±1.01	0	0
Dorosoma cepedianum	0	1.51±0.64	0	0	0.56±0.56	5.84±3.64	7±3.32	0.34±0.34
Dorosoma petenense	0	0	0	0	0	0	1.15±0.78	0
Cyprinus carpio	0	0	0	0.56±0.56	0	0.22±0.22	0.69±0.49	0.24±0.24
Ictiobus bubalus	0	6.9±3.22	1.53±1.53	0	0	13.43±6.21	5.05±2.92	2.46±1.84
Ictiobus cyprinellus	0	0	0	0.56±0.56	0.28±0.28	0	0.36±0.36	0
Ictiobus niger	0	0	0	0	0	0	0.26±0.26	0
Ictalurus furcatus	266.12±69.69	90.83±32.54	17.76±7.12	13.13±7.95	267.3±147.43	569.85±175.77	15.83±7.17	152.4±41.8
Ictalurus punctatus	9.97±5.5	93.88±28.75	29.07±26.94	0.56±0.56	0.56±0.56	141.9±81.89	2.42±1.8	9.04±4.17
Pylodictis olivaris	0.7±0.7	1.68±1.68	0.77±0.77	0.42±0.42	1.47±0.97	1.93±0.61	0	1.48±0.82
Morone chrysops	0.41±0.41	1.09±1.09	0	0	0	0.23±0.23	1.7±1.11	0

Morone mississippiensis	0	0	0	0	0	1.3±1.06	6.38±4.26	0.3±0.3
Morone saxatilis	0	0	0	0	0	0	0	0.3±0.3
Chaenobryttus gulosus	0	0.55±0.55	0	0	0	0.45±0.45	0	0
Lepomis cyanellus	0	0	0	0	0	0	0.36±0.36	0
Lepomis macrochirus	0	1.47±1.06	0	0	0	61.39±27.82	21.04±9.36	0
Lepomis microlophus	0	0	0	0	0	54.17±27.67	4.52±1.57	0
Lepomis miniatus	0	0	0	0	0	1.05±1.05	0	0
Micropterus salmoides	0	0	0	0	0	0	1.72±1.09	0
Pomoxis annularis	0	0	0	0	0	2.58±1.49	2.32±1.23	0
Pomoxis nigromaculatus	0	0	0	0	1.4±1.4	14.78±5.75	11.31±4.22	0.96±0.68
Aplodinotus grunniens	19.37±4.96	259.68±104.71	1.42±0.72	0	74.5±49.91	182.79±29.3	128.46±94.25	4.46±1.48
Cynoscion arenarius	0	0	0	0	0.28±0.28	0.19±0.19	0	1.1±0.79
Micropogonias undulatus	0.68±0.68	0	0	0	0.28±0.28	0	0	0.33±0.33
Dormitator maculatus	0	0	0	0	0	1.28±0.69	0	0
Ctenogobius shufeldti	0	0	0	0.72±0.72	0.34±0.34	0	0	0.66±0.45
Trinectes maculatus	0	0.93±0.58	0.66±0.66	0	4.79±2.49	17.35±5.68	0.26±0.26	18.98±5.52

Table 20.3. CPUE of species sampled by trawling at the White Ditch Siphon. CPUE is the mean number (± standard error) of fish taken per km of trawl. N is the number of trawls. Species are listed in systematic order following Nelson (2006).

Period	**Oct-Dec 2009**	**Apr-Jun 2010**	**Jul-Sep 2010**
N	1	4	6
Mean CPUE	150.1	152.0	131.4
Entrained CPUE	0.0	2.5	2.7
Percent Catch Entrained	0.00	1.65	2.08
Total Species	5	14	17
Total Entrained	0	1	1
Percent Entrained Species	0.0	7.1	5.9
Entrained Species per Unit Catch	0.00	0.007	0.008
Species			
Dasyatis sabina	0	0	0.44±0.44
Lepisosteus oculatus	22.52	0	0
Elops saurus	0	0	2.16±1.52
Anchoa mitchilli	30.02	113.02±90.99	24.68±4.19
Dorosoma petenense	0	2.46±2.46	0
Brevoortia patronus	0	2.01±1.23	16.07±10.27
Ictiobus bubalus	0	2.51±2.51	2.73±1.57
Ictalurus punctatus	0	0.63±0.63	3.35±1.32
Ictalurus furcatus	0	4.63±2.15	54.47±11.22
Mugil cephalus	22.52	0	0
Morone chrysops	0	0.63±0.63	0
Pomoxis annularis	0	0	0.54±0.54
Chaenobryttus gulosus	0	0	0.56±0.56
Lepomis microlophus	0	0	1.2±0.77
Pomoxis nigromaculatus	0	0	2.4±1.26
Lepomis macrochirus	67.55	0.77±0.77	1.2±0.77
Cynoscion arenarius	0	7.16±5.34	0.5±0.5
Aplodinotus grunniens	0	0.75±0.75	18.06±5.47
Micropogonias undulatus	7.51	10.44±6.05	0.99±0.63
Eleotris pisonis	0	0	0.44±0.44
Dormitator maculatus	0	4.82±3.13	0
Ctenogobius shufeldti	0	0.75±0.75	0
Trinectes maculatus	0	1.38±0.8	1.53±1.09

Table 21.3. CPUE of species sampled by trawling at the Naomi Siphon. CPUE is the mean number (± standard error) of fish taken per km of trawl. N is the number of trawls. Species are listed in systematic order following Nelson (2006).

Period	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**
N	2	3	8	7	5	6
Mean CPUE	325.4	76.8	131.6	656.0	309.9	247.1
Entrained CPUE	8.0	7.5	6.8	54.1	3.3	4.5
Percent Catch Entrained	2.46	9.74	5.18	8.24	1.07	1.82
Total Species	11	5	19	26	16	13
Total Entrained	2	2	3	3	2	2
Percent Entrained Species	18.2	40.0	15.8	11.5	12.5	15.4
Entrained Species per Unit Catch	0.006	0.026	0.023	0.005	0.006	0.008
Species						
Atractosteus spatula	11.35±6.28	0	0	0.48±0.48	0	0
Lepisosteus osseus	5.07±5.07	4.98±4.98	2.58±1.32	9.21±3.51	0.9±0.9	3.19±2.1
Lepisosteus oculatus	5.07±5.07	0	0.71±0.71	35.93±10.62	5.65±3.56	3.12±1.89
Anchoa mitchilli	0	0	6.12±3.39	5.88±2.6	27.04±16.79	1.54±1.54
Brevoortia patronus	0	0	0.71±0.71	0	0	0
Dorosoma cepedianum	15.21±15.21	0	2.12±2.12	18.5±16.94	0	0.51±0.51
Dorosoma petenense	0	0	6.94±5.61	25.42±9.69	77.09±75.2	0
Macrhybopsis storeriana	0	0	0.71±0.71	0	0	0
Cyprinus carpio	0	0	0	1.58±1.05	0	0
Ictiobus niger	0	0	0	0.48±0.48	0	1.31±1.31
Ictiobus bubalus	2.94±2.94	2.49±2.49	3.53±3.53	44.4±24.1	2.4±2.4	0
Ameiurus natalis	0	0	0	1.53±1.53	0	0
Pylodictis olivaris	0	0	0.67±0.67	0.48±0.48	0	0.76±0.76
Ictalurus punctatus	71.79±60.03	2.11±2.11	4.11±2.93	8.88±4.34	7.21±7.21	0
Ictalurus furcatus	135.17±123.41	60.8±29.75	67.98±32.07	76.47±37.04	77.57±34.61	209.44±95.41
Mugil cephalus	0	0	0	83.14±60.58	50.91±47.19	0
Gambusia affinis	0	0	0	0	1.53±1.53	0

Morone saxatilis x M. chrysops	0	0	0	0.95±0.95	0	0
Morone mississippiensis	0	0	0	0.69±0.69	0.84±0.84	0
Morone chrysops	2.54±2.54	0	1.86±1.26	1.82±0.88	0	0
Micropterus salmoides	0	0	0.71±0.71	0.48±0.48	0	0
Lepomis megalotis	0	0	0	2.11±1.48	2.52±2.52	0
Pomoxis annularis	0	0	4.76±3.19	8.59±1.99	0	0.51±0.51
Chaenobryttus gulosus	0	0	4.62±2.84	17.57±6.31	0	0.51±0.51
Lepomis microlophus	0	0	0	21.36±13.39	25.5±19.51	0
Pomoxis nigromaculatus	2.94±2.94	0	9.44±6.26	60.13±23.71	0.84±0.84	5.69±2.67
Lepomis macrochirus	8.01±2.13	0	0.64±0.64	186.71±116.55	27.26±21.98	0
Aplodinotus grunniens	65.3±0.62	0	8.56±3.16	40.64±14.76	1.77±1.08	9.79±6
Dormitator maculatus	0	0	4.83±3.38	2.64±2.64	0	0
Ctenogobius shufeldti	0	6.4±6.4	0	0	0	8.59±5.66
Trinectes maculatus	0	0	0	0	0.86±0.86	2.1±2.1

Table 22.3. CPUE of species sampled by gillnetting at the Bonnet Carré Spillway. CPUE is the mean number (± standard error) of fish taken per hour of gillnet set. N is the number of gillnet sets. Species are listed in systematic order following Nelson (2006).

Period	Jul-Sep 2009	Oct-Dec 2009	Jan-Mar 2010	Apr-Jun 2010	Jul-Sep 2010	Apr-Jun 2011	Jul-Aug 2011
N	16	9	2	10	2	11	23
Mean CPUE	15.4	10.1	6.7	11.4	5.7	30.2	15.2
Entrained CPUE	1.2	2.2	1.5	0.9	2.7	1.3	1.2
Percent Catch Entrained	7.51	21.83	21.57	8.15	47.94	4.19	7.99
Total Species	30	23	8	20	12	33	29
Total Entrained	9	8	4	6	4	10	9
Percent Entrained Species	30.0	34.8	50.0	30.0	33.3	30.3	31.0
Entrained Species per Unit Catch	0.584	0.790	0.595	0.529	0.698	0.331	0.594
Species							
Scaphirhynchus platorynchus	0	0	0	0	0	0.44±0.16	0.04±0.03
Scaphirhynchus albus	0	0	0	0	0	0.04±0.04	0
Polyodon spathula	0.06±0.05	0	0	0	0	0	0.04±0.03
Lepisosteus oculatus	0.45±0.19	0.21±0.13	0	0.04±0.02	1.06±0.58	0.22±0.13	0.09±0.03
Lepisosteus osseus	0.01±0.01	0.06±0.03	0	0.08±0.07	0	0.04±0.03	0.05±0.03
Lepisosteus platostomus	0.07±0.05	0.34±0.18	0	0	1.79±1.25	0.12±0.05	0.23±0.07
Atractosteus spatula	0	0	0	0	0	0.03±0.03	0
Amia calva	0	0	0	0	0.09±0.09	0	0
Hiodon alosoides	0	0.06±0.06	0	0	0	0.18±0.1	0.22±0.1
Hiodon tergisus	0.04±0.04	0	0	0	0	0	0
Anguilla rostrata	0	0	0	0	0	0.12±0.12	0
Elops saurus	0.03±0.03	0	0	0	0	0	0
Dorosoma cepedianum	8.64±2.27	4.54±0.82	5.05±0.48	7.22±3.36	1.08±0.36	1.14±0.43	2.22±0.3
Alosa chrysochloris	0.71±0.31	0	0.07±0.07	1.4±0.6	0	5.25±1.67	7.19±1.94
Dorosoma petenense	0.13±0.05	0	0	0.66±0.39	0	0.66±0.27	0.14±0.08
Brevoortia patronus	0.41±0.13	0	0	0	0	0.34±0.15	0.03±0.02
Cyprinus carpio	0.35±0.25	1.1±0.53	0.07±0.07	0.1±0.09	0.25±0.07	0.05±0.03	0.01±0.01
Hypophthalmichthys molitrix	0.06±0.05	0.08±0.05	0	0.02±0.02	0.08±0.08	0.1±0.06	0.02±0.02

Hypophthalmichthys nobilis	0	0.03±0.03	0	0	0	0	0
Carpiodes carpio	0.21±0.13	0.44±0.25	0.14±0.14	0.61±0.41	0	0.2±0.11	0.15±0.06
Carpiodes cyprinus	0.09±0.05	0.04±0.04	0	0	0	0	0
Carpiodes vellifer	0	0	0	0.01±0.01	0	0	0
Ictiobus bubalus	0.5±0.18	0.69±0.28	0.44±0.13	0.08±0.06	0.59±0.05	0.13±0.07	0.38±0.16
Ictiobus cyprinellus	0.12±0.08	0.52±0.16	0.57±0.57	0.11±0.11	0.27±0.27	0.05±0.03	0.05±0.03
Ictiobus niger	0.06±0.04	0.07±0.04	0.3±0.01	0.03±0.03	0.09±0.09	0.06±0.04	0.06±0.03
Ictalurus furcatus	1.4±0.43	0.18±0.09	0	0	0	10.94±4.49	2.52±0.46
Ictalurus punctatus	0.73±0.25	0.22±0.12	0	0.48±0.13	0.26±0.1	0.72±0.26	0.75±0.16
Pylodictis olivaris	0.14±0.09	0.26±0.22	0.08±0.08	0.2±0.2	0	0.7±0.31	0.28±0.1
Mugil cephalus	0.24±0.14	0.44±0.25	0	0.11±0.08	0.08±0.08	2.63±1.51	0.06±0.06
Morone mississippiensis	0.08±0.05	0.05±0.03	0	0.02±0.02	0	0.53±0.36	0.22±0.06
Morone chrysops	0.07±0.05	0.14±0.08	0	0	0	0	0.07±0.03
Morone saxatilis	0	0	0	0	0	0.02±0.02	0
Micropterus salmoides	0.06±0.04	0	0	0.05±0.05	0	3.11±2.89	0.06±0.04
Pomoxis nigromaculatus	0.17±0.13	0.22±0.11	0	0	0.08±0.08	0.32±0.24	0.03±0.02
Lepomis macrochirus	0.13±0.06	0.06±0.06	0	0.03±0.03	0	0.21±0.12	0
Lepomis megalotis	0	0	0	0.07±0.06	0	0.29±0.24	0.03±0.03
Chaenobryttus gulosus	0.14±0.07	0	0	0	0	0.22±0.22	0.01±0.01
Lepomis humilis	0	0	0	0	0	0.36±0.36	0
Pomoxis annularis	0.04±0.03	0.08±0.06	0	0	0	0.15±0.12	0.04±0.03
Lepomis microlophus	0.05±0.04	0	0	0	0	0.17±0.12	0
Aplodinotus grunniens	0.19±0.1	0.31±0.1	0	0.03±0.03	0	0.71±0.41	0.16±0.06
Micropogonias undulatus	0	0	0	0	0	0	0.02±0.02

Table 23.3. CPUE of species sampled by gillnetting at the Davis Pond Diversion. CPUE is the mean number (± standard error) of fish taken per hour of gillnet set. N is the number of gillnet sets. Species are listed in systematic order following Nelson (2006).

Period	**Jul-Sep 2009**	**Oct-Dec 2009**	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**	**Jul-Aug 2011**
N	16	8	12	10	6	10	8	6	2
Mean CPUE	6.7	12.0	2.5	9.5	7.5	5.6	4.6	8.6	8.1
Entrained CPUE	0.0	0.8	0.3	0.3	0.4	1.3	0.2	0.0	0.3
Percent Catch Entrained	0.53	6.61	10.79	2.86	5.27	22.85	3.88	0.37	3.28
Total Species	11	14	16	20	14	12	15	14	6
Total Entrained	2	4	4	6	3	4	4	1	2
Percent Entrained Species	18.2	28.6	25.0	30.0	21.4	33.3	26.7	7.1	33.3
Entrained Species per Unit Catch	0.30	0.33	1.62	0.63	0.40	0.71	0.88	0.12	0.25
Species									
Dasyatis sabina	0	0	0	0	0	0	0	0.03±0.03	0
Scaphirhynchus platorynchus	0.02±0.02	0	0	0.02±0.02	0	0	0	0	0
Lepisosteus osseus	0.02±0.02	0.11±0.07	0.01±0.01	0.09±0.08	0.15±0.07	0.77±0.48	0.02±0.02	0	0
Lepisosteus oculatus	0.02±0.02	0.03±0.03	0.35±0.15	0.02±0.02	0	0	0	0.17±0.11	0
Atractosteus spatula	0	0	0.01±0.01	0	0	0	0	0	0
Amia calva	0	0	0.02±0.02	0	0	0	0.02±0.02	0	0
Hiodon alosoides	0	0	0.05±0.03	0	0.11±0.11	0	0	0	0
Dorosoma cepedianum	0.06±0.04	0.48±0.09	0.84±0.37	0.35±0.11	0.04±0.04	0.14±0.06	2.96±1.59	0.23±0.15	0
Alosa chrysochloris	0.07±0.04	0.05±0.05	0.01±0.01	0.18±0.13	0.1±0.07	0	0.03±0.03	0.06±0.04	0
Dorosoma petenense	0	0	0	0.07±0.06	0	0	0.07±0.07	0.12±0.06	0
Cyprinus carpio	0	0.05±0.03	0.03±0.02	0	0.06±0.04	0.02±0.02	0.1±0.08	0.06±0.04	0
Hypophthalmichthys molitrix	0	0	0	0.15±0.05	0.04±0.04	0	0	0	0
Ictiobus bubalus	0	0.48±0.32	0.22±0.06	0.1±0.05	0.19±0.07	0.43±0.19	0.09±0.07	0	0
Ictiobus cyprinellus	0	0.18±0.1	0	0.04±0.03	0.06±0.04	0.07±0.03	0.05±0.05	0	0.14±0.14
Ictiobus niger	0	0	0	0.02±0.02	0	0.02±0.02	0	0	0
Minytrema melanops	0	0	0.01±0.01	0	0	0	0	0	0
Ictalurus furcatus	4.72±0.88	9.82±3.61	0.38±0.26	5.16±0.9	4.52±1.64	3.01±0.74	0.96±0.21	6.12±0.86	6.61±0.36
Ictalurus punctatus	0.64±0.21	0.08±0.05	0	1.77±0.65	0.5±0.1	0.05±0.03	0	0.89±0.66	0.26±0.01
Pylodictis olivaris	0.19±0.09	0.14±0.08	0.03±0.02	0.31±0.15	0.19±0.06	0.1±0.07	0.03±0.03	0.3±0.1	0.51±0.24
Mugil cephalus	0	0	0	0.13±0.08	0	0	0	0	0

Morone chrysops	0.02±0.02	0.18±0.07	0.19±0.05	0.45±0.13	0.03±0.03	0.37±0.16	0.03±0.03	0.11±0.06	0
Morone mississippiensis	0	0	0	0.02±0.02	0	0	0.04±0.03	0.11±0.11	0
Morone saxatilis	0	0	0	0	0	0	0.02±0.02	0.03±0.03	0.13±0.13
Morone saxatilis x M. chrysops	0.02±0.02	0	0	0.01±0.01	0	0	0	0	0
Pomoxis nigromaculatus	0	0.03±0.03	0.03±0.02	0.09±0.06	0	0.07±0.05	0.07±0.05	0.06±0.04	0
Chaenobryttus gulosus	0	0	0	0	0.03±0.03	0	0	0	0
Sander canadensis	0	0.03±0.03	0.02±0.02	0.01±0.01	0	0	0	0	0
Aplodinotus grunniens	0.89±0.33	0.38±0.09	0.26±0.07	0.55±0.15	1.51±0.42	0.58±0.53	0.08±0.04	0.34±0.21	0.4±0.15

Table 24.3. CPUE of species sampled by gillnetting at the Violet Siphon. CPUE is the mean number (± standard error) of fish taken per hour of gillnet set. N is the number of gillnet sets. Species are listed in systematic order following Nelson (2006).

Period	**Jul-Sep 2009**	**Oct-Dec 2009**	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**
N	13	4	1	8	6	6	6	6
Mean CPUE	8.8	10.2	2.1	7.0	5.1	6.4	5.8	5.7
Entrained CPUE	0.3	0.1	0.0	0.0	0.1	0.0	0.1	0.1
Percent Catch Entrained	3.82	0.72	0.00	0.35	1.78	0.00	1.87	1.50
Total Species	18	4	5	13	13	15	14	14
Total Entrained	4	1	0	1	1	0	2	2
Percent Entrained Species	22.2	25.0	0.0	7.7	7.7	0.0	14.3	14.3
Entrained Species per Unit Catch	0.46	0.10	0.00	0.14	0.20	0.00	0.34	0.35
Species								
Dasyatis sabina	0	0	0	0	0.04±0.04	0	0	0
Lepisosteus oculatus	1.16±0.45	3.17±1.74	0.52	0.37±0.12	1.91±0.88	1.9±0.7	1.13±0.76	0.08±0.05
Atractosteus spatula	0.19±0.1	0	0	0.03±0.03	0.34±0.13	0.27±0.09	0	0
Lepisosteus osseus	0.03±0.03	0.07±0.07	0	0	0	0	0	0
Elops saurus	0.06±0.06	0	0	0	0.42±0.19	0	0	0
Dorosoma cepedianum	1.1±0.48	6.84±3.31	0.78	3.84±2.14	0.33±0.13	0.6±0.2	2.89±1.22	1.07±0.59
Alosa chrysochloris	4.44±1.19	0	0	1.14±0.52	0.91±0.31	0.56±0.23	0.07±0.07	2.54±1.44
Dorosoma petenense	0	0	0	0.2±0.2	0	0.08±0.05	0.57±0.38	1.01±0.87
Brevoortia patronus	0.03±0.03	0	0	0	0	1.16±1.12	0	0
Cyprinus carpio	0	0	0	0	0	0	0.22±0.14	0
Ictiobus niger	0.14±0.09	0	0	0	0	0	0.04±0.04	0.04±0.04
Ictiobus cyprinellus	0.09±0.07	0	0	0	0	0	0.07±0.05	0.04±0.04
Ictiobus bubalus	0.08±0.08	0	0	0.02±0.02	0.09±0.06	0	0	0
Ictalurus furcatus	0.83±0.24	0	0	0.48±0.28	0.64±0.21	0.54±0.45	0.04±0.04	0.04±0.04
Ictalurus punctatus	0.12±0.07	0	0	0.13±0.09	0.09±0.06	0.08±0.08	0.07±0.07	0.42±0.23
Pylodictis olivaris	0.03±0.03	0	0	0.09±0.09	0.1±0.06	0	0	0
Bagre marinus	0.19±0.08	0	0	0	0	0	0	0
Mugil cephalus	0	0.07±0.07	0	0	0	0.11±0.08	0	0.12±0.12
Morone chrysops	0.08±0.08	0	0.26	0.54±0.28	0.05±0.05	0.62±0.43	0.07±0.04	0.09±0.05

Morone mississippiensis	0	0	0	0	0	0	0.1±0.1	0
Lepomis macrochirus	0	0	0.26	0	0	0.17±0.17	0.19±0.19	0
Micropterus salmoides	0	0	0	0	0	0.16±0.05	0.36±0.18	0
Pomoxis nigromaculatus	0	0	0	0	0	0.04±0.04	0	0.04±0.04
Chaenobryttus gulosus	0	0	0	0	0	0	0	0.04±0.04
Aplodinotus grunniens	0.14±0.06	0	0.26	0.05±0.03	0.09±0.09	0.04±0.04	0.04±0.04	0.09±0.09
Micropogonias undulatus	0.01±0.01	0	0	0	0	0	0	0.04±0.04
Cynoscion arenarius	0	0	0	0.02±0.02	0	0	0	0
Paralichthys lethostigma	0.05±0.05	0	0	0.03±0.03	0.09±0.06	0.04±0.04	0	0

Table 25.3. CPUE of species sampled by gillnetting at the Caernarvon Diversion. CPUE is the mean number (± standard error) of fish taken per hour of gillnet set. N is the number of gillnet sets. Species are listed in systematic order following Nelson (2006).

Period	**Jul-Sep 2009**	**Oct-Dec 2009**	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**
N	15	8	6	4	6	8	6	8
Mean CPUE	5.4	13.4	3.1	5.3	8.5	11.6	21.9	9.2
Entrained CPUE	0.1	0.6	1.2	0.2	0.4	1.6	0.5	0.3
Percent Catch Entrained	1.67	4.10	37.59	4.05	4.77	13.86	2.10	3.13
Total Species	12	20	17	13	14	19	16	17
Total Entrained	2	5	5	2	3	4	3	4
Percent Entrained Species	16.7	25.0	29.4	15.4	21.4	21.1	18.8	23.5
Entrained Species per Unit Catch	0.37	0.37	1.60	0.38	0.35	0.35	0.14	0.44
Species								
Dasyatis sabina	0.02±0.02	0	0	0	0	0.03±0.03	0	0.02±0.02
Atractosteus spatula	0.03±0.03	0.12±0.12	0.06±0.03	0.08±0.08	0	0	0	0
Lepisosteus oculatus	0	0.57±0.49	0.3±0.15	2.8±2.52	0	0	0	0
Lepisosteus osseus	0.05±0.03	0.32±0.22	0.16±0.09	0.07±0.07	0	0.18±0.09	0	0.06±0.04
Lepisosteus platostomus	0	0.02±0.02	0	0	0	0	0	0.03±0.03
Hiodon alosoides	0	0	0.01±0.01	0	0	0	0	0
Elops saurus	0	0	0	0	0.06±0.06	0	0	0
Dorosoma cepedianum	0	0.24±0.12	0.57±0.19	0.33±0.33	0	2.3±1.43	1.29±0.46	0.29±0.16
Alosa chrysochloris	0.35±0.2	0	0	0.21±0.13	0.97±0.47	0.17±0.14	0	0.18±0.11
Dorosoma petenense	0	0	0	0	0	0	0	0.03±0.03
Hypophthalmichthys molitrix	0	0.02±0.02	0.16±0.15	0	0.03±0.03	0	0.21±0.16	0
Cyprinus carpio	0	0	0	0	0.09±0.06	0	0	0
Ictiobus bubalus	0	0.15±0.13	0.87±0.47	0.14±0.08	0.17±0.11	0.86±0.32	0.25±0.12	0.1±0.05
Ictiobus cyprinellus	0.02±0.02	0.02±0.02	0.1±0.06	0	0.14±0.11	0.37±0.1	0.11±0.06	0.05±0.03
Ictiobus niger	0	0.02±0.02	0.05±0.05	0	0.1±0.07	0.19±0.05	0.03±0.03	0
Ictalurus furcatus	4.02±1.24	9.33±4.09	0.37±0.19	0.13±0.08	4.64±1.15	4.87±1.07	9.92±3.95	7.56±1.94
Ictalurus punctatus	0.48±0.18	0.26±0.13	0	0.5±0.5	0.14±0.11	0.23±0.1	2.88±1.67	0.05±0.04
Pylodictis olivaris	0	0.07±0.07	0	0	0.03±0.03	0	0.1±0.07	0.11±0.06

Ameiurus nebulosus	0	0	0.06±0.06	0	0	0	0	0
Mugil cephalus	0	0	0	0.42±0.42	0	0.03±0.03	0	0
Strongylura marina	0	0	0	0.07±0.07	0	0	0	0
Morone chrysops	0.1±0.08	0.66±0.26	0.24±0.08	0.3±0.14	0.09±0.04	0.29±0.17	0.1±0.07	0.06±0.06
Morone mississippiensis	0.02±0.02	0.08±0.05	0.01±0.01	0	0	0.06±0.04	0.1±0.07	0.18±0.14
Morone saxatilis	0.01±0.01	0.02±0.02	0	0	0	0	0.06±0.04	0.05±0.03
Morone saxatilis x M. chrysops	0	0	0.01±0.01	0	0	0	0	0
Lepomis microlophus	0	0.02±0.02	0	0	0	0.48±0.31	0.02±0.02	0
Pomoxis nigromaculatus	0	0.06±0.04	0.07±0.05	0	0.04±0.04	0.05±0.03	0.1±0.07	0.03±0.03
Lepomis macrochirus	0	0.04±0.02	0.01±0.01	0	0.03±0.03	0.18±0.1	0.02±0.02	0
Micropterus salmoides	0	0	0	0.08±0.08	0	0.03±0.03	0.15±0.12	0
Lepomis miniatus	0	0	0	0	0	0.02±0.02	0	0
Chaenobryttus gulosus	0	0.02±0.02	0	0	0	0	0	0
Aplodinotus grunniens	0.28±0.11	1.39±0.9	0.11±0.05	0.14±0.14	1.96±1.12	1.19±0.5	6.54±3.12	0.31±0.2
Leiostomus xanthurus	0	0	0	0	0	0.03±0.03	0	0
Paralichthys lethostigma	0.02±0.02	0	0	0	0	0	0	0.07±0.07

Table 26.3. CPUE of species sampled by gillnetting at the White Ditch Siphon. CPUE is the mean number (± standard error) of fish taken per hour of gillnet set. N is the number of gillnet sets. Species are listed in systematic order following Nelson (2006).

Period	**Oct-Dec 2009**	**Apr-Jun 2010**	**Jul-Sep 2010**
N	4	4	4
Mean CPUE	12.8	9.3	8.7
Entrained CPUE	0.5	0.8	0.3
Percent Catch Entrained	3.91	8.46	3.62
Total Species	14	14	11
Total Entrained	1	3	2
Percent Entrained Species	7.1	21.4	18.2
Entrained Species per Unit Catch	0.08	0.32	0.23
Species			
Atractosteus spatula	0.33±0.33	0.13±0.07	0
Lepisosteus oculatus	7.86±4.03	1.9±1.16	0.22±0.15
Elops saurus	0.17±0.17	0	0
Alosa chrysochloris	0	0.56±0.36	0.28±0.22
Dorosoma cepedianum	1.31±0.61	0.5±0.35	0.05±0.05
Ictiobus niger	0	0.06±0.06	0
Ictiobus cyprinellus	0	0.35±0.21	0.05±0.05
Ictiobus bubalus	0.5±0.5	0.37±0.13	0.26±0.16
Pylodictis olivaris	0.25±0.25	0.06±0.06	0.16±0.1
Ictalurus punctatus	0	0.49±0.3	0.11±0.06
Ictalurus furcatus	0.67±0.47	3.99±1.3	6.5±0.75
Mugil cephalus	0.5±0.5	0.05±0.05	0
Micropterus salmoides	0.08±0.08	0	0
Lepomis microlophus	0.17±0.17	0	0
Pomoxis nigromaculatus	0	0.13±0.07	0.06±0.06
Pomoxis annularis	0.25±0.25	0	0
Sciaenops ocellatus	0.17±0.17	0	0
Micropogonias undulatus	0.29±0.17	0	0.06±0.06
Aplodinotus grunniens	0.25±0.25	0.61±0.47	0.9±0.23
Paralichthys lethostigma	0	0.06±0.06	0

Table 27.3. CPUE of species sampled by gillnetting at the Naomi Siphon. CPUE is the mean number (± standard error) of fish taken per hour of gillnet set. N is the number of gillnet sets. Species are listed in systematic order following Nelson (2006).

Period	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**
N	2	3	8	7	5	6
Mean CPUE	14.9	3.8	2.6	9.3	12.1	3.3
Entrained CPUE	5.0	0.8	0.1	1.3	1.9	1.0
Percent Catch Entrained	33.28	22.30	4.79	14.38	15.76	31.97
Total Species	14	14	13	21	22	15
Total Entrained	5	4	2	4	5	5
Percent Entrained Species	35.7	28.6	15.4	19.0	22.7	33.3
Entrained Species per Unit Catch	0.34	1.07	0.78	0.43	0.41	1.52
Species						
Polyodon spathula	0	0	0	0	0.3±0.19	0.1±0.06
Amia calva	0	0	0	0	0.13±0.13	0
Atractosteus spatula	0.58±0.24	0.11±0.11	0	0.18±0.07	0	0
Lepisosteus oculatus	2.59±0.87	1.16±0.6	0.37±0.2	3.22±1.68	1.16±1.16	0.51±0.44
Lepisosteus osseus	1.32±0.56	0.12±0.07	0	0.1±0.06	0.08±0.05	0
Lepisosteus platostomus	0.03±0.03	0	0	0	0	0
Megalops atlanticus	0	0	0	0.06±0.04	0	0
Dorosoma cepedianum	4.82±1.88	0.61±0.49	0.53±0.25	1.02±0.27	1.97±0.71	0.32±0.11
Dorosoma petenense	0	0.06±0.06	0	0	0	0
Hypophthalmichthys molitrix	0	0.05±0.05	0	0	0.16±0.06	0.05±0.05
Cyprinus carpio	0	0	0	0	0.17±0.1	0.06±0.06
Ctenopharyngodon idella	0	0	0	0	0.04±0.04	0
Ictiobus bubalus	1.47±0.66	0.27±0.14	0	0.53±0.48	0.42±0.22	0.57±0.23
Ictiobus cyprinellus	1.64±0.63	0.06±0.06	0.08±0.05	0.56±0.29	0.54±0.23	0.21±0.09
Ictiobus niger	0.5±0.24	0.39±0.17	0.05±0.05	0.15±0.08	0.57±0.2	0.11±0.11
Cycleptus elongatus	0	0	0	0	0	0.06±0.06
Ictalurus furcatus	0.24±0.16	0.33±0.1	1.03±0.44	1.16±0.87	0.51±0.31	0.53±0.28
Ictalurus punctatus	0.21±0.12	0.05±0.05	0.05±0.05	0.18±0.14	0.14±0.1	0.11±0.06
Pylodictis olivaris	0	0	0	0.07±0.07	0.04±0.04	0.06±0.06

Mugil cephalus	0	0	0.07±0.05	1.57±1.05	3.86±3.26	0
Morone chrysops	0.93±0.59	0.21±0.12	0.12±0.05	0.09±0.09	0.07±0.07	0.22±0.22
Morone mississippiensis	0.04±0.04	0	0.04±0.04	0.03±0.03	0.07±0.07	0.06±0.06
Pomoxis nigromaculatus	0.36±0.25	0.29±0.21	0.03±0.03	0.09±0.05	0.31±0.18	0.32±0.15
Lepomis macrochirus	0	0	0	0.1±0.07	0.58±0.58	0
Micropterus salmoides	0	0	0	0.04±0.04	0.43±0.31	0
Lepomis microlophus	0	0	0	0.05±0.03	0.26±0.26	0
Pomoxis annularis	0	0	0.03±0.03	0.05±0.05	0	0
Aplodinotus grunniens	0.18±0.09	0.05±0.05	0.05±0.05	0.05±0.03	0.32±0.32	0
Paralichthys lethostigma	0	0	0.14±0.14	0.04±0.04	0	0

Table 28.3. CPUE of species sampled by electrofishing at the Bonnet Carré Spillway. CPUE is the mean number (± standard error) of fish taken per electrofishing station (500 seconds). N is the number of electrofishing stations. Species are listed in systematic order following Nelson (2006).

Period	**Jul-Sep 2009**	**Oct-Dec 2009**	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Apr-Jun 2011**	**Jul-Aug 2011**
N	7	5	1	3	2	3	9
Mean CPUE	233.6	53.8	24.0	39.3	339.5	143.7	72.2
Entrained CPUE	6.4	7.6	10.0	5.3	30.5	2.3	1.0
Percent Catch Entrained	2.75	14.13	41.67	13.56	8.98	1.62	1.38
Total Species	37	27	8	25	24	29	26
Total Entrained	7	7	4	5	5	5	3
Percent Entrained Species	18.9	25.9	50	20	20.8	17.2	11.5
Entrained Species per Unit Catch	0.03	0.13	0.17	0.13	0.01	0.03	0.04
Species							
Polyodon spathula	0	0	0	0	0.5±0.5	0	0
Lepisosteus oculatus	1±1	0.4±0.24	0	1.33±0.88	2.5±1.5	2±1.15	0.56±0.29
Lepisosteus osseus	0	0	0	0	0	1±1	0
Lepisosteus platostomus	0.14±0.14	0.8±0.58	1	0.33±0.33	0	0	0.11±0.11
Anguilla rostrata	0.14±0.14	0	0	0	0	0.67±0.67	0.33±0.24
Elops saurus	0.14±0.14	0	0	0	0	0	0.11±0.11
Anchoa mitchilli	3.14±1.7	0	0	0	0	0.33±0.33	1.89±1.77
Alosa chrysochloris	0.86±0.86	0	0	1.67±1.67	0	0	4.22±3.01
Brevoortia patronus	7.43±4.44	0	0	0.33±0.33	0	5.33±2.91	13.11±7.25
Dorosoma cepedianum	21.43±7.23	8.4±6.18	7	5.67±5.67	95.5±4.5	6±1.53	12.22±4.03
Dorosoma petenense	67.71±27.8	4.4±2.29	0	2.67±1.67	147±29	5.33±5.33	2.67±1.8
Cyprinus carpio	0.14±0.14	0.4±0.24	0	1.67±0.88	1±1	0	0
Hypophthalmichthys molitrix	0.29±0.29	0.2±0.2	0	0	25±15	0.33±0.33	0.11±0.11
Lythrurus fumeus	0.57±0.43	0	0	0	0	0	0
Notemigonus crysoleucas	0	0	0	0.33±0.33	0	0	0
Opsopoeodus emiliae	0	0.2±0.2	0	0.33±0.33	0.5±0.5	0.33±0.33	0
Pimephales vigilax	0.29±0.18	0	0	0	0	0	0

Carpiodes carpio	0	2.2±1.74	7	2.67±0.88	0	0.33±0.33	0
Carpiodes cyprinus	0.43±0.43	0	0	0	0	0	0
Ictiobus bubalus	4.14±1.68	2.2±0.73	0	1.67±0.67	26.5±9.5	0.33±0.33	0.67±0.24
Ictiobus cyprinellus	0.57±0.3	1±0.77	1	0.33±0.33	2.5±1.5	0.33±0.33	0.22±0.22
Ictiobus niger	0.29±0.18	1±0.45	1	0	0	0	0
Ictalurus furcatus	3±3	0.2±0.2	0	1±0.58	0	0.67±0.33	0.78±0.32
Ictalurus punctatus	0.29±0.18	0	0	0	1±1	0.67±0.67	0
Pylodictis olivaris	0	0.2±0.2	0	0	0	0.33±0.33	0.22±0.15
Mugil cephalus	11±4.48	0.8±0.37	0	1.33±0.33	12±3	7.33±2.91	18.78±3.41
Menidia beryllina	5.86±2.44	0.8±0.58	0	1.67±0.88	2.5±2.5	8±7.02	2.33±1.25
Strongylura marina	0.29±0.18	0	0	0	0	0	0.11±0.11
Gambusia affinis	0.14±0.14	4.2±3.95	0	0.33±0.33	0	41±24.58	0.11±0.11
Cyprinodon variegatus	0	0	0	0	0	0.33±0.33	0
Morone chrysops	1.57±0.69	0.4±0.4	0	0.33±0.33	0	0	0.11±0.11
Morone mississippiensis	0	0	1	0	1±0	0	0
Morone saxatilis	0	0	0	0	0.5±0.5	0	0
Chaenobryttus gulosus	3.86±1.67	0.2±0.2	0	2±1.15	0.5±0.5	0.67±0.67	0
Lepomis cyanellus	1.71±0.71	0	0	0.67±0.67	0.5±0.5	1.67±1.2	0
Lepomis humilis	4.14±1.94	0.2±0.2	0	0.33±0.33	3.5±3.5	11±5.86	0
Lepomis macrochirus	52.57±9.84	18.2±6.79	0	4±2.52	4.5±1.5	14.67±8.57	3.22±1.42
Lepomis megalotis	21.86±8.93	5.2±2.22	0	4.33±3.38	0.5±0.5	19.67±9.06	2.44±0.9
Lepomis microlophus	1.71±0.75	0.8±0.37	0	0	1.5±1.5	1.33±1.33	1.22±0.88
Lepomis miniatus	1±0.44	0	0	0	0	2±2	0.67±0.67
Lepomis symmetricus	0	0	0	0	0	2±1.53	0
Micropterus salmoides	13±2.87	0.4±0.4	0	3.67±2.19	5.5±2.5	9.67±3.93	5.44±1.26
Pomoxis annularis	0.43±0.3	0.2±0.2	0	0	1±0	0	0
Pomoxis nigromaculatus	0.57±0.37	0.4±0.4	4	0.33±0.33	1.5±0.5	0	0
Percina maculata	0	0.2±0.2	0	0	0	0	0
Aplodinotus grunniens	1.57±0.87	0.2±0.2	2	0.33±0.33	2.5±0.5	0.33±0.33	0.44±0.18
Herichthys cyanoguttatus	0.14±0.14	0	0	0	0	0	0
Paralichthys lethostigma	0.14±0.14	0	0	0	0	0	0
Trinectes maculatus	0	0	0	0	0	0	0.11±0.11

Table 29.3. CPUE of species sampled by electrofishing at the Davis Pond Diversion. CPUE is the mean number (± standard error) of fish taken per electrofishing station (500 seconds). N is the number of electrofishing stations. Species are listed in systematic order following Nelson (2006).

Period	**Jul-Sep 2009**	**Oct-Dec 2009**	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**	**Jul-Aug 2011**
N	10	4	4	7	8	12	8	6	2
Mean CPUE	322.9	129.5	43.3	262.3	116.3	127.9	85.0	176.0	177.5
Entrained CPUE	4.6	4.5	1.3	5.4	4.4	3.5	0.6	3.3	1.0
Percent Catch Entrained	1.42	3.47	2.89	2.07	3.76	2.74	0.74	1.89	0.56
Total Species	44	38	21	41	38	37	29	36	24
Total Entrained	11	8	4	9	11	7	5	7	2
Percent Entrained Species	25.0	21.1	19.0	22.0	28.9	18.9	17.2	19.4	8.3
Entrained Species per Unit Catch	0.03	0.06	0.09	0.03	0.09	0.05	0.06	0.04	0.01
Species									
Polyodon spathula	0	0	0	0.14±0.14	0	0	0	0	0
Lepisosteus oculatus	2.3±0.56	1±0.71	0.25±0.25	3.43±1.36	1.13±0.74	0.92±0.51	0	2.83±1.54	0
Lepisosteus osseus	0.4±0.22	0.5±0.5	0	0.29±0.18	0.13±0.13	1.33±0.67	0.13±0.13	0.17±0.17	0.5±0.5
Lepisosteus platostomus	0.1±0.1	0.25±0.25	0	0.71±0.29	0	0	0	0.33±0.21	0
Amia calva	0.1±0.1	0	0.25±0.25	0.29±0.29	0	0.08±0.08	0.38±0.26	0.5±0.5	0
Hiodon alosoides	0	0.25±0.25	0	0	1.5±0.5	0.08±0.08	0	0	0
Anguilla rostrata	0.4±0.22	2.25±1.03	0.75±0.48	2.29±1.32	0.88±0.48	0.67±0.28	1.63±0.98	1.67±0.67	0.5±0.5
Elops saurus	3.5±1.59	0	0	0	0	0	0	0	0
Anchoa mitchilli	16.5±6.16	1.75±1.11	0	2.29±1.54	0.75±0.37	10±6.78	0	8.67±3.74	1±0
Alosa chrysochloris	0.3±0.21	0.25±0.25	0	0.86±0.55	0	0.17±0.11	0	0	0.5±0.5
Brevoortia patronus	2.4±1.18	1.25±0.95	0	4.43±4.26	0.13±0.13	1.58±1.41	0	2.17±1.51	0
Dorosoma cepedianum	13.3±3.4	11.75±8.48	8.5±4.09	7.57±2.44	9±2.39	4.67±2.29	5.25±4.26	0.67±0.49	4±4
Dorosoma petenense	17.5±7.54	0.5±0.5	0	32.29±13.86	2.13±1.99	1.17±1.08	0.13±0.13	3±2.45	4.5±1.5
Ctenopharyngodon idella	0	0	0	0	0	0	0	0.33±0.33	0
Cyprinus carpio	0	0.25±0.25	0.5±0.5	7.14±2.52	0.13±0.13	0	2.38±0.94	3±2.61	0
Cyprinella lutrensis	0	0	0	0	0.13±0.13	0	0	0	0
Cyprinella venusta	0	0	0	0	0.13±0.13	0	0	0.17±0.17	0
Hybopsis amnis	0	0	0	0	0.13±0.13	0	0.13±0.13	0	0
Hybognathus hayi	0.1±0.1	0	0	0	0	0	0	0	0

Hybognathus nuchalis	1±0.8	0	0	0	0.13±0.13	0	0	0	0
Hypophthalmichthys molitrix	0.1±0.1	0	0	1.14±0.46	0	0	0	0	0.5±0.5
Lythrurus fumeus	0.6±0.4	0	0	0	0	0	0	0	0
Macrhybopsis storeriana	0	0	0.25±0.25	0	0	0.25±0.18	0	0	0
Notropis atherinoides	0	0.25±0.25	0	0.71±0.36	0.13±0.13	0.58±0.5	0	0	0
Notemigonus crysoleucas	0.1±0.1	0	0	0	0.13±0.13	0	0.13±0.13	0	0
Notropis volucellus	0	0	0	0.29±0.29	0	0	0	0	0
Opsopoeodus emiliae	0	0	0.25±0.25	0	0	0	0	0	0
Carpiodes carpio	0	0	0	0	0.25±0.25	0	0	0	0
Carpiodes cyprinus	0	0	0	0	0	0	0.13±0.13	0	0
Cycleptus elongatus	0	0	0	0.14±0.14	0	0	0	0	0
Ictiobus bubalus	0.8±0.29	1.75±0.85	0.5±0.29	1.43±0.75	1.63±0.56	0.92±0.47	0.13±0.13	1.83±0.98	0.5±0.5
Ictiobus cyprinellus	0.3±0.21	0.25±0.25	0	1.57±1	0.13±0.13	0.17±0.11	0.13±0.13	0.33±0.33	0
Ictiobus niger	0.1±0.1	0	0	0.14±0.14	0	0	0	0.33±0.21	0
Ameiurus natalis	0	0.25±0.25	0	0	0	0	0	0	0
Ictalurus furcatus	2.3±1.12	19±7.14	1±1	35.57±15.89	7.75±2.26	3.83±1.39	1.25±0.62	6.83±2.46	16±3
Ictalurus punctatus	3.3±1	1.5±0.5	0	4.29±2.08	3±1.75	0.67±0.5	0.13±0.13	4±1.95	9±5
Pylodictis olivaris	2.6±0.91	0.25±0.25	0	1.14±0.55	2±1.12	0.25±0.25	0	0.67±0.33	3±3
Aphredoderus sayanus	0	0	0	0	0	0	0.13±0.13	0	0
Mugil cephalus	8.6±3.1	10.75±7.09	5.25±4.92	71±29.08	5±1.51	5.42±1.74	15.25±9.74	34±10.89	3.5±2.5
Mugil curema	1.4±1.4	3.75±3.42	0	0	0	0	0	0	0
Membras martinica	0	0	0	0.14±0.14	0	0	0	0	0
Menidia beryllina	1.2±0.66	0.25±0.25	1±0	1.71±0.64	1.38±0.46	3.5±1.61	5.5±2.75	0.67±0.33	1.5±0.5
Strongylura marina	0	0	0	0	0	0	0	0.33±0.33	0
Fundulus chrysotus	0	0.25±0.25	0	0	0	0	0	0	0
Gambusia affinis	1.5±0.89	1.25±0.95	0	3.71±3.55	0.75±0.49	0.08±0.08	0	0	0
Poecilia latipinna	0	0	0	0	0	0.25±0.18	0	0	0
Morone chrysops	13.8±6.36	3±0.58	1.25±1.25	2.86±1.08	3.75±1.31	0.67±0.67	0.25±0.16	0.33±0.21	2.5±0.5
Morone mississippiensis	0.4±0.31	0	0	0.14±0.14	0	0.58±0.58	0.38±0.26	0.33±0.33	2.5±1.5
Morone saxatilis	0.8±0.51	0.75±0.48	0.25±0.25	0	0.13±0.13	0	0	0.17±0.17	0
Chaenobryttus gulosus	35.8±9.84	7.75±2.59	3±1.22	16.86±3.39	6.75±2.5	11.5±4.98	11.25±3.12	18.17±5.99	31±22
Lepomis cyanellus	13.8±4.49	6±2.86	3±1.78	5.86±1.82	4.38±1.67	4.08±1.71	2.75±1.18	2.17±0.48	0.5±0.5

Lepomis humilis	0.1±0.1	0	0	0.29±0.18	0	0	0.25±0.25	2.17±0.95	0
Lepomis macrochirus	51.3±17.8	7.5±3.88	7±4.02	21.29±5.46	19.25±3.27	35.08±17.79	14.13±3.64	38.17±6.1	23±19
Lepomis marginatus	0	3.25±2.63	0	0	0	0	0	0	0
Lepomis megalotis	17±3.46	2.75±1.11	6±3.72	9.14±1.34	9.75±5.34	17.67±5.11	13.38±6.47	10.67±2.86	4±3
Lepomis microlophus	1.3±0.52	0	0.25±0.25	0.43±0.3	0.5±0.27	0.67±0.51	0.75±0.53	0	1±1
Lepomis miniatus	1.7±0.5	0	0	0.29±0.18	0.88±0.48	1.08±0.26	0.63±0.32	16±7.18	7±7
Lepomis symmetricus	0	0	0	0	0	0	0	0.17±0.17	0
Micropterus punctulatus	0	0.5±0.29	0	0	0	0.17±0.17	0	0	0
Micropterus salmoides	72.6±21.96	8±4.71	0.75±0.48	8.57±2.39	23.38±7.95	15.75±7.8	1.88±0.44	11.17±2.65	43.5±26.5
Pomoxis annularis	0.4±0.22	0.25±0.25	0	1±0.69	0.25±0.16	0.25±0.18	0.25±0.16	1.83±1.83	3±1
Pomoxis nigromaculatus	15.6±7.79	3.5±1.32	3±1.91	8.14±2.57	5.25±2.24	2.92±1	6±1.79	1.33±0.42	14.5±5.5
Sander canadensis	0.3±0.15	0	0	0	0	0	0	0	0
Lutjanus griseus	0	0.25±0.25	0	0	0	0	0	0	0
Aplodinotus grunniens	0	0.5±0.5	0.25±0.25	1.71±0.57	1.75±0.73	0.42±0.42	0.38±0.38	0.67±0.67	0
Dormitator maculatus	16.6±15.27	25.25±25.25	0	0	1.38±0.6	0.08±0.08	0	0	0
Eleotris pisonis	0.3±0.21	0.75±0.48	0	0.14±0.14	0.5±0.27	0.33±0.19	0	0	0
Gobiomorus dormitor	0.1±0.1	0	0	0	0	0	0	0	0
Ctenogobius shufeldti	0.2±0.2	0	0	0.86±0.7	0	0.08±0.08	0	0.17±0.17	0

Table 30.3. CPUE of species sampled by electrofishing at the Violet Siphon. CPUE is the mean number (± standard error) of fish taken per electrofishing station (500 seconds). N is the number of electrofishing stations. Species are listed in systematic order following Nelson (2006).

Period	**Jul-Sep 2009**	**Oct-Dec 2009**	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**
N	9	4	1	8	5	3	7	6
Mean CPUE	111.7	46.0	48.0	198.4	200.4	98.3	181.7	153.2
Entrained CPUE	0.2	0.3	0.0	0.0	0.6	0.3	0.1	2.2
Percent Catch Entrained	0.20	0.54	0.00	0.00	0.30	0.34	0.08	1.41
Total Species	37	15	8	31	23	20	24	27
Total Entrained	2	1	0	0	1	1	1	1
Percent Entrained Species	5.4	6.7	0.0	0.0	4.3	5.0	4.2	3.7
Entrained Species per Unit Catch	0.02	0.02	0.00	0.00	0.005	0.01	0.01	0.01
Species								
Atractosteus spatula	0	0	0	0.25±0.16	0	0.33±0.33	0	0
Lepisosteus oculatus	2±0.78	2.75±1.55	15	2±0.93	4.6±1.96	4.67±2.73	1±0.72	0.83±0.48
Lepisosteus osseus	0	0.25±0.25	0	0	0	0	0	0
Anguilla rostrata	0.78±0.43	0	0	0.75±0.31	0.4±0.24	0.67±0.67	0	1.33±0.71
Elops saurus	1.33±0.9	0	0	8±3.67	0.2±0.2	0	0	0
Anchoa mitchilli	3.44±1.11	0.5±0.5	0	4.25±1.01	1.6±1.17	3.33±1.76	70.86±58.31	4±1.03
Alosa chrysochloris	0.22±0.15	0	0	2.63±2.63	0.6±0.6	0	1.43±0.75	0.5±0.34
Brevoortia patronus	49±15.08	0	0	143.25±69.06	72±25.4	1±0.58	8.57±5.95	22.17±18.26
Dorosoma cepedianum	1±0.44	2.25±0.75	9	3.13±0.85	19±13.07	14.33±9.49	1±1	13.33±3.99
Dorosoma petenense	0.11±0.11	0	0	0.25±0.16	0	0	0.14±0.14	1.5±0.96
Hypophthalmichthys molitrix	0	0	0	0.13±0.13	0	0	0	0
Lythrurus fumeus	0.11±0.11	0	0	0	0	0	0	0
Ictiobus bubalus	0	0	0	0	0.6±0.4	0.33±0.33	0	0
Ictiobus cyprinellus	0	0	0	0	0	0	0	2.17±1.42
Ictiobus niger	0.11±0.11	0	0	0	0	0	0.14±0.14	0
Ictalurus furcatus	1.11±0.65	0	0	0.5±0.27	0.4±0.24	0.33±0.33	0.14±0.14	0.5±0.34
Ictalurus punctatus	0	0	0	0.5±0.27	0.4±0.24	1±0.58	0.86±0.86	0.5±0.22
Mugil cephalus	18±4.62	16.25±3.54	3	7.38±1.95	64.6±30.92	16±5.69	1.71±0.78	78.5±39.04

Menidia beryllina	6.78±1.28	0.75±0.75	0	3.38±1.97	0.4±0.4	0	0.14±0.14	1.17±0.75
Strongylura marina	0.11±0.11	0	0	0.75±0.37	0	0	0	0.5±0.34
Fundulus chrysotus	0	0	0	0	0	0.33±0.33	0	0
Fundulus grandis	5.89±2.45	0.25±0.25	3	2.25±1.18	0.8±0.37	0.67±0.67	0.71±0.29	0.33±0.21
Lucania parva	1.22±0.74	1±0.41	4	2.13±0.55	0	0	8.43±4.74	9.83±2.55
Gambusia affinis	0.78±0.46	4±4	5	2±0.85	1.6±0.51	1.33±0.33	62.14±35.39	0
Poecilia latipinna	0	7.25±3.66	0	0	0	19.67±15.39	0.29±0.29	0
Cyprinodon variegatus	0	0.25±0.25	0	0	0	0	11.29±10.46	0
Morone chrysops	0.22±0.15	0	0	0.13±0.13	0	0	0	0
Chaenobryttus gulosus	2.33±0.88	1.25±0.75	0	2.75±1	3.2±0.49	5.67±2.96	1±0.38	4.17±1.49
Lepomis cyanellus	0.44±0.24	0	0	0	0	0	1.14±0.7	0.67±0.33
Lepomis humilis	0	0	0	0	0	0	0.14±0.14	0
Lepomis macrochirus	7.44±1.6	7.75±3.71	8	3.5±0.96	4.2±1.24	4.33±3.38	3.43±2.33	4.17±1.96
Lepomis megalotis	1.56±0.85	0	0	0.38±0.26	0	0.67±0.33	0	1.33±0.42
Lepomis microlophus	0	0	1	0	0	0	0.29±0.18	0.33±0.21
Lepomis miniatus	0	0	0	0	0	0	0	0.17±0.17
Micropterus salmoides	2.56±0.71	1.25±0.63	0	1.88±0.77	2±0.71	1.33±1.33	4.71±1.15	2±0.68
Pomoxis nigromaculatus	0.22±0.22	0	0	1.25±0.56	0.6±0.24	1±1	0	0.67±0.21
Oligoplites saurus	0.78±0.46	0	0	0	0	0	0	0
Aplodinotus grunniens	0.44±0.24	0	0	0.25±0.16	0.6±0.6	0	1.57±1.15	0.67±0.49
Bairdiella chrysoura	0.11±0.11	0	0	0	0	0	0	0
Cynoscion arenarius	0.11±0.11	0	0	0.75±0.49	0	0	0	0
Leiostomus xanthurus	0.22±0.22	0	0	0.63±0.42	0	0	0	0
Micropogonias undulatus	0.33±0.24	0	0	1.88±0.83	0	0	0	1.17±0.31
Sciaenops ocellatus	0.11±0.11	0	0	0.25±0.16	0	0	0	0
Dormitator maculatus	0.44±0.34	0.25±0.25	0	0	21.6±7.51	21.33±18.41	0	0
Eleotris pisonis	0.22±0.22	0	0	0.13±0.13	0	0	0	0
Ctenogobius shufeldti	0.78±0.78	0	0	1.13±0.48	0.6±0.24	0	0.57±0.3	0.5±0.5
Gobionellus oceanicus	0.33±0.17	0	0	0	0	0	0	0
Citharichthys spilopterus	0.33±0.33	0	0	0	0	0	0	0
Paralichthys lethostigma	0.67±0.44	0	0	0	0.2±0.2	0	0	0.17±0.17
Trinectes maculatus	0	0	0	0	0.2±0.2	0	0	0

Table 31.3. CPUE of species sampled by electrofishing at the Caernarvon Diversion. CPUE is the mean number (± standard error) of fish taken per electrofishing station (500 seconds). N is the number of electrofishing stations. Species are listed in systematic order following Nelson (2006).

Period	**Jul-Sep 2009**	**Oct-Dec 2009**	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**
N	10	4	3	7	6	6	3	7
Mean CPUE	754.7	131.0	90.3	84.6	90.5	450.2	253.0	257.3
Entrained CPUE	3.4	3.0	0.3	0.3	0.3	1.8	0.3	0.7
Percent Catch Entrained	0.45	2.29	0.37	0.34	0.37	0.41	0.13	0.28
Total Species	34	21	20	29	29	27	14	30
Total Entrained	9	3	3	7	6	5	1	6
Percent Entrained Species	26.5	14.3	15.0	24.1	20.7	18.5	7.1	20.0
Entrained Species per Unit Catch	0.01	0.02	0.03	0.08	0.07	0.01	0.004	0.02
Species								
Atractosteus spatula	0.1±0.1	0	0	0	0	0	0	0
Lepisosteus osseus	0.7±0.21	0	0.33±0.33	0.86±0.7	0.33±0.21	1.33±0.49	0	0.57±0.57
Lepisosteus platostomus	0	0	0	0.14±0.14	0	0	0	0.29±0.29
Lepisosteus oculatus	1.9±0.66	0.75±0.75	0.67±0.67	4.71±2.42	1.5±0.72	1.33±0.84	0.33±0.33	2.29±1.51
Anguilla rostrata	0.6±0.22	0.75±0.48	4.67±2.73	0.57±0.2	0.17±0.17	0.83±0.31	0	1.57±0.78
Elops saurus	8.2±4.19	0	0	6.14±3.98	5.83±3.23	0.17±0.17	0	0.29±0.29
Anchoa mitchilli	619.3±282.84	3.25±1.97	0.33±0.33	0.14±0.14	1.17±0.83	12.33±10.38	0	23.14±11.32
Alosa chrysochloris	2.5±1.66	0	0	0.71±0.36	0.83±0.65	0.5±0.5	1.67±1.67	0
Dorosoma petenense	6.9±3.51	1±0.71	11.67±11.17	11.57±6.06	0.67±0.49	0	0	3.57±1.51
Dorosoma cepedianum	8.6±3.17	10.5±6.02	1.33±0.88	2.14±0.91	6±2.65	93.83±84.91	0.33±0.33	1.86±0.94
Brevoortia patronus	18±10.15	0	0	5.86±4.56	3.17±0.87	3.17±1.4	0	118.29±62.63
Cyprinus carpio	0	0	0	0.71±0.36	0.17±0.17	0	0	1.14±0.83
Cyprinella lutrensis	0	0	0	0	0.17±0.17	0	0	0
Cyprinella venusta	0.1±0.1	0	0	0	0	0	0	0
Hybognathus nuchalis	0.4±0.4	0	0	0.57±0.37	0	0	0	0
Hypophthalmichthys molitrix	0	0	0	0.29±0.18	0.17±0.17	0.17±0.17	0	0.57±0.57
Lythrurus fumeus	0.8±0.47	0	0	0	0	0	0	0
Macrhybopsis storeriana	0.1±0.1	0	0	0	0	0	0	0
Notropis atherinoides	0	3±2.04	0.33±0.33	0	0	0	0	0

Notemigonus crysoleucas	0	0	0.33±0.33	0	0	0	0	0
Notropis shumardi	0.4±0.4	0	0	0	0	0	0	0
Opsopoeodus emiliae	0	0	0	0.14±0.14	0	0	0	0.43±0.43
Ictiobus cyprinellus	0	0.25±0.25	0	0.29±0.18	0	0.67±0.67	0	0.43±0.43
Ictiobus niger	0	0	0	0	0.17±0.17	0.17±0.17	0	0
Ictiobus bubalus	0.4±0.31	0.25±0.25	0	0.57±0.43	0.5±0.22	1.17±0.98	0	2.43±0.84
Ameiurus melas	0	0	0	0	0	0	0.33±0.33	0
Ameiurus natalis	0	0.25±0.25	2.33±1.86	0	0.17±0.17	0.17±0.17	0	0
Pylodictis olivaris	0.4±0.22	0	0	0.43±0.43	0.5±0.22	0.33±0.21	0	0
Ictalurus punctatus	5.9±2.11	0.75±0.48	0	3.71±1.21	4.67±2.46	5.5±2.29	0	0.57±0.3
Ictalurus furcatus	8.5±3.37	1±0.71	0	3.57±1.13	4±1.24	3.33±1.41	0.67±0.67	10±3.77
Mugil curema	0	0.25±0.25	0	0	0	0.33±0.33	0	0
Mugil cephalus	9.3±4.97	3.5±1.55	0	16.57±5.95	2.33±1.2	14.33±4.2	0.33±0.33	28.43±11.15
Membras martinica	0	0	0	0	0	0	0	7.29±6.79
Menidia beryllina	0.5±0.31	16.25±12.3	11±10.02	0	0	0	0	0.86±0.7
Strongylura marina	0.7±0.4	0.25±0.25	0	0.14±0.14	0	0	0	6.14±4.14
Gambusia affinis	0.1±0.1	0	0	0	0.17±0.17	0.17±0.17	0	0
Morone mississippiensis	0.1±0.1	0	1±1	0.43±0.3	0.33±0.21	0	0	0.71±0.47
Morone saxatilis	0.4±0.22	0	0	0.29±0.18	0.17±0.17	0	0	0.71±0.57
Morone chrysops	2.2±1.01	0.75±0.48	0.33±0.33	2±0.53	2.17±1.25	1.83±1.64	0	1.29±1.29
Lepomis humilis	0	0	0.33±0.33	0	0	0	0.33±0.33	0.14±0.14
Micropterus punctulatus	0	0	0	0	0.17±0.17	1.83±1.83	0.33±0.33	0
Pomoxis annularis	0.1±0.1	0	1.67±0.88	0.43±0.3	0	0	0	1.57±0.43
Lepomis cyanellus	0.8±0.42	1.5±0.65	0.33±0.33	0.29±0.18	0.5±0.5	1.17±0.6	0.33±0.33	0.57±0.3
Lepomis megalotis	1.1±0.8	2.25±1.31	2.33±0.67	0.14±0.14	0.5±0.34	3±1.32	0.33±0.33	0.14±0.14
Pomoxis nigromaculatus	3.4±0.99	1.75±1.75	5.33±3.38	3.14±0.7	2.17±0.7	2.17±0.6	0.33±0.33	2.71±1.27
Chaenobryttus gulosus	1.4±0.4	8.5±3.86	11.67±6.67	0	0	0.17±0.17	0.67±0.33	0.43±0.2
Lepomis macrochirus	17.7±4.09	18.5±5.87	22.33±5.24	3.86±2.13	3.5±1.34	26.33±7.9	42±19.86	10.71±2.11
Lepomis miniatus	1.1±0.41	16.75±6.94	6.33±1.2	0	0.5±0.5	69.33±41.11	62.67±22.24	2.43±1.15
Lepomis microlophus	0	30.5±10.9	3.67±1.86	2.43±2.27	0.83±0.83	94.17±54.53	64±44.02	3.43±1.65
Micropterus salmoides	29.4±9.84	8.25±2.29	0.33±0.33	9.57±5.96	46±20.38	34.33±13.91	78.33±54.17	19.57±8.62
Etheostoma asprigene	0	0	0.33±0.33	0	0	0	0	0

Sander canadensis	0.1±0.1	0	0	0	0	0	0	0
Caranx hippos	0.4±0.27	0	0	0	0	0	0	0
Micropogonias undulatus	0	0	0	0.43±0.3	0	0	0	0
Aplodinotus grunniens	1.3±0.47	0.75±0.48	1.67±0.88	1.29±0.42	1.17±0.48	0.67±0.49	0	2±1.18
Eleotris pisonis	0.1±0.1	0	0	0	0	0	0	0
Dormitator maculatus	0.1±0.1	0	0	0.86±0.46	1±0.45	78.5±71.6	0	0
Ctenogobius shufeldti	0.1±0.1	0	0	2±1.84	0	0	0	4.43±1.51
Paralichthys lethostigma	0.1±0.1	0	0	0	0	0	0	0
Trinectes maculates	0.4±0.22	0	0.33±0.33	0	0	0.17±0.17	0	0

Table 32.3. CPUE of species sampled by electrofishing at the White Ditch Siphon. CPUE is the mean number (± standard error) of fish taken per electrofishing station (500 seconds). N is the number of electrofishing stations. Species are listed in systematic order following Nelson (2006).

Period	**Oct-Dec 2009**	**Apr-Jun 2010**	**Jul-Sep 2010**
N	2	3	3
Mean CPUE	163.5	686.7	76.7
Entrained CPUE	1.5	4.7	0.7
Percent Catch Entrained	0.92	0.68	0.87
Total Species	18	33	20
Total Entrained	1	2	2
Percent Entrained Species	5.6	6.1	10.0
Entrained Species per Unit Catch	0.01	0.003	0.03
Species			
Atractosteus spatula	0	1±1	0
Lepisosteus oculatus	3.5±2.5	12.33±7.31	2.33±1.45
Anguilla rostrata	0	0.33±0.33	0
Elops saurus	0	6.67±6.67	1.33±0.88
Anchoa mitchilli	3.5±1.5	3.67±3.18	0
Brevoortia patronus	1±1	74.67±45.43	3±1.73
Dorosoma cepedianum	4±2	7.33±4.67	30.33±24.92
Dorosoma petenense	17.5±16.5	0.67±0.67	0
Hybognathus hayi	0	0	0.33±0.33
Hybognathus nuchalis	0	3.67±3.67	0
Ictiobus bubalus	1±1	0	0.33±0.33
Ictiobus cyprinellus	0	1±0.58	0
Ameiurus natalis	0.5±0.5	0	0
Ictalurus furcatus	0	5±3.21	5.67±3.18
Ictalurus punctatus	0	2.33±1.2	0.67±0.33
Pylodictis olivaris	0	0.33±0.33	0
Mugil cephalus	26±2	1.67±0.67	0
Menidia beryllina	17.5±6.5	4.67±1.76	0
Strongylura marina	0	0.33±0.33	0
Fundulus grandis	0.5±0.5	0	0
Lucania parva	0	1±1	0
Gambusia affinis	21±5	1±0.58	6±3.06
Heterandria formosa	0.5±0.5	0	0
Morone chrysops	0	0.33±0.33	0.33±0.33
Chaenobryttus gulosus	0	0.67±0.33	0.33±0.33
Lepomis cyanellus	0	0.33±0.33	0
Lepomis macrochirus	34.5±0.5	6±2.65	2±0.58
Lepomis megalotis	0	0	0.67±0.67
Lepomis microlophus	4±0	5±4.51	6.67±6.17
Lepomis miniatus	25.5±4.5	2.67±1.76	3±0.58
Micropterus salmoides	1.5±0.5	0.67±0.33	4.33±1.76

Pomoxis nigromaculatus	0	2.33±1.45	1±0
Aplodinotus grunniens	0	0	1.33±1.33
Cynoscion arenarius	0	2±2	0.33±0.33
Micropogonias undulatus	0	12±12	0
Sciaenops ocellatus	0.5±0.5	0	0
Dormitator maculatus	1±0	525.67±487.37	6.67±2.6
Eleotris pisonis	0	0.33±0.33	0
Ctenogobius boleosoma	0	0.33±0.33	0
Gobiosoma bosc	0	0.33±0.33	0
Trinectes maculatus	0	0.33±0.33	0

Table 33.3. CPUE of species sampled by electrofishing at the Naomi Siphon. CPUE is the mean number (± standard error) of fish taken per electrofishing station (500 seconds). N is the number of electrofishing stations. Species are listed in systematic order following Nelson (2006).

Period	**Jan-Mar 2010**	**Apr-Jun 2010**	**Jul-Sep 2010**	**Oct-Dec 2010**	**Jan-Mar 2011**	**Apr-Jun 2011**
N	3	5	8	7	5	6
Mean CPUE	122.3	67.6	77.6	165.7	206.4	90.3
Entrained CPUE	7.3	7.2	2.4	9.0	16.8	10.2
Percent Catch Entrained	5.99	10.65	3.06	5.43	8.14	11.25
Total Species	16	30	35	38	31	37
Total Entrained	3	4	7	5	5	5
Percent Entrained Species	18.8	13.3	20.0	13.2	16.1	13.5
Entrained Species per Unit Catch	0.02	0.06	0.09	0.03	0.02	0.06
Species						
Atractosteus spatula	0	0.6±0.6	0	0.14±0.14	0.2±0.2	0
Lepisosteus oculatus	9±4	7±0.84	7±1.73	11.71±2.71	7.8±4.37	4.67±1.74
Lepisosteus osseus	0	0	0.25±0.16	1.86±0.83	1.4±1.17	0.5±0.22
Lepisosteus platostomus	0	0.2±0.2	0	0	0	0
Amia calva	0	0	0.25±0.16	1.57±0.2	0.8±0.37	0.67±0.21
Hiodon alosoides	0	0	0.25±0.25	0	0	0
Anguilla rostrata	0	0	0.13±0.13	0.43±0.2	0	0.83±0.48
Elops saurus	0	0	0	0	0	0.17±0.17
Anchoa mitchilli	0	0.4±0.24	1±0.73	6.71±1.98	1.2±0.97	1.33±0.61
Brevoortia patronus	0	0.2±0.2	0.88±0.48	0	0	11.67±6.46
Dorosoma cepedianum	4.33±1.45	2.2±0.73	2.13±0.93	2.57±1.31	2.4±0.51	10.17±3.04
Dorosoma petenense	0	2.2±1.02	1.75±0.75	0.29±0.18	0.8±0.49	0.67±0.33
Ctenopharyngodon idella	0	0.4±0.24	0	0	0.2±0.2	0
Cyprinus carpio	0	0.6±0.6	0.25±0.25	0	1.4±0.75	0.5±0.34
Hybognathus nuchalis	0	0	0	0.14±0.14	0	0
Hypophthalmichthys molitrix	0	0	0	0	0	0.67±0.33
Notemigonus crysoleucas	0	0	0	0.71±0.18	0.4±0.24	0.17±0.17
Opsopoeodus emiliae	0	0	0.13±0.13	0	0.4±0.4	0.17±0.17
Ictiobus bubalus	6.33±3.48	2.6±0.24	1.25±0.62	5±1.63	8.2±3.37	4.17±1.85
Ictiobus cyprinellus	0.67±0.67	2.4±1.94	0.25±0.25	1.71±0.68	4.8±1.39	3.33±1.73
Ictiobus niger	0.33±0.33	2±0.84	0.13±0.13	0.29±0.18	2±1.3	2±0.93
Ameiurus natalis	0	0	0	0	0	0.33±0.21
Ictalurus furcatus	1±1	5.8±3.2	3±1.05	2.14±0.63	5.8±2.87	7±2.97
Ictalurus punctatus	0.67±0.67	1.2±0.58	0.63±0.26	0.57±0.2	0.8±0.2	0.17±0.17
Pylodictis olivaris	0	0.2±0.2	0.13±0.13	0.43±0.3	0	0.83±0.4
Mugil cephalus	0	8.8±4.12	3±2.1	9±1.11	69.2±39.66	12.5±2.4
Menidia beryllina	0	0.2±0.2	0.13±0.13	0.14±0.14	0.4±0.4	0.17±0.17
Fundulus chrysotus	0.33±0.33	0	0	0.43±0.2	0	0
Fundulus grandis	0	0	0	0.29±0.29	0	0
Lucania parva	0	0.4±0.24	0	0	0.2±0.2	0.17±0.17
Gambusia affinis	0	0.2±0.2	1.75±0.94	1.57±0.87	0.4±0.24	2.17±1.64
Heterandria formosa	0	0	0	0.29±0.18	0	0
Poecilia latipinna	0	0	0	2.14±1.16	0.4±0.4	0
Morone chrysops	0.33±0.33	0.4±0.4	0.13±0.13	0.57±0.3	0	0.17±0.17
Morone mississippiensis	0	0	0.13±0.13	0.57±0.2	0.4±0.24	0.5±0.5
Morone saxatilis	0	0	0.13±0.13	0	0	0
Chaenobryttus gulosus	0.33±0.33	2.4±1.03	0.75±0.49	2.57±0.87	5±1.9	2.33±0.84
Lepomis cyanellus	0	0	0	0.29±0.18	0	0.17±0.17
Lepomis humilis	0	0.6±0.4	0	0	0	0
Lepomis macrochirus	61.33±16.5	6.8±3.14	4.63±1.61	33.57±9.48	15.6±2.93	4.83±1.25
Lepomis megalotis	0	0	0	4±1.05	4.4±2.25	1.67±0.56
Lepomis microlophus	3.33±0.88	0.6±0.6	0.5±0.5	25.29±5.76	25.6±15.04	0
Lepomis miniatus	2.67±0.67	3.2±1.59	2.88±1.78	27.29±6.01	14.8±3.73	3.17±1.17
Lepomis symmetricus	0	0	0.13±0.13	0	0	0

Micropterus salmoides	1.67±0.33	3.2±1.16	8.25±3.42	15±4.21	24±13.31	6±2.08
Pomoxis annularis	0	0.6±0.4	0.25±0.16	0.71±0.29	0	0.83±0.48
Pomoxis nigromaculatus	29.67±10.14	6.4±3.75	2.25±0.75	1.57±0.2	6.8±2.52	3.5±1.15
Aplodinotus grunniens	0.33±0.33	0	0.25±0.16	0.14±0.14	0.4±0.24	0.17±0.17
Dormitator maculatus	0	5.6±2.73	32.75±10.5	3.71±1.7	0	0
Eleotris pisonis	0	0.2±0.2	0	0	0	0
Ctenogobius shufeldti	0	0	0.25±0.16	0.14±0.14	0.2±0.2	1.83±1.45
Paralichthys lethostigma	0	0	0	0.14±0.14	0	0
Trinectes maculatus	0	0	0.13±0.13	0	0	0.17±0.17

Figure 1.3. Location of the diversions sampled.

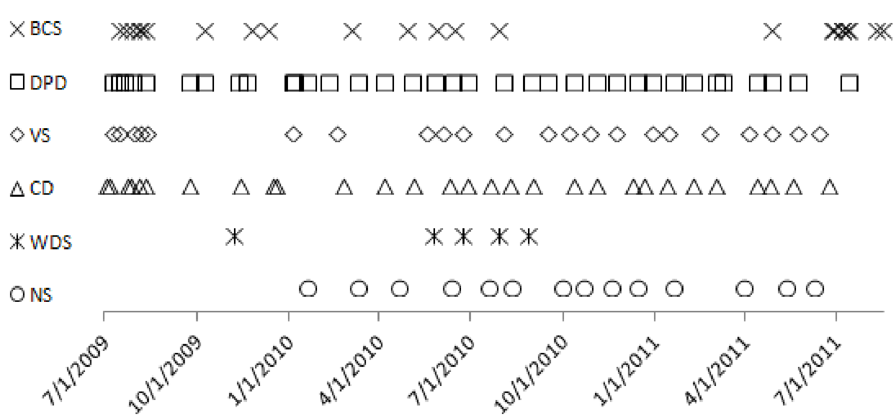

Figure 2.3. Graphical representation of days of sampling effort at each diversion. BCS = Bonnet Carré Spillway, DPD = Davis Pond Diversion, VS = Violet Siphon, CD = Caernarvon Diversion, WDS = White Ditch Siphon, NS = Naomi Siphon.

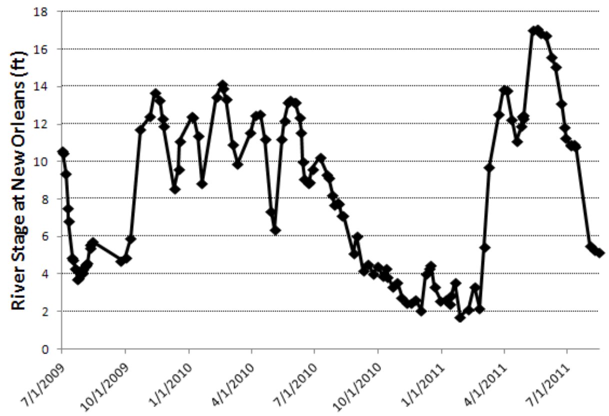

Figure 3.3a. River stage at New Orleans (Carrolton gauge) at 12:00 PM on each date samples were taken in this study.

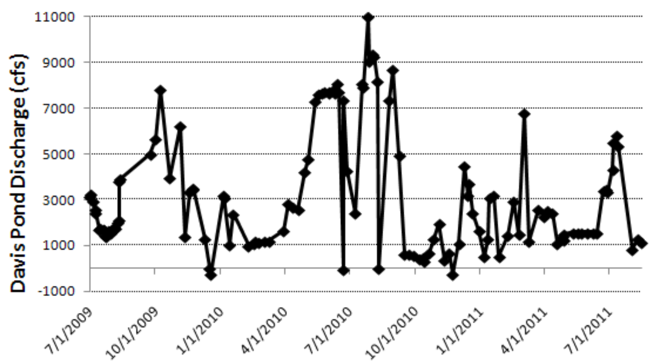

Figure 3.3b. Average daily discharge of the Davis Pond Diversion on each date samples were taken in this study.

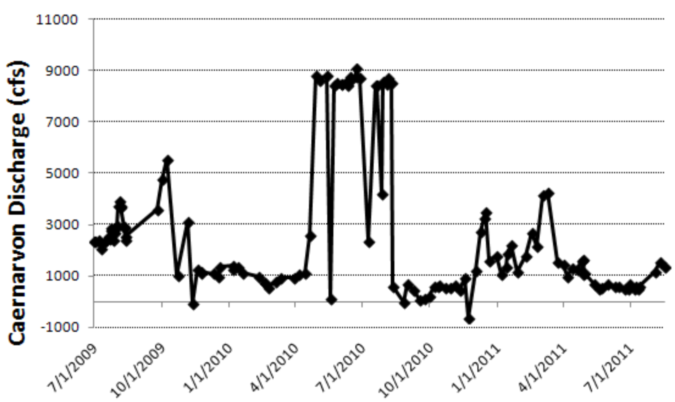

Figure 3.3c. Average daily discharge of the Caernarvon Diversion on each date samples were taken in this study.

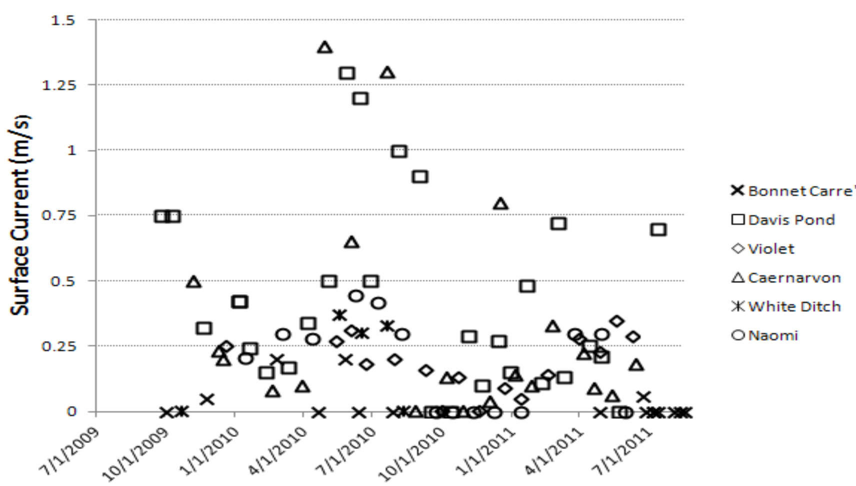

Figure 3.3d. Surface current velocity on sampling days in each diversion.

Chapter 4

Evaluation of Entrainment of Sturgeon Through the Morganza and Bonnet Carré Spillways

by

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Abstract

The Bonnet Carré Spillway, opened in 2008 and 2011, and the Morganza Spillway, opened in 2011, were sampled to evaluate entrainment of pallid sturgeon from the Mississippi River. Pallid sturgeon were collected only in the Bonnet Carré Spillway after the structure was closed. In 2008, a total of 14 pallid sturgeon and 41 shovelnose sturgeon were collected over a 4-week period. In 2011, a total of 20 pallid, 78 shovelnose, and one possible intermediate sturgeon were collected over a 1.5-week period. Higher discharge and longer opening in 2011 resulted in greater numbers of sturgeon caught. The majority of these fish were relocated back into the Mississippi River; some were retained for taxonomic studies by USFWS. Field surveys indicated that it was unlikely that pallid sturgeon, an obligate riverine species, would be entrained through the Morganza Spillway because of the long distance of the floodplain between the main channel of the Mississippi River and the structure.

Introduction

The Bonnet Carré Spillway was constructed in response to the 1927 flood to protect New Orleans. The spillway diverts water from the Mississippi River into a floodway that empties into Lake Pontchartrain to reduce flood stages downstream; design capacity flow is 250,000 cfs. The USACE opened the spillway for the first time in 11 years on April 11, 2008. Within nine days, a total of 160 bays were open diverting a maximum flow of 160,000 cfs from the Mississippi River. The structure was completely closed May 8, 2008 and pallid sturgeon were captured below the structure documenting entrainment of this federally endangered species for the first time.

Based on documented entrainment of pallid sturgeon through the Bonnet Carré Spillway, the New Orleans District made a commitment to monitor entrainment of pallid sturgeon for any future openings of either the Bonnet Carré or Morganza Spillways and attempt rescue efforts to minimize impacts to this endangered species. Both structures were opened during the 2011 flood, and as a result, monitoring and rescue efforts were initiated. This chapter describes field efforts and results of the monitoring/rescue program during the 2008 and 2011 floods.

Each Spillway had unique properties that required modified sampling approaches to effectively capture entrained sturgeon. The Bonnet Carré Spillway empties into Lake

Pontchartrain where detection or capture is difficult and was not sampled during this study. The fate of pallid sturgeon moving into Lake Pontchartrain is uncertain because their salinity tolerance is unknown. The Morganza Spillway empties into the Atchafalaya Basin where fish can widely disperse, and they can move upstream towards the Old River Control Complex where entrainment also occurs. Bonnet Carré and Morganza Spillways do have well-defined, low-flow channels immediately below the structures that form when water recedes and where capture efficiency is highest. However, upstream movement of pallid sturgeon entrained through the Spillways is dependent on rheotactic behaviors possibly disrupted in artificial environments associated with the floodways. Lastly, Morganza has a 7,000-acre forebay that becomes isolated from both the Atchafalaya and Mississippi Rivers at lower stages potentially trapping sturgeon. Despite these challenges, the Spillways were sampled multiple times to document sturgeon entrainment, and if possible, rescue sturgeon after closure of the structures.

Morganza Spillway

The Morganza Spillway, constructed in 1954, is a 4,159-foot structure located along the western bank of the Mississippi River at river mile 280. The structure consists of two sluice gates and 125 gated (bay) openings with a design maximum discharge of 600,000 cfs. During major floods, Mississippi River water is diverted through the gated openings into a floodway 20 miles long and 5 miles wide, which then flows into the Atchafalaya Basin down to the Gulf of Mexico. The spillway has been operated twice, during the 1973 and 2011 floods, to lower Mississippi river stages above and below Baton Rouge and to prevent the Mississippi River from permanently altering course down the Atchafalaya River. During the 2011 flood, Morganza Spillway was operated from 14 May to 7 July with a total of 17 bays opened reaching peaking flows of approximately 180,000 cfs.

ERDC and USACE Rangers with the New Orleans District sampled the Morganza Spillway on July 14 and 18, 2011 for pallid sturgeon. A boat-mounted electroshocker was used to sample the stilling basin below the structure, downstream canal, and the forebay above the structure. Total shocking (pedal) time below the structure was 53 minutes and 19 minutes along the forebay above the structure (Figure 1.4). In addition, a total of six hauls was made with a 20-ft seine in the forebay. Water quality parameters varied below and above the structure, with lower water temperature, dissolved oxygen, and turbidity measured below the structure (Table 1.4). Dissolved oxygen was 5 mg/l below the structure, and since these measurements were taken during early afternoon, hypoxic conditions (<3.0 mg/l) may have occurred during early morning hours. Other areas below the structure were too shallow to sample by boat or had completely dried, but large numbers of dead fish were present. Therefore, two people surveyed these areas by foot for a total combined time of 9.5 hours. Approximately one hour was also expended in the forebay for dead sturgeon. However, no sturgeon were observed or captured below or above the structure.

Because of the massive number of dead fishes present, we only kept track of species and ranked abundance into three categories (abundant, common, and rare). A total of 35 species of fishes comprised of 14 families were observed or collected (Table 2.4). Gar were observed swimming near the structure (Figure 2.4), but most fish were dead (Figures 3.4 – 5.4). The dominant fishes observed were silver carp, gizzard shad, and bigmouth buffalo. Common fishes included gar, catfishes, silversides, and sunfishes. Rare fishes consisted of a few individuals of skipjack herring, mullet and flathead catfish. Most of the fishes observed were backwater species or tolerant of environmental fluctuations, and most rare species are typically found in riverine environments. In addition, five species of freshwater mussels typically found in backwaters were observed (Table 3.4).

The absence of sturgeon is likely due to the position of the Morganza Spillway relative to the Mississippi River. The structure is set back a considerable distance from the River compared to the Bonnet Carré Spillway. In addition, riverine fish originating from the Mississippi River must travel through backwaters in the floodplain and over the potato levee. These barriers likely hamper movement towards the structure. Consequently, it is our opinion that entrainment of pallid sturgeon, which is an obligate riverine fish, through the Morganza Spillway would be a rare event.

Bonnet Carré Spillway

The Bonnet Carré Spillway, constructed in 1931, is located 32.8 miles above New Orleans. The structure consists of 350 bays, each 20 feet wide, for a total width of 7,000 feet at the weir opening. The structure's design flow is 250,000 cfs, which diverts flood waters from the Mississippi River into a 5.7-mile floodway that empties into Lake Pontchartrain to reduce river stages at New Orleans. It has been opened twice over the past four years, although frequency of openings prior to this period was approximately once every 10 years. In 2008, it was open for 27 days beginning April 11th with a maximum of 160 bays in operation creating a maximum discharge through the structure of 160,144 cfs. In 2011, it was open for 42 days beginning May 9th with a maximum of 330 bays in operation creating a maximum discharge of 315,930 cfs, which was twice as high compared to 2008. The structure is closed by placing pins across each bay. However, water continues to seep between the pins for a period of time, creating low flow channels down the floodway.

During both openings, USACE, Louisiana Department of Wildlife and Fisheries (LDWF), and Nicholls State University evaluated entrainment of pallid sturgeon through the structure. Nicholls State University prepared a separate report on their collection efforts (Chapter 3) and these data are not included in this Chapter. The pallid sturgeon is a freshwater, riverine species and it was assumed that any individual entrained and moved into Lake Pontchartrain would not survive in this brackish, lacustrine environment. The floodway could not be sampled during operation because of safety concerns. However, once the structure was closed, USACE and LDWF began sampling the floodway for sturgeon to evaluate entrainment. In both years, sturgeon were captured during the first week after the structure was closed and sampling continued until the floodway became dewatered. Sampling also occurred in the floodway one week prior to the 2011 opening, but no sturgeon were captured.

2008 Opening

Shortly after the Bonnet Carré spillway was open in 2008, a pallid sturgeon was captured by LDWF in the Mississippi River near the structure, suggesting for the first time that this species could be entrained through the spillway. We surmised that the most likely location where entrained sturgeon would occur was in the upper end (closest to the structure) of Barbars Canal, the primary distributary in the floodway where water leaking through the pins after closure would concentrate creating a low flow channel (Figure 6.4). Within one hour of setting a gill net at this location, the first pallid sturgeon was caught.

Multiple gears were used over a five-week period in an attempt to capture pallid sturgeon, including a boat-mounted electroshocker operating at 60 Hz, two types of gill nets (experimental - 90 ft long x 6 ft deep with 6, 15 ft long panels, mesh size ranged from 1 to 3 ½ inches; Trammel - 2 ½ inch mesh), two sizes of hoop nets (3 ft hoops with 1-inch mesh and 4 ft hoops with 4 inch mesh), trotlines (200 ft long with 60 dropper lines baited with worms or shrimp), trawls (10-ft mouth opening with two mesh sizes to retain small fish: exterior was ½ inch and interior was 2 inch), and seines (30 ft in length with ¼ inch mesh; also an experimental gill net retrofitted as a seine). Although species other than sturgeon were recorded during sampling, we did not make a concerted effort to collect every fish because it would jeopardize capture efficiency of pallid sturgeon.

With one exception, all pallid sturgeon were collected by electroshocking (effort=15 hours of pedal time) and gill nets (effort=20 net-sets during the day only, checked every 1-3 hours). One pallid sturgeon was collected at the base of the structure by seining with a gill net. Overall, a total of 14 pallid sturgeon were collected below the structure in Barbars canal during a 3-week period. Other locations were sampled in the floodway, including its confluence with Lake Pontchartrain, but no sturgeon were captured. We assumed that because pallid sturgeon are strongly rheotactic (Adams et al. 1999), individuals displaced downstream oriented into the direction of the flow and moved towards the base of the structure, against the current, until they reached an impassable road crossing where they were susceptible to capture.

Sampling continued for two more weeks, but no additional pallid sturgeon were collected. In addition, 41 shovelnose sturgeon (*S. platorynchus*) were captured below the structure, mostly in the upper end of Barbars canal. All sturgeon were measured, tagged, and released back into the Mississippi River. Water quality and hydraulics in Barbars canal a week after closure was within acceptable limits to support sturgeon (Table 4.4). Water temperature was 23.7 °C, dissolved oxygen was 6 mg/l, and the discharge in the canal was 1,882 cfs. Discharge in Barbars canal gradually decreased in subsequent weeks as the Mississippi River stage elevation dropped below the sill and water stopped leaking between the pins. Five weeks after closure, Barbars canal became dewatered and sampling was discontinued.

2011 Pre-Opening

Several reaches associated with the Bonnet Carré Spillway were sampled on May 4-5, 2011 for the pallid sturgeon. The reaches included the Mississippi River in the vicinity of the spillway structure, the upper portion of Barbars Canal, and the upper portion of Y Canal. Each reach was sampled using a boat-electroshocker operated at 60 Hz. At Barbars Canal and Y Canal, additional sampling gear was deployed which included experimental gillnets, a 2 ½ trammel net, and 3 and 4-ft hoop nets previously described.

A total of 21 species of fish were collected in Barbars and Y Canal (Table 5.4). Many of the species were represented by a single individual. Striped mullet and gizzard shad were the dominant species collected. No sturgeon were observed or collected. The majority of the fish collected were by boat-electroshocking (Shocking time = 1,897 seconds). Gillnets, hoop nets, and trammel nets were fished overnight with limited success. Low catch with these gears was attributed to trash entangled in the nets from floating plant debris displaced by the rising water levels. Most of the species collected during pre-opening are tolerant of fluctuating habitat conditions and tend to exploit newly created waterbodies. These include gar, shad, and sunfishes. As water leaks through the pins into the floodway, resident fish species either move into the canals from the adjacent lakes or from Lake Pontchartrain. Water quality was within acceptable limits for most fish species (Table 4.4). Discharge in Barbars and Y canal was 763 and 502 cfs, respectively. Therefore, the approximate discharge in Barbars Canal below the confluence of Y Canal on May 4, 2011 was 1265 cfs and rising.

Electroshocking was conducted along the Bonnet Carré Spillway (MS River side). Three reaches (each end and the middle) of the spillway was shocked for 300 seconds each and all fish stunned were captured and identified. Additional shocking was conducted in the vicinity of entire spillway structure in search for sturgeon only. That shocking time accounted for 2,256 seconds (Figure 7.4).Water velocity was essentially zero and water temperature was almost 3 degrees higher in the river compared to the floodway 9Table 4.4). No sturgeon were observed or captured.

2011 Opening

Sampling began once the structure was closed on June 20th. Based on the 2008 collections, three primary areas of the floodway were sampled regularly: stilling basin, canals (primarily Barbars and Y), and lakes (Figure 8.4). Over 24 days were expended by three crews working either together or separately representing LDWF, Nicholls State, and USACE. However, after the first week when the structure was closed in 2011, discharge in Barbars canal went from 716 cfs to near zero (Table 4.4), and the majority of sampling occurred in the lakes and stilling basin thereafter.

Higher discharge and longer opening in 2011 resulted in greater number of sturgeon caught. In 2008, a total of 14 pallid and 41 shovelnose sturgeon were collected over a 4-week period. In 2011, a total of 20 pallid, 78 shovelnose, and one possible intermediate sturgeon were collected over a 1.5-week period. Pallid to shovelnose ratio were similar between the two years; 1:3 in 2008 and 1:4 in 2011. Ratio in this reach of the lower Mississippi River is typically 1:3. Mean length of pallid sturgeon collected in 2011 was 773 mm FL, compared to 712 mm FL in 2008. Sizes in 2011 ranged from 449 – 924 mm FL corresponding to ages ranging from three to greater than 15 years. Mean size of shovelnose sturgeon caught in 2011 was slightly smaller (607 mm FL) than in 2008 (665 mm FL).

A notable collection was a tagged pallid sturgeon originally captured in the floodway during 2008 and released back into the Mississippi River. Also, a large adult Paddlefish entrained from the Mississippi River through the Bonnet Carré spillway, injured and underweight, was captured and released back into the Mississippi River. It was re-captured eight months later in north Mississippi, 627 km upriver from where it was released (Hoover et al. 2014). These incidents suggest that entrained fish, trapped for several days in a hyperthermic and hypoxic habitat, can be viable when returned to the river. It also demonstrated that rescue efforts can reduce impacts of spillway operations to fish populations.

Discharge patterns after the structure was closed differed substantially between the two years (Figure 9.4). The 2008 hydrograph exhibited a slow decline over a period of four weeks, whereas the 2011 hydrograph dropped to almost zero discharge in the floodway within a week. Pallid and shovelnose sturgeon catch generally followed the same trend as the hydrograph (Figure 9.4). Sturgeon were caught over a four-week period in 2008, whereas almost all sturgeon captured in 2011 occurred within the first week after closure. The greater magnitude of discharge through the floodway and the abbreviated period of flow in the canals in 2011 displaced sturgeon to a greater extent compared to 2008, and contributed to different sturgeon catch patterns. Both pallid and shovelnose sturgeon are strongly rheotactic and orient into the direction of the flow. As water velocity in the canals below the structure essentially went to zero within a week after the 2011 closure and water levels dropped precipitously throughout the floodway, displaced sturgeon were less likely to move towards the base of the structure as they did in 2008 when discharge persisted for 4-5 weeks in the canals. Rapid drop in water levels in 2011 also hampered physical movement through or over road crossings that crisscross the floodway. In addition, water temperature in Barbars canal was considerably higher in 2011 (28 °C) compared to 2008 (Table 4.4), which likely created stressful conditions for sturgeon necessitating rapid recovery. As water levels declined in the canals after the 2011 opening, sturgeon became stranded in the stilling basin and possibly in floodway lakes that became disconnected with the canals. Numerous sturgeon were caught in the stilling basin, which retained water for weeks with depths approximately 3 feet, but by June 30, 2011, water temperature was over 30 °C and dissolved oxygen averaged 0.9 mg/l. Although no major fish kills were observed in the stilling basin, water quality conditions were degraded and those sturgeon collected at this location were in various stages of stress.

The USFWS issued a non-jeopardy, emergency Biological Opinion for the 2008 opening with an estimated incidental loss of 88 adult pallid sturgeon. A Biological Opinion will likely be issued for the 2011 opening. Differences in hydrograph and catch rates should be considered for future operations. Rapid decreases in discharge below the structure, which happened in 2011, will probably result in more sturgeon becoming stranded and non-recoverable. Gradual decreases in discharges, like 2008, will provide rheotactic cues for sturgeon to move upstream towards the structure, congregate, and become easier to catch. Regardless of the discharge patterns, however, it has been demonstrated twice under different circumstances that rapid rescue of entrained pallid sturgeon can be successfully accomplished to minimize impacts to this endangered species.

Telemetry - 2011

Following the 2011 opening, we used acoustic telemetry to monitor movement of entrained shovelnose sturgeon (*Scaphiryhnchus platorynchus*), a species closely related to and sympatric with pallid sturgeon, within the floodway. Twelve VEMCO VR2Ws (remote receivers) were deployed from the Bonnet Carré floodway down Barbars Canal to Lake Pontchartrain to establish an automated acoustic telemetry array. Eighteen shovelnose sturgeon ranging in size from 501-830 mm FL were captured from upper Barbars, Y-Canal, and the Bonnet Carré stilling basin and equipped with acoustic telemetry tags (V9 coded acoustic transmitters, 289 day battery life) during the period 20-27 June 2011. Tagged fish were then redistributed within the system near telemetry buoys (Barbars 1, 2, 4, 5, 8 and Y-canal 1, see Figure 10.4). The array was deployed from 20 June 2011 through 25 August 2012 and accumulated over 120,000 detections. No mortalities were reported and initially all individuals moved extensively near their original release point. There were no detection patterns to support movement of telemetry tagged individuals from the Bonnet Carré floodway into Lake Pontchartrain after 13 July 2011.

The initial acoustic array within the floodway was deployed on 20 June prior to sampling but the remaining receivers at Lake Pontchartrain were not deployed until 13 July. This created an “open window” for undocumented movement into Lake Pontchartrain (21 June-13 July = 20-32 days depending on when fish were captured, tagged and released). Six individuals were unaccounted for after 13 July suggesting they moved quickly through the floodway and into Lake Pontchartrain before the final receivers were deployed. None were documented returning back to the floodway. Those fish that remained in the system experienced sporadic, localized movement. However, overall movement of telemetry tagged fish began to decrease by early August, as water levels within the floodway decreased, in part creating isolated pools and remnant channels, and as water temperatures increased (31° C). Salinity during this period where the floodway enters Lake Pontchartrain was ≥ 2 ppt; detections during this period on the receivers nearest to Lake Pontchartrain were few to none.

Fish Assemblage of the Bonnet Carre

In addition to sturgeon captured during the 2008 and 2011 openings, a total of 43 species of freshwater and euryhaline fishes were collected (Table 5.4). Catfishes and cluepeids were the most common species, with blue catfish being the most abundant. Sunfishes were the most speciose of all families. Euryhaline species included Gulf menhaden, bay anchovy, Atlantic needlefish, freshwater goby, and hogchocker, all likely originating from Lake Pontchartrain after the structure was opened providing an upstream pathway towards the structure. Species richness doubled after the opening indicating entrainment of riverine fishes, and at least one invasive species, silver carp, from the Mississippi River. American eels were observed at the structure attempting to climb over the sill into the Mississippi River. Schultz (Chapter 3, this document) reported ten additional species not collected by USACE/LDWF. These included smaller individuals primarily captured by seining, and one invasive species (Rio Grande cichlid, *Herichthys cyanoguttatus*). Therefore, total species richness documented in the Bonnet Carre spillway after the 2008 and 2011 openings is 55 including shovelnose and pallid sturgeon.

Estimating Entrainment

Capture of sturgeon in the outflow of diversions verifies entrainment. However, the magnitude of entrainment will remain speculative. Population Viability Models (see next chapter) require input of different “take” levels to properly evaluate the range of alternatives in assessing risk to pallid sturgeon populations. It is likely that a combination of at least three different approaches will be used to determine different take scenarios (Figure 11.4). Examples of the different approaches are presented in Appendix 1. The statistic-based estimate uses predictive models derived from the field study to determine numbers of sturgeon entrained, if any, over a given time period. The hydraulic-based estimate uses the statistical model as an initial starting point, estimate numbers of sturgeon on a volumetric scale (e.g., numbers per cubic meter), and multiply this value by the total volume of water diverted into the marshes. If information is available, volumetric estimates of sturgeon abundance can be supplemented from published rates of entrainment for a given volume of water during dredging or other diversion activities. The biology-based estimate incorporates swimming speeds, rheotactic behavior, and other types of avoidance behavior by sturgeon to modify the hydraulic-based estimates.

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Table 1.4. Water quality data for Morganza Spillway, July 5, 2011		
Parameters	Below Structure	Above Structure
Width (ft)	25	-
Depth (ft)	5.98	-
Velocity (ft/s)	0.79	-
Discharge (cfs)	354	-
Water Temperature (ºC)	29.50	31.38
Dissolved oxygen (mg/L)	5.10	7.44
pH	7.36	7.63
Conductivity (mS)	0.344	0.332
Turbidity (NTU)	18.39	49.9

Table 2.4. Fish species documented in the Morganza Spillway, July 2011

Family	Scientific Name	Common Name	Status
Polyodontidae	*Polyodon spathula*	Paddlefish	Common
Lepisosteidae	*Lepisosteus oculatus*	Spotted gar	Common
	Lepisosteus osseus	Longnose gar	Common
	Lepisosteus platostomus	Shortnose gar	Common
Amiidae	*Amia calva*	Bowfin	Common
Anguillidae	*Anguilla rostrata*	American eel	Rare
Clupeidae	*Alosa chrysochloris*	Skipjack herring	Common
	Dorosoma cepedianum	Gizzard shad	Abundant
	Dorosoma petenense	Threadfin shad	Common
Cyprinidae	*Cyprinus carpio*	Common carp	Common
	Hypophthalmichthys molitrix	Silver carp	Abundant
	Hypophthalmichthys nobilis	Bighead carp	Abundant
	Ctenopharyngodon idella	Grass carp	Rare
Catostomidae	*Carpiodes carpio*	River carpsucker	Rare
	Ictiobus bubalus	Smallmouth buffalo	Rare
	Ictiobus cyprinellus	Bigmouth buffalo	Common
	Ictiobus niger	Black buffalo	Common
Ictaluridae	*Ameiurus melas*	Black bullhead	Common
	Ameiurus natalis	Yellow bullhead	Common
	Ictalurus furcatus	Blue catfish	Rare
	Ictalurus punctatus	Channel catfish	Common
	Pylodictus olivaris	Flathead catfish	Rare
Belonidae	*Strongylura marina*	Atlantic needlefish	Rare
Atherinopsidae	*Menidia beryllina*	Inland silverside	Common
Moronidae	*Morone chrysops*	White bass	Rare
	Morone mississippiensis	Yellow bass	Rare
Centrarchidae	*Lepomis cyanellus*	Green sunfish	Abundant
	Lepomis gulosus	Warmouth	Common
	Lepomis macrochirus	Bluegill	Common
	Lepomis megalotis	Longear sunfish	Rare
	Micropterus salmoides	Largemouth bass	Common
	Pomoxis annularis	White crappie	Rare
	Pomoxis nigromaculatus	Black crappie	Common
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	Rare
Mugilidae	*Mugil cephalus*	Striped mullet	Rare
Total number of species			35

Table 3.4 Alive and dead freshwater mussels observed above and below the Morganza Spillway.	
Species	Status
Family Unionidae	
Pyganodon grandis, giant floater	Abundant
Utterbackia imbecillis, paper pondshell	Common
Quadrula apiculata, southern mapleleaf	Common
Toxolasmus texasensis, Texas lilliput	Common
Uniomerus tetralasmus, pond horn	Common

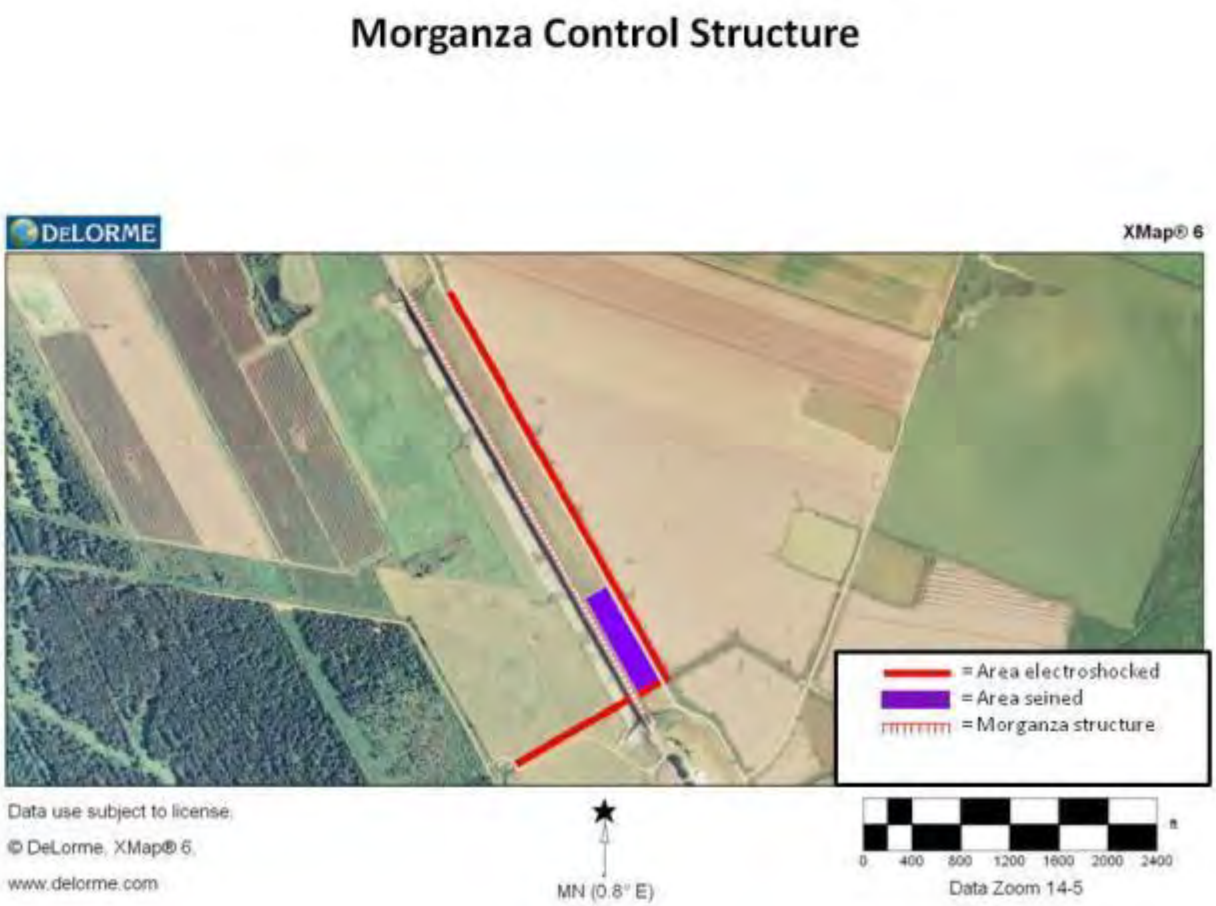


Figure 1.4. Aerial view of the Morganza Spillway showing the areas sampled using electroshocking and seines.

Figure 2.4. Gar species swimming in the current in the outflow sluice gates of the Morganza Spillway.

Figure 3.4. Alive and freshly dead fishes on July 14, 2011 downstream of the sluice gates of the Morganza Spillway. Cause of death is low dissolved oxygen. Most of the fishes (bass and bluegill) are backwater species.

Figure 4.4. Decomposed dead carp and buffalo below the Morganza Spillway structure.

Figure 5.4. Typical scene examined for the presence of sturgeon; however, no sturgeon were found.

Table 4.4. Water quality and hydraulic data for the Bonnet Carré Spillway, 2008 and 2011.

Site	Water Temperature (ºC)	Conductivity (µmhos/cm)	pH	Dissolved Oxygen (mg/l)	Turbidity (NTU)	Average Depth (ft)	Average Velocity (ft/s)	Width (ft)	Discharge (cfs)
2008 – Barbars Canal	23.7	292	7.44	6.01	48	7.1	3.38	78	1882
May 23, 2008									
Pre-Opening – Barbars Canal	18.39	344	7.12	6.75	47	9	0.83	93	763[1]
May 5, 2011									
Pre-Opening – Y Canal	18.94	344	7.41	8.40	42	6.5	0.71	93	502
May 5, 2011									
Pre-Opening – MS River	22.2	342	7.48	7.06	38	7.4	0	-	-
May 5, 2011									
2011 – Barbars Canal	28.4	393	8.27	6.28	50	8.5	0.88	96	716
June 20, 2011									

[1] – Discharge measured above the confluence of Y Canal.

Table 5.4. Number of fishes captured, excluding sturgeons, and cumulative for all sampling gears, in the Bonnet Carré Spillway after the 2008 and 2011 openings and prior to the 2011 opening (May 4-5).

Family	Scientific Name	Common Name	Number Post-Opening	Number Pre-Opening
Polyodontidae	*Polyodon spathula*	Paddlefish	11	0
Lepisosteidae	*Atractosteus spatula*	Alligator gar	2	0
	Lepisosteus oculatus	Spotted gar	16	0
	Lepisosteus osseus	Longnose gar	7	3
Amiidae	*Amia calva*	Bowfin	1	0
Anguillidae	*Anguilla rostrata*	American eel	50	0
Clupeidae	*Alosa chrysochloris*	Skipjack herring	219	3
	Brevoortia patronus	Gulf menhaden	11	0
	Dorosoma cepedianum	Gizzard shad	102	14
	Dorosoma petenense	Threadfin shad	65	3
Engraulidae	*Anchoa mitchilli*	Bay anchovy	1	0
Hiodontidae	*Hiodon alosoides*	Goldeye	1	0
Cyprinidae	*Cyprinus carpio*	Common carp	5	1
	Hypophthalmichthys molitrix	Silver carp	18	7
	Hypophthalmichthys nobilis	Bighead carp	6	0
	Macrhybopsis hyostomus	Speckled chub	1	0
	Macrhybopsis storeriana	Silver chub	2	0
	Notropis shumardi	Silverband shiner	1	0
	Notropis wickliffi	Channel shiner	5	0
Catostomidae	*Carpiodes carpio*	River carpsucker	3	3
	Ictiobus bubalus	Smallmouth buffalo	18	9
	Ictiobus cyprinellus	Bigmouth buffalo	2	2
	Ictiobus niger	Black buffalo	1	0
Ictaluridae	*Ictalurus furcatus*	Blue catfish	1345	1
	Ictalurus punctatus	Channel catfish	65	2
	Pylodictus olivaris	Flathead catfish	129	1
Belonidae	*Strongylura marina*	Atlantic needlefish	4	0
Poeciliidae	*Gambusa affinis*	Western mosquitofish	10	1
Atherinopsidae	*Menidia beryllina*	Inland silverside	1	0
Moronidae	*Morone mississippiensis*	Yellow bass	2	0
	Morone saxatilis	Striped bass	5	0

Table 5.4. Number of fishes captured, excluding sturgeons, and cumulative for all sampling gears, in the Bonnet Carré Spillway after the 2008 and 2011 openings and prior to the 2011 opening (May 4-5).

Family	Scientific Name	Common Name	Number Post-Opening	Number Pre-Opening
Centrarchidae	*Lepomis gulosus*	Warmouth	1	0
	Lepomis humilis	Orangespotted sunfish	3	0
	Lepomis macrochirus	Bluegill	28	4
	Lepomis megalotis	Longear sunfish	2	1
	Lepomis microlophus	Redear	0	1
	Lepomis miniatus	Redspotted sunfish	135	0
	Lepomis symmetricus	Bantam sunfish	0	1
	Micropterus salmoides	Largemouth bass	3	1
	Pomoxis annularis	White crappie	3	1
	Pomoxis nigromaculatus	Black crappie	2	0
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	30	1
Mugilidae	*Mugil cephalus*	Striped mullet	47	41
Gobiidae	*Ctenogobius shufeldti*	Freshwater goby	5	0
Soleidae	*Trinectes maculatus*	Hogchoker	5	0
Total number of species			43	21

Figure 6.4. Running a large mesh hoopnet in Barbars Canal, notice the silver carp in the net.

Figure 7.4. ERDC personnel sampling for sturgeon using electroshocking in the Mississippi River adjacent to Bonnet Carré Spillway.

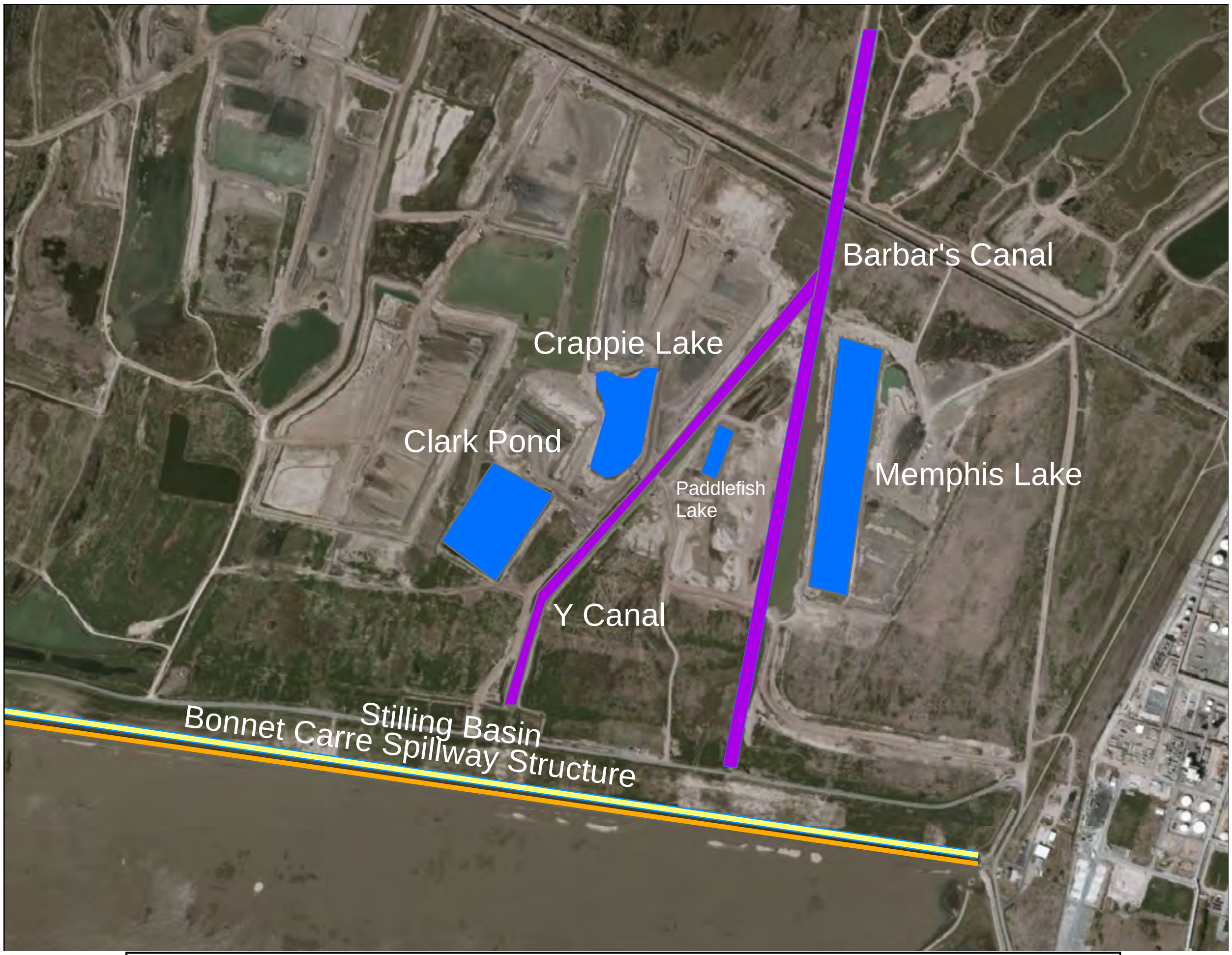


Figure 8.4. Three primary areas where sturgeon were collected in 2011: Stilling Basin, Canals (Barbars and Y), and Lakes.

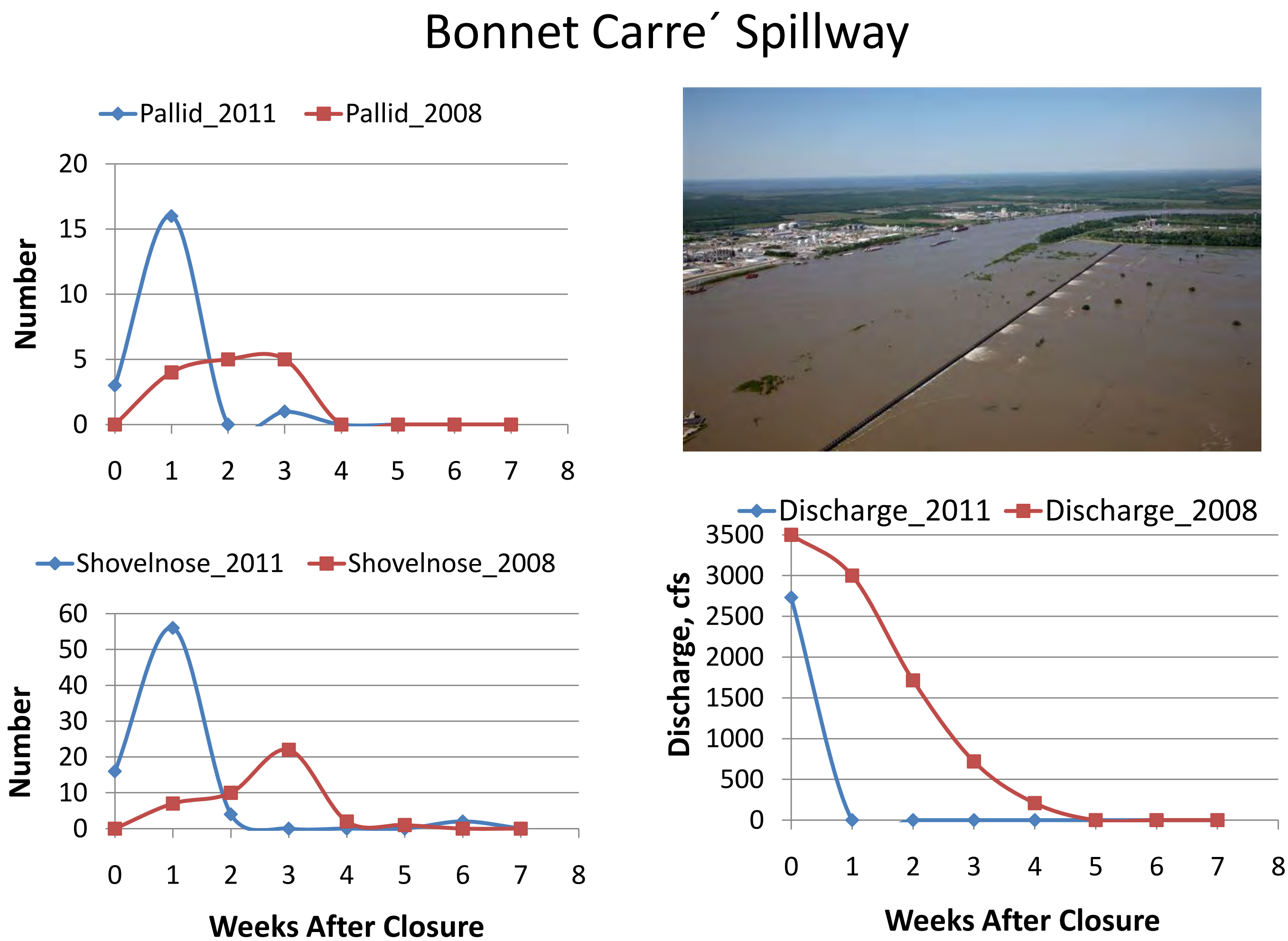


Figure 9.4. A summary of discharge (CFS) in the floodway and sturgeon catch after closure of the Bonnet Carre spillway in 2008 and 2011.

Figure 10.4. Location of 12 VR2Ws (remote receivers, green dots) deployed in the Bonnet Carre Spillway down to Lake Pontchartrain. Red arrows indicate relocation of receivers from waterbodies that became disconnected from primary canals.

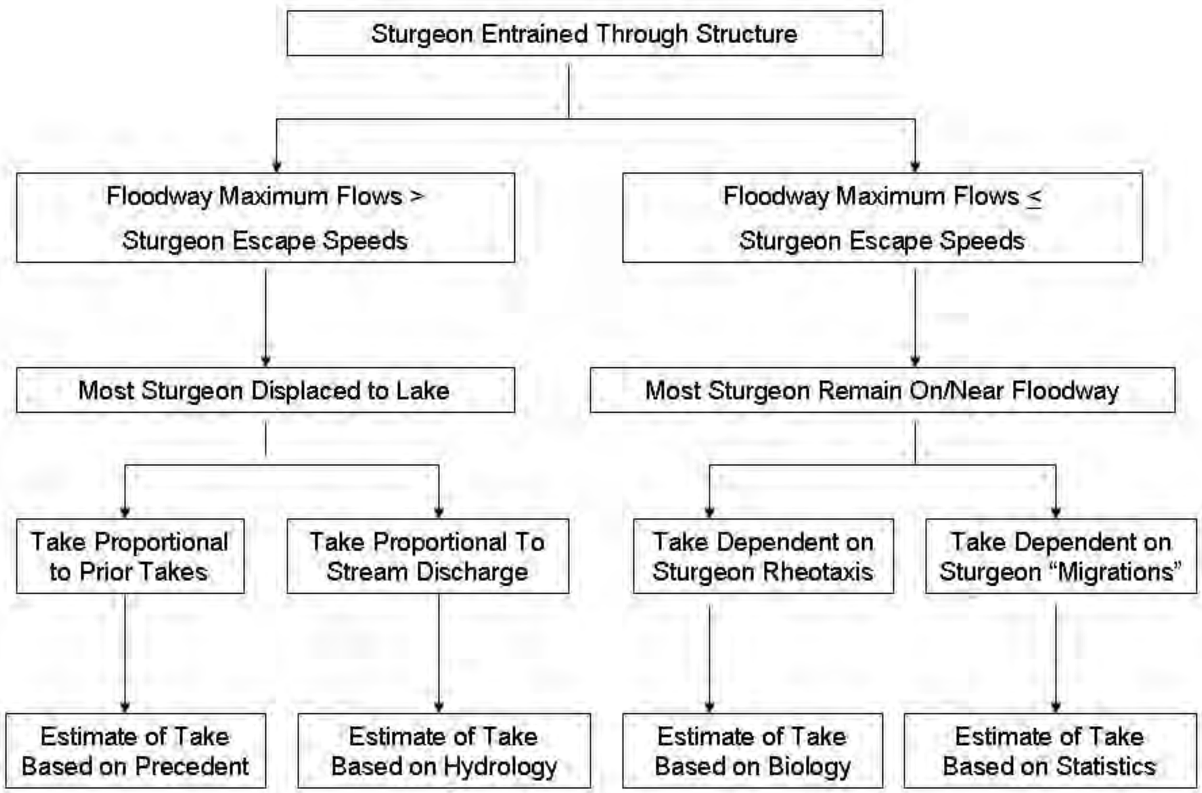


Figure 11.4. Rationale for Sturgeon Take Estimates by Water Diversions

Appendix 1

Estimation of Take

by

Jan J. Hoover
ERDC-EL

This appendix provides rationale for sturgeon take estimates entrained through water diversions based on collections at Bonnet Carré in 2008.

Precedent-Based Estimate

Assumptions:

1. Flows exceed swimming performance of fish; fish are entrained in numbers proportional to discharge
2. There is no upstream movement from fish displaced to lake
3. Numbers of fish entrained can be estimated from previously documented rates of entrainment (other studies) and relative abundance of fish in the river (i.e., Killgore et al., 2007)
4. Fish do not occur in the water column and are entrained only from water occurring very close to the bottom of the river.
5. Fish are entrained only on dates of moderate to high discharge.

Calculations:

For Shovelnose sturgeon:

Precedent used was 2008 Chain-of-Rocks Dredging Data (Nathan Badgett, Ecological Specialists, Inc., 2008): 4 shovelnose sturgeon were entrained in 319,309 m^3 water discharged by dredge.

We assumed that 1% of the Bonnet Carré peak discharge represented bottom water. We also assumed that bottom water was entrained on dates of moderate to high discharge: i.e., dates > 150,000cfs.

Total Number Entrained/Total Volume of Bottom Water =
Previous Number Entrained/Previous Volume of Bottom Water

Total Number Entrained =
Previous Number Entrained*Total Volume of Bottom Water/Previous Volume of Bottom Water

(4 sturgeon)*(0.01)(1.59)(10^{11})m^3/319,309m^3 = 19,918 sturgeon

(This number represents how many shovelnose sturgeon would have been entrained if volume of water pumped at Chain-of-Rocks was equivalent to volume of bottom water diverted through Bonnet Carré)

To estimate number of shovelnose sturgeon that would have been entrained at Bonnet Carré, we "correct" the number based on the ratio of sturgeon abundance near Bonnet Carré to sturgeon abundance at Chain-of-Rocks (Killgore et al., 2007).

19, 918 shovelnose * (1.88 CPUE at New Orleans-Atchaf/22.24 CPUE at Chain-of-Rocks) = 1684 shovelnose

For pallid sturgeon:

To estimate number of pallid sturgeon entrained that would have been entrained at Bonnet Carré, we use the ratio of pallid sturgeon abundance to shovelnose sturgeon abundance in the river near Bonnet Carré:
1684 shovelnose * (1 pallid/6 shovelnose) = 281 pallid sturgeon

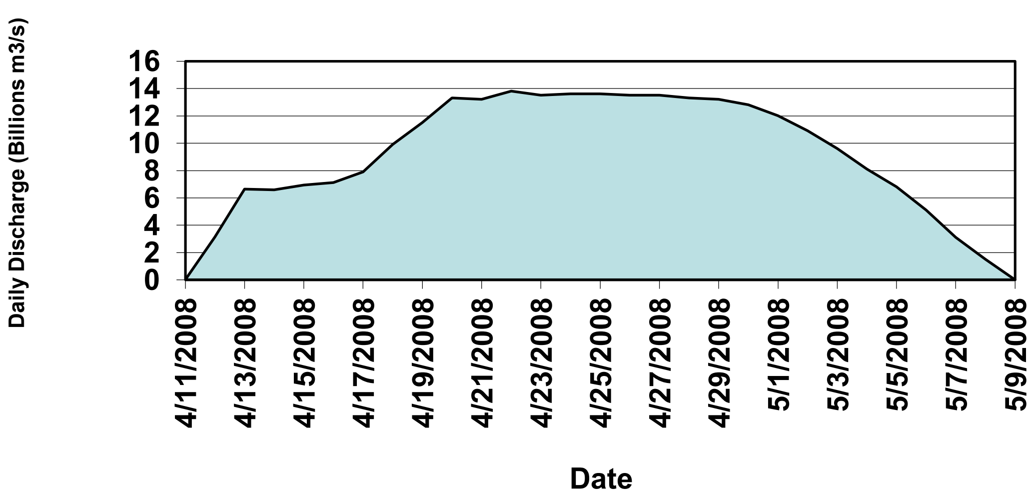
Estimate of Unrecovered Take = 281-14 = 266 pallid sturgeon

Refinements:
We could develop a sliding scale of what represents bottom water (instead of using a fixed value of 1%). Value could be lower during higher stages to represent relatively greater distance of substrates from the surface of the water.

Note:
This number is conservatively high. Whether entrainment rate of a small dredge operating in an area of high sturgeon density can be extrapolated to a large diversion drawing water from an area of moderate sturgeon density would be difficult to resolve.

Hydrology-Based Estimate

Assumptions:
1. Flows exceed swimming performance of fish; fish are entrained in numbers proportional to discharge
2. There is no upstream movement from fish displaced to lake (11 Apr -30 Apr).
3. All fish remaining on floodplain after gate closure were entrained during the declining hydrograph (01-09 May)
4. All fish remaining on floodplain were collected



Calculations:

Total Number Entrained/Total Volume of Water =
Number collected/01-09 May Volume of Water

Total Number Entrained =
Number collected * Total Volume of Water/01-09 May Volume of Water

Total Number Entrained = 14 $(2.64)(10^{11})m^3$ / $(5.67)(10^{10})$ m^3

Total Number Entrained = 65.2

Estimate of Unrecovered Take = 65 – 14 = 51

Refinements:
Frequency and downstream displacement rates of sturgeon (from Old River Control Structure) could be used to better estimate time interval represented by fish collected post-closure.

Biology-Based Estimate

Assumptions:
1. Flows do not exceed swimming performance of fish.
2. Fish remain on floodplain or in lake near outflow.
3. Non-rheotactic fish drift to lake (or are stranded) and do not return – numbers decrease continuously over time
4. Rheotactic fish seek and remain in flow as water recedes – numbers increase continuously over time
5. Percentage of non-rheotactic fish can be estimated from laboratory studies of swimming performance. Data suggest that it ranges from 0.00 for adult shovelnose sturgeon (ERDC, unpublished data; Adams et al. 1998; Parsons et al. 2003) to 0.27 for some groups of juvenile sturgeon (ERDC, unpublished data; Hoover et al. 2005).

Calculations:

Total Number Entrained =
[Number collected] + [(Number collected)*(Percentage presumed non-rheotactic)]

Total Number Entrained =
14 + 14*(0.27)

Total Number Entrained = 17.8

Estimate of Unrecovered Take = 18-14 = 4

Refinements:
If flow fields could be generated from hydraulic models, we could develop a risk-based analysis (sensu Hoover et al., 2005). We would need data for the following variables:
i.) number of fish in vicinity of gates, or moving through structure

ii) water velocities at bottom of gates
iii) escape speeds of fish (could be extrapolated from ERDC swim tunnel studies)
iv) chronology of gate openings (distribution and linear extent of low and high gates)

Statistics-Based Estimate

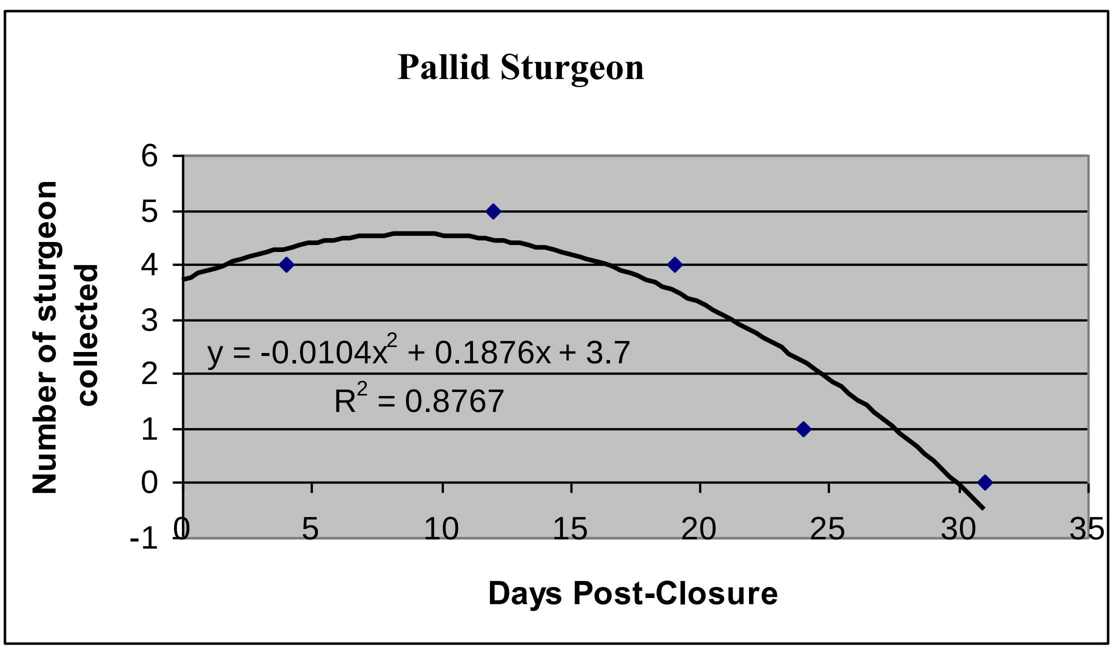
Assumptions:
1. Flows do not exceed swimming performance of fish.
2. Fish remain on floodplain or in lake near outflow.
3. Non-rheotactic fish drift to lake (or are stranded) and do not return: Emigration (E)
4. Rheotactic fish seek and remain in flow as water recedes: Immigration (I)
5. Numbers of fish at any point in time based on net migrations (fish moving upstream – fish moving downstream) – not necessarily continuous over time

Migrations	**Number over time**	**Area Under Curve As Estimate of Take**
I > E	Positive correlation	Underestimate (requires extrapolation and forecast)
I = E	No correlation	Underestimate (requires WAG, BPJ)
I > E, then I = E, then I < E	Parabolic correlation	Variable (dependent on fit of model)
I < E	Negative correlation	Underestimate (requires extrapolation and hindcast)

Calculations:

Time series analysis
Best fit model of frequency distribution over time
Total Number Entrained = Area under curve + extrapolations

Area under curve approximated by bar graphs at 1- week sample intervals.



Total Number Entrained = 14 [No extrapolation required]

Estimate of Unrecovered Take = 0*

*** Note:**
If a bell-shaped distribution is assumed, area under curve would be approximately 18 and unrecovered take would be estimated at 4.

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Chapter 5

Water Diversions and Pallid Sturgeon Population Viability in the Lower Mississippi River: Uncertainties and Priorities for Ecological Risk Assessment

by

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Abstract

Management of pallid sturgeon (*Scaphiryhnchus albus*) in the Lower Mississippi River (LMR) should be supported by a region-specific demographic model. Among the challenges faced by this long-lived fish is entrainment in water diversion structures used to manage the hydrology of the river and its surrounding drainage. We developed an age-based model of pallid sturgeon that included both demographic and environmental stochasticity. Using abundance estimates derived in a companion study, we translated projected numbers of entrained fish into per capita entrainment rates to explore the ecological risk posed by episodic and chronic water diversion actions in the southernmost reach of the LMR occupied by pallid sturgeon. Uncertainty was addressed by testing a range of entrainment rates, abundance levels, and spatial structures. Entrainment during episodic diversions characteristic of the Bonnet Carré spillway reduced median local population size by 0-20% in 60 years. Entrainment in chronic annual water diversions, characteristic of those proposed for wetlands nourishment in Louisiana, reduced median local population size by 2-50%. The effect of combined episodic and cumulative entrainment was multiplicative. Model projections revealed that the greatest gains in certainty would come from a more precise population size estimate. Improved understanding of large-scale movements of age-1+ fish would also greatly improve our ability to manage pallid sturgeon in the free-flowing Mississippi River.

Introduction

The pallid sturgeon, *Scaphirhynchus albus*, occupies portions of the Missouri and Mississippi River basins from Montana to Louisiana (Dryer and Sandvol 1993). The species varies dramatically in growth, size, and longevity over its range. While adults in northern populations are large and long-lived (Keenlyne et al. 1992), individuals in the south are smaller, reproduce at an earlier age, have a higher mass-specific fecundity (George et al. 2012), and appear to have shorter lives (Killgore et al. 2007b). The Mississippi River is the only portion of the range in which natural recruitment is apparent (U.S. Fish and Wildlife Service 2013). While populations in the middle and upper Missouri River are well studied and form the "type" reference for the species, the size and reproductive potential of the Mississippi River population is still poorly understood.

Demographic models are essential tools for guiding research priorities and modifying adaptive management plans (Bakker and Doak 2009) and can provide unbiased projections of risk to threatened populations (Brook et al. 2000). Given the geographic variation in pallid sturgeon life history, it is important to develop a population model specific to the Mississippi River. A plan for the recovery of pallid sturgeon from endangered status calls for a quantification of mortality due to entrainment as well as its consequences for population viability.

Several large diversion structures exist in the Lower Mississippi River (LMR). Some, including the Morganza and Bonnet Carré spillways, are only opened episodically at high river stage to protect communities downstream from flooding. Others, such as the Old River Control Complex and smaller diversions, operate on a continual basis either to regulate river flows or nourish wetlands. Entrainment of pallid sturgeon through both episodic and chronic diversion structures has been confirmed by limited monitoring. In this study, we developed a demographic model specific to the LMR population of pallid sturgeon. We used the model to extrapolate abundance estimates from a companion study (Friedenberg et al. 2013) to all age classes. We then used the model in case studies of the effect of episodic and chronic entrainment on future risk of population decline.

Methods

Reproduction

As outlined by the equations in Table 1.5, we estimated age specific egg production, E_t, using a Bertalanffy growth model and allometric relationships of mass-to-length and eggs-to-mass. Growth parameters were specific to the LMR population (Killgore et al. 2007b). The mass-length relationship was fit to the LMR survey samples by log-log ordinary least squares regression. Mass-specific egg production was established using the mean mass and egg counts of two female pallid sturgeon collected in the Atchafalaya River, LA, at the Old River Control Structure on 23 October 2009 (George et al. 2012). The two fish weighed 2.85 kg and 3.20 kg and contained 50,759 and 51,959 eggs, respectively. DeVore et al. (1995) found that white sturgeon egg production scaled as the 0.91 power of mass, slightly less than linearly. Using an allometric relationship of the form $E = aM^b$ with $b = 0.91$, we solved for the intercept, *a,* using the geometric mean of mass, *M*, and number of eggs, *E*, of the two Atchafalaya females. We used the resulting allometry to calculate age-specific egg production from expected age-specific mass (Table 1.5). All individuals age 25 or greater were assigned age-25 fecundity.

Estimates of age of first spawning in the Mississippi River basin range from a high of 15 (Keenlyne and Jenkins 1993) to as low as eight (George et al. 2012). To accommodate this range, we modeled variation in age of first reproduction as the accumulated variance of a normally-distributed developmental rate (sensu Dennehy et al. 2007) with a mean of 9.1% per year and standard deviation of 1%. As illustrated in Figure 1, the inverse of the normal distribution of developmental rates is a skewed distribution of maturation ages with a median of 11, the mean of the two mature Atchafalaya females measured by George et al. (2012). The distribution was conservative in that the earliest age of reproduction was nine rather than eight and some individuals did not mature until age 16. We used a reproductive interval of three years, consistent with the fraction of adult fish caught in the survey that were reproductive (JJH, personal observation). While possibly a low value (Mayden and Kuhajda 1997), any effect of reproductive interval was removed by our method of estimating survival from egg to age-1, as described below.

Fecundity and Survival

Age-specific fecundity, F_t, representing in this case the number of age-1 females produced by a female of age *t*, incorporated sex ratio, reproductive interval, and distribution of age of first reproduction, in addition to our estimate of first-year survival discussed in the next paragraph.

An annual survival rate of 0.93 for age classes 3 through 24 was taken from Killgore et al. (2007b). Survival of age-2 fish, 0.75, was taken from a low observation in mark-recapture experiments in the upper Missouri River basin (Hadley and Rotella 2009) and follows Bajer and Wildhaber (2007). An initial age-0 survival rate of 0.004 (Bajer and Wildhaber 2007) and age-1 survival rate of 0.69 (Steffensen et al. 2010) were subsequently adjusted such that the model projected no change in expected abundance over time for a population at the stable age distribution given by the dominant eigenvector of the transition matrix (i.e., at the population's equilibrium age structure, births balanced deaths) (Caswell 2001). For a deterministic model, this would be equivalent to finding survival rates that give an asymptotic growth rate of 1.0, as indicated by the dominant eigenvalue of the transition matrix (Caswell 2001). In our model, which included environmental and demographic stochasticity, the asymptotic growth rate needed to exceed slightly 1.0 for long-term stability of expected abundance under baseline conditions. Environmental variation in pallid sturgeon demography may be driven by factors such as hydrograph and temperature (Phelps et al. 2010). A four-year study of larval abundance in the Middle Mississippi River (MMR) (Phelps et al. 2010) yielded a mean catch per unit effort of 0.85 (SD 0.51), translating to a 60% coefficient of variation in larval production. This empirical estimate of environmental variation is inflated by measurement error and demographic stochasticity (Akcakaya 2002). We assumed a 50% coefficient of variation around fecundity (the variability of age-0 mortality was subsumed into variation in fecundity). On the premise that a long-lived species will have less variation in survival than in reproduction, we assumed a 10% coefficient of variation around age-1+ survival rates. Environmental variation in vital rates was log-normal. We found final values for age-0 and age-1 survival by iteratively adjusting survival and the attendant stable age distribution and variability until the median 60-year projection of 10,000 simulations changed by less than 0.5%. The use of a longer reproductive interval (or any other age-independent decrease in fecundity, such as fractional spawning success) would lead to a higher estimate of age-0 survival but would not otherwise affect the model. The use of a demographically balanced model allowed us to examine the population-level effects of entrainment in isolation from any existing trends or cumulative stresses affecting population dynamics.

Sensitivity Analysis

We examined the sensitivity of asymptotic population growth rate to small changes in vital rates. While RAMAS Metapop provides elasticities for each entry in the transition matrix, we instead took the approach of examining the effect of a 5% change in vital rates across a range of age classes. Specifically, we measured sensitivity to a change in fecundity of all reproductive classes (age-9 through age-25), survival of all age classes, survival of non-reproductive age classes (age-1 through age-8), and survival of reproductive age classes. Sensitivity was measured as the percent decrease in asymptotic growth rate relative to the percent decrease in vital rate. A sensitivity of 100% would indicate that a 5% decrease in vital rate yields a 5% decrease in population growth rate. Additional calculations showed that the sensitivity for small increases and decreases in vital rates was nearly identical.

Abundance

The population size of pallid sturgeon in the LMR is not known with any precision. Lower bounds on the abundance of pallid sturgeon in the LMR and MMR have been estimated based on the absence of recaptures during the survey (Friedenberg et al. 2013). Various assumptions affected the abundance estimates, but a rough value for the lower 99% confidence limit was 4000 age-3+ individuals in the LMR and MMR combined. The lower 75% confidence limit was 20,000 age-3+ individuals. This five-fold range of abundance served to investigate the sensitivity of population-level impacts to uncertainty in population size. To extrapolate from age-3+ abundance to total abundance, we assumed that the population was initially at the stable age distribution indicated by our estimates of fecundity and survival.

Spatial structure

The water diversion structures we were concerned with lie within a reach of the LMR between New Orleans and the Old River control structure, named reach B by Killgore et al. (2007a). The remainder of the LMR north of reach B originates at the confluence of the Ohio River near Cairo, IN. For our study, we referred to this portion of the river as reach CD because it encompasses the reaches named C and D in Killgore et al. (2007a). The MMR comprises the reach between confluences with the Ohio River and Missouri River. Results of the Mississippi River pallid sturgeon survey were reported separately for sampling locations in the greater part of the MMR and the Chain of Rocks, referred to as reaches E and F, respectively, by Killgore et al. (2007a). Following Friedenberg (Friedenberg et al. 2013), we treated the MMR as a single reach. We only considered the MMR for the purposes of calculating abundance in populations B and CD; the geographic scope of the population model was restricted to the LMR.

Catch per unit effort in the Mississippi River pallid sturgeon survey suggested variation in relative abundance among reaches (Killgore et al. 2007a). However, there is a possibility that such variation was driven by the availability and suitability of sampling locations. We addressed the uncertainty in the spatial structure of abundance by developing two sets of models, one with uniform population density and the other with observed relative abundance. For uniform spatial structure, relative abundance was based on the length of reaches. The lengths of reaches B, C, D, and E are 349, 433, 598, and 314 km, respectively. Hence, uniform relative abundance was 0.21, 0.26, 0.35, and 0.19, respectively, indicating that 21% of the Mississippi River pallid sturgeon population is in reach B, while 61% resides in reaches C and D. In contrast, the observed catch per unit effort among reaches was 0.31, 0.14, 0.18 and 0.16, respectively (Killgore et al. 2007a), giving an index of relative population density of 0.39, 0.18, 0.23, and 0.20, respectively. Weighted by the length of reaches, the observed pattern of population density suggests that reach B contains 33% of the population while 52% resides in reaches C and D. As described below, the two spatial structures led to distinct sets of parameters for relative fecundity and dispersal. We assumed all environmental variability was perfectly correlated across the two populations.

Relative Fecundity and Larval Drift

We assumed uniform age structure among reaches. Given the lack of spawning substrate in reach B, we assumed that relative fecundity in reach B was 0 and that all age-1 individuals were supplied by larval drift from reach CD, a plausible scenario given that pallid sturgeon larvae are likely to drift more than 300 km in the LMR (Kynard et al. 2007). Hence, we adjusted relative fecundity in reach CD upward to produce all age-1 individuals expected in the LMR at the stable age distribution. The dispersal rate of offspring via larval drift was then calculated based on the assumed spatial structure of the population. Under the uniform spatial structure, 21 / (21 + 61) = 25.6% of larvae drifted to reach B. Under the observed spatial structure, drift relocated 33 / (33 + 52) = 38.8% of larvae to reach B.

Dispersal

Telemetry has determined that as many as almost 15% pallid sturgeon emigrate from the MMR in a year (Koch et al. 2012). In calculating dispersal between reaches, we assumed that all emigrants from the MMR move into the LMR. For reaches C and D, we assumed an equal number of emigrants moved upstream and downstream. For reach B, we assumed all emigrants moved upstream. We further assumed that all age classes had the same dispersal probabilities and that survival was the same in all reaches (in contrast with Friedenberg et al. 2013). With these assumptions, it was possible to calculate dispersal rates between neighboring reaches consistent with either the uniform or observed spatial structure of abundance. Given relative abundance and in reaches *i* and *j*, w_i *and* w_j, and the rate of dispersal from reach *i* to reach *j*, d_{ij}, the balanced reciprocal rate of dispersal is $d_{ji} = d_{ij}w_i / w_j$. For reaches with bi-directional dispersal, the total emigration rate is 2*d*. Starting with reach E and working southward, this logic leads to a reach B dispersal rate of 13.5% for the uniform spatial structure and 7% for the observed spatial structure. Using the summed relative abundance of reach CD, dispersal from reach CD to reach B was therefore set to 4.6% and 4.4% for the uniform and observed spatial structures, respectively. All dispersal rates varied annually with a coefficient of variation of 10%.

Density Dependence

In addition to our main analysis using density-independent population growth models, we explored a subset of scenarios using a model with density-dependent fecundity. We used a Ricker density dependence function (Ricker 1954) to maintain a total population growth rate of 1.0 by adjusting relative fecundity in reach CD based on the abundance of age-8+ adults (using the “scramble” option for density dependence in RAMAS Metapop 5.0) (Akcakaya and Root

2005). We assumed a maximum population growth rate, R_{max}, of 1.05 in reach CD. The loss of larvae to downstream drift reduced the local maximum growth rate, $R_{max\ local}$, in reach CD, requiring a carrying capacity, K, that was higher than our target for equilibrium abundance. $R_{max\ local}$ was calculated as the eigenvalue of the transition matrix after relative fecundity was adjusted for larval drift from the value necessary to give R_{max}. An initial value for carrying capacity was then calculated as $K = N^{*}\ln(R_{max}) / \ln(R_{max\ local})$, where N^{*} was our target for equilibrium abundance of age 8+ individuals based on the stable age distribution of the transition matrix with relative fecundity set to 1.0. Given that R_{max} was larger than $R_{max\ local}$, K was larger than N^{*}. We assigned K a 10% annual coefficient of variation. The initial value of K and its standard deviation were adjusted iteratively until stochastic baseline models showed no change in expected abundance over time.

Episodic Entrainment

The level of the Mississippi River is managed by a number of large water diversion structures, including the Bonnet Carré spillway linking the river and Lake Pontchartrain in Louisiana, a location within reach B. From 11 April to 9 May 2008, the spillway diverted an estimated 7.5×10^{9} m^{3} of water. The maximum number of bays in operation was 160 out of 350 and the maximum discharge rate through the structure was 160,144 cfs. Entrainment of pallid sturgeon during operation of the Bonnet Carré diversion was confirmed by sampling in the floodway after the structure was closed. Entrained sturgeon were detected for up to a month after closure using a variety of gear, including a boat-mounted electroshocker, seines, trawls, and gill nets. Sampling detected 14 pallid sturgeon 528-884 mm fork length in addition to 43 shovelnose sturgeon, *Scaphirhynchus platorynchus* 570-841 mm fork length.

A range of rough estimates of the true number of individuals entrained by the Bonnet Carré spillway in 2008 was developed using a variety of approaches. We developed a low estimate using a behavioral justification. If only rheotactic individuals, which can account for as little as 77% of pallid sturgeon (Hoover et al. 2005), remained in the floodplain, then a total of 14 / 0.77 = 18 individuals were entrained. A high estimate followed from a calculation of detectability based on a measurement of shovelnose entrainment rate in dredges in the MMR (Nathan Badgett, Ecological Specialists, Inc., 2008). If we assumed that 10% of the water diverted was from low enough in the water column to entrain sturgeon and applied this volume to the dredge entrainment rate, then 400 shovelnose sturgeon were expected to be entrained, giving a detectability of 43 / 400 = 0.1075. Assuming the same detectability for both species gave an expected entrainment of 130 pallid sturgeon. An intermediate estimate of pallid sturgeon entrainment assumed that peak flow of the water through the floodplain was great enough to wash all individuals out of the study area and that sampling only detected sturgeon entrained during the declining hydrograph from 1-9 May. Of the total volume of water diverted during the 2008 opening of the Bonnet Carré spillway, 21.5% was released from 1-9 May. If entrainment was proportional to the volume of water diverted, then 65 pallid sturgeon were expected to have passed through the spillway over the full course of its operation.

The smallest pallid sturgeon detected in the spillway (528 mm) was smaller than the smallest individual measured during a 6-year survey of the LMR and MMR (540 mm). The youngest individual aged from fin ray sampled taken during the survey was age-3 (Killgore et al. 2007b). Therefore, we treated conservatively the three estimates as representative of per capita episodic entrainment rates of age-3+ fish. We assumed age-1 and age-2 individuals were subject to the same probability of entrainment but were not detectable. We further assumed that half the individuals entrained were female. Final estimates of episodic entrainment rates depended on the abundance level and spatial structure used in each model scenario (Table 2.5).

The Bonnet Carré water diversion was opened 10 times in the 80 years between its completion in 1931 and 2011 (USACE New Orleans District 2013), leading to a conservative estimate of the frequency of episodic entrainment events of once per eight years. Therefore, episodic entrainment events were modeled as random catastrophes in RAMAS Metapop with a probability of 0.125 y^{-1} that affected the abundance of all stages proportionally given the take of 18, 65, or 130 age-3+ individuals.

Chronic Entrainment

A proposed wetlands replenishment project will nourish marshes with Mississippi River water and sediment using diversion structures located both in and south of reach B. Studies below an existing diversion structure, the Davis Pond diversion at rkm 191, detected the entrainment of one pallid and three shovelnose sturgeon (D. Schultz, McNeese University, pers. comm.). Two other structures, the Medium Diversion at White Ditch at rkm 103 and the Small Diversion at Convent Blind River at rkm 262, are proposed for the nourishment project as well. These three structures and others will operate continually, creating a chronic risk of entrainment.

Chronic entrainment rates were estimated by first considering the detectability of sturgeon and the abundance of pallid sturgeon relative to that of shovelnose sturgeon in reach B to determine the number of fish entrained at Davis Pond. The total number of individuals entrained at three sites was then estimated by assuming a constant probability of entrainment per volume of discharge. Planned discharge rates were provided by D. Walter of the U.S. Fish and Wildlife Service (USFWS). Local sampling indicated a detectability of 10% based on previously finding 2 of 20 tagged individuals in the diversion canal (D. Walther, USFWS, pers.comm..). We further assumed that, as in the Mississippi River survey and sampling below the Bonnet Carré spillway, only age-3+ individuals were detectable. Of 271 sturgeon caught in reach B during the Mississippi River survey, 44 were pallid sturgeon (Killgore et al. 2007a), a relative abundance of roughly 1/6. The four sturgeon discovered at Davis Pond suggest the presence of 40 sturgeon given 10% detectability, of which seven would be age-3+ pallid sturgeon based on relative abundance. The volume of water diverted annually through Davis Pond, 2.55×10^9 m^3, translates to a volumetric entrainment rate of one pallid sturgeon per 3.64×10^8 m^3 of discharge. The projected operating volume for the Whites Ditch diversion, 6.31×10^9 m^3, gave an expected 18 age-3+ pallid sturgeon entrained per year. At the proposed Convent Blind River diversion, the projected 1.79×10^9 m^3 annual discharge would entrain an expected 3 age-3+ pallid sturgeon. Lower and upper estimates around the expected total annual entrainment of 28 age-3+ individuals were then produced by developing 80% Clopper-Pearson confidence intervals (Walley 1996) around the observed detectability and relative abundance. Assuming independence, the product of these intervals generated the 98% confidence interval of 8-56 age-3+ pallid sturgeon. As with episodic entrainment, we assumed half the entrained individuals were female. Per capita entrainment probabilities varied with population size and spatial structure and extended to age-1 and age-2 individuals (Table 2.5).

Experimental Design

The effects of episodic or chronic entrainment on the LMR population of pallid sturgeon were investigated separately using three-way factorial designs that crossed population size (low or high), spatial structure (uniform or observed), and the level of entrainment (none, low, medium, or high). Simulations were run for 60 years (approximately 3 generations) and each scenario was replicated 10,000 times to ensure the precision of results. For each scenario, we calculated the probability of declining by at least 0-100% to produce exceedance curves that allow comparison of risk over all possible levels of decline. We further summarized results using the median final population size in each scenario (probability of no decline = 0.5), which provides information on the sensitivity of expected population size to factors in the model. We also chose to monitor the probability of declining by at least 30% to examine sensitivity in the probability of a threshold population size. This threshold was chosen because a projected 30% decline over three generations indicates population vulnerability by IUCN standards (IUCN Standards and Petitions Subcommittee 2010).

Additional Investigations

We performed additional simulations to investigate model behavior under the combination of episodic and chronic entrainment. Only best and worst cases were examined to develop the envelope of risk under the combined stresses. We also explored sensitivity to dispersal rate using only the uniform spatial structure under a scenario of low population size and the intermediate value of either episodic or chronic entrainment. Finally, we used models with density-dependent fecundity in reach CD to examine how spatial structure and population size might interact with compensatory population growth under high episodic or chronic entrainment.

Results

Reproduction

Table 1.5 summarizes the parameters used to calculate age-specific egg production, E_t. Our reanalysis of the updated Mississippi River survey dataset yielded an allometric relationship between mass (kg) and length (mm) of $M = 10^{-9.22}L^{3.42}$ ($r^2 = 0.95$, $F_{1,235} = 4101$, $P < 0.0001$). The geometric mean intercept for the allometry between egg number and mass (kg) was 18,780 eggs. The resulting allometry between length (mm) and egg production was $E = 10^{-8.39}L^{3.11}$, nearly proportional to the cube of length.

Fecundity and Survival

After iteratively adjusting survival and the attendant stable age distribution and variability, the final values for age-0 and age-1 survival were 2.4×10^{-5} and 0.63, respectively, leading to an asymptotic population growth rate of 1.0002. Age-specific fecundity ranged from 0.004 at age-9 to 0.375 for the compound age-25+ stage (Figure 2.5). Fecundity increased with age both because of an increasing proportion of reproductively mature individuals and increased expected body size.

Sensitivity

Sensitivity analysis indicated that survival of age-1+ fish, especially reproductive adult classes, had the largest proportional effect on asymptotic population growth rate. In response to a 5% decrease in survival of age-1+ fish, population growth rate decreased from 1.0002 to 0.9525, indicating a sensitivity of 95%. The sensitivity of survival was 39% in immature age classes (1-8) and 57% in reproductive age classes (9-25). The sensitivity of population growth rate to fecundity was 5%.

Age Structure, Population Size, and Relative Fecundity

At the stable age distribution, the transition matrix indicated that age-3+ fish represented 79% of the population, allowing us to extrapolate age-3+ abundance to total abundance. Asymptotic analysis also predicted that more than half of the population, 52.5%, was age-8+. For the low and high population levels, total abundance in the Mississippi River was roughly 5,000 and 25,000 individuals, respectively, half of which we assumed were female. Total and age-8+ abundance in reaches B and CD of the LMR are given in Table 3.5.

The relative fecundity of reach CD differed between the two spatial structures we explored (Table 3.5). Under the assumption of uniform population density among reaches, the LMR population as a whole was expected to include 193 or 961 age-1 pallid sturgeon for the low and high population level, respectively. Given the assumption of no spawning in reach B, reach CD required a relative fecundity of 1.34 to balance births and deaths in the LMR on average. The observed spatial structure, which placed a larger proportion of the population in reach B, required a higher relative fecundity in reach CD, 1.64, to produce the expected total of 165 or 823 age-1 individuals. Relative fecundity calculations rested on the assumption that age structure was the same in both reaches.

Density Dependence Parameters

Cursory exploration of density dependent scenarios illustrated that the observed spatial structure puts a greater strain on reach CD and results in less capacity for compensatory population growth than the uniform spatial structure. A maximum population growth rate, R_{max}, of 1.05 in reach CD was high enough to allow persistence under both spatial structures, representing a maximum 2.68-fold increase in fecundity (i.e., through higher first-year survival or mass-specific egg production) over the baseline rate. For the uniform spatial structure, the 26% emigration rate of larvae to reach B reduced the maximum contribution to local recruitment to 2 times the baseline level, resulting in a local maximum population growth rate, R_{loc}, of 1.035 (Table 3.5). For the observed spatial structure, emigration of 39% of larvae to reach B reduced maximum relative local fecundity in population CD to 1.64 times the baseline level, yielding R_{loc} = 1.025 (Table 3.5). For both spatial structures and population levels, the carrying capacity (of age-8+ adults) in reach CD required to maintain target equilibrium population sizes was higher than the target adult abundance (Table 3.5), a result that stems from the need to maintain elevated fecundity in reach CD.

Impact of Episodic Entrainment

Due to the stochasticity of vital rates, baseline models without entrainment exhibited some probability for increase or decrease over time (Figure 3.5), including a 1% to 2% chance of declining by 30% after 60 years (Table 4.5). With episodic entrainment, the projected median final number of age-3+ fish across all scenarios with entrainment ranged approximately seven-fold, from 1,290 to 8,362, representing a reduction of 0% to 20% from baseline abundance (Table 4.5). The five-fold difference in abundance between population levels was reflected by a roughly 5-fold difference in entrainment impact on median abundance (Table 4.5). For the high abundance estimate, even the highest entrainment level only led to a doubling in the probability of 30% decline for either spatial structure (Table 4.5). However, for the low abundance estimate, the probability of a 30% decline rose from 2% in the baseline model to as much as 26% with entrainment (Table 4.5). Unlike median declines, 30% decline risk did not echo the 5-fold difference in abundance between high and low population levels, becoming 6-fold for the uniform spatial structure and 8-fold in the observed spatial structure with high episodic entrainment. As illustrated by Figure 4.5, the observed spatial structure was generally more robust to entrainment, exhibiting smaller probabilities than the uniform spatial structure for any level of decline. Figure 4.5 also demonstrates that uncertainty in projected decline risk was driven primarily by current uncertainty about abundance; uncertainty about the entrainment rate only had an appreciable effect if abundance was low.

Impact of Chronic Entrainment

Figure 5.5 provides the risk curves for all density independent chronic scenarios. As with episodic entrainment, abundance estimate had the largest absolute effect on risk, followed by entrainment rate and spatial structure. Compared with episodic entrainment (Figure 4.5), the risk curves associated with chronic entrainment (Figure 5.5) were steeper due less variance in outcome and indicated greater risk of decline. Mean final age-3+ abundance in the LMR ranged approximately an order of magnitude, from 813 to 8,232, across all scenarios with entrainment (Table 5.5). As compared with baseline projections, median abundance with entrainment was between 2% and 50% lower after 60 years (Table 5.5). Despite the five-fold difference in abundance between high and low population estimates, the impact of chronic entrainment generally differed by less than a factor of five between corresponding scenarios at high and low abundance (Table 5.5). At the highest chronic entrainment rate, 56 age-3+ females per year, spatial structure made a nearly two-fold difference in the risk of a 30% decline at the high abundance estimate (Table 5.5). In contrast, spatial structure had little effect on the probability of a 30% decline at the low abundance estimate (Table 5.5). As can be seen from the vertical distance between curves in Figure 5.5d, spatial structure had larger effects on risk at higher decline thresholds.

Combined Entrainment Effects

The impacts of chronic and episodic entrainment were multiplicative, as would be expected in the absence of nonlinearities such as a strong impact of demographic stochasticity at small population size. Figure 6.5 depicts the decline risk of best- and worst-case scenarios. If purely multiplicative, the best case scenarios (high abundance estimate and lowest entrainment rates) should have exhibited 4% and 2% declines from baseline median abundance for the uniform and observed spatial structures, respectively. In line with these expectations, the best-case scenarios showed 3% and 2% declines for the uniform and observed spatial structures, respectively. Worst-case scenarios (low abundance estimate and highest entrainment rates) displayed a similar multiplicative response. We expected declines from median abundance of 60% and 55% and recorded 57% and 52% for the uniform and observed spatial structures, respectively.

Age-1+ Dispersal

Changes to the dispersal rate of age-1+ individuals affected a large and qualitatively important change in population dynamics (Figure 7.5). In the absence of age-1+ dispersal, the population in reach B declined to a lower but stable median abundance supported by larval drift from reach CD. The degree of decline from initial abundance depended on the type and magnitude of entrainment. While the impacted median abundance of reach B was stable, it was not an actual equilibrium; the trajectories of individual replicates of the simulations were random walks above and below the median. The absence of age-1+ dispersal prevented any upstream impact of entrainment in reach B, preserving the reproductive capacity of the population in reach CD. As illustrated by the lowermost curves in Figure 7.5, the risk of decline for the LMR as a whole was substantially lower in the absence of age-1+ dispersal than at our baseline dispersal rates. For the low-abundance, uniform spatial structure scenario with intermediate entrainment and no dispersal, the impact on median final abundance was 3% and 8% for episodic and chronic entrainment, respectively, as compared with 11% and 31% at baseline dispersal rates. The probability of 30% decline was 0.04 and 0.07 for episodic and chronic entrainment, respectively, as compared with 0.10 and 0.54 at baseline dispersal rates.

Higher dispersal rates led to increased impacts on the LMR (Figure 7.5). Setting age-1+ dispersal from reach CD to equal larval drift and increasing reach B dispersal to balance the exchange individuals between reaches, an approximately five-fold increase in movement. Under the high dispersal scenario, reach CD was un-buffered from impacts of entrainment in reach B, the opposite of the case of no dispersal. As a result, reach CD declined more quickly, on average, than in simulations with baseline dispersal. In the intermediate-entrainment scenarios we explored, the impact on median final abundance in the LMR as a whole was 14% and 39% for episodic and chronic entrainment, respectively, with 30% decline probabilities of 0.13 and 0.79.

Density Dependence

The capacity for compensatory population growth reduced the impact of entrainment on final median abundance relative to density-independent scenarios. Decline in risk was slightly higher for the observed spatial structure than for the uniform, a reversal of the outcome in density-independent scenarios.

With the uniform spatial structure, median final abundance in the absence of entrainment was 1,621 or 8,135 for the low and high abundance level, respectively, with a 30% decline probability of 0.00. Episodic entrainment of 130 individuals age-3+ decreased median final abundance by 10% or 2% and resulted in a 30% decline probability of 0.01 or 0.00. Chronic entrainment of 56 age-3+ individuals decreased median final abundance by 21% or 6% and resulted in a 30% decline probability of 0.44 or 0.00.

With the observed spatial structure, median final abundance in the absence of entrainment was 1,668 or 8,370 for the low and high abundance level, respectively, with a 30% decline probability of 0.00. Episodic entrainment of 130 age-3+ individuals decreased median final abundance by 11% or 3% and resulted in a 30% decline probability of 0.02 or 0.00. Chronic entrainment of 56 age-3+ individuals decreased median final abundance by 31% or 8% and resulted in a 30% decline probability of 0.57 or 0.00.

Discussion

Population Model

The demographic model we developed for this study is, to our knowledge, the first to focus on the LMR population of pallid sturgeon. The model accounted for the reduced size and accelerated life history that appears typical of LMR individuals as compared with more northern populations (Killgore et al. 2007b; Murphy et al. 2007; George et al. 2012). Growth differs between Mississippi River pallid sturgeon and those in the Missouri River. Bertalanffy growth models for pallid sturgeon in the lower Missouri River (Bajer and Wildhaber 2007) and the LMR (Killgore et al. 2007b) suggest that southern fish reach the mass of northern age-15 fish by age nine, but achieve an asymptotic maximum fork length that is less than 60% of that found in the north. Latitudinal gradients in growth and life history are common to ectothermic species and can be explained in large part by variation in temperature (Munch and Salina 2009).

Despite our use of a decelerating mass-fecundity relationship, mass-specific egg production was higher than previously estimated based on a pallid sturgeon from North Dakota (Keenlyne et al. 1992), again illustrating the dramatic differences between southern and northern populations. Studies commonly assume that fecundity scales linearly with mass (Keenlyne et al. 1992; Bajer and Wildhaber 2007; Doukakis et al. 2010). Accelerating mass-fecundity relationships have been found in other species, such as Gulf sturgeon (Pine et al. 2001) and shovelnose sturgeon (Bajer and Wildhaber 2007). Our choice of a less-than-linear function to extrapolate fecundity across age classes therefore appears conservative.

The estimate of survival from egg to age one, on the order of 10^{-5}, is comparable to young-of-year survival estimated for shortnose and white sturgeon using similar methods (Gross et al. 2002), and two orders of magnitude higher than that of Atlantic sturgeon (Gross et al. 2002) and beluga sturgeon (Doukakis et al. 2010). In practice, we implied a higher age-0 survival rate when we increased the relative fecundity of reach CD.

Our final fecundity estimates for reach CD rested heavily on the assumptions that there is no reproduction in reach B and age structure is the same in all reaches of the LMR. Adults in reach B may make upstream movements to spawn. Large seasonal movements have been observed in other parts of the range (Bramblett and White 2001) and there is indirect evidence consistent with upstream spawning migrations in the LMR (Hoover et al. 2007). It is also possible that individuals in reach B have a propensity to relocate permanently to upstream reaches upon maturation, which would result in a difference in age structure among reaches.

Sensitivity analysis indicated that management actions affecting the survival had the greatest effect on expected population growth rate. In contrast, changes in fecundity, which includes age-0 survival, had little influence on population growth rate. Previous studies have found age-0 survival to be a relatively sensitive parameter, supporting conservation methods that improve fecundity and early survival (e.g., Bajer and Wildhaber 2007). The difference in our analysis is that we assumed a management action, like entrainment through water diversions, was likely to affect multiple age classes. The general rule that long-lived species with delayed maturation are most sensitive to changes in adult survival is, not surprisingly, built upon stage-based models in which demographic rates apply to a range of age classes (Lande 1988; Heppell 2007). Sensitivity analysis should always be interpreted with caution

(Bakker and Doak 2009). For instance, though fecundity was less sensitive than survival to a comparable proportional change, management may be able to increase age-0 survival by a much larger margin than is possible for the survival of older age classes.

The population model is useful for making inferences about population size from information on a subset of age classes. We demonstrated the use of projected age structure when extrapolating total abundance from the abundance of age-3+ fish. A similar approach can be applied to other sources of data that exclude some age classes. For instance, in a study of commercial bycatch of sturgeon in the Mississippi River (Bettoli et al. 2009), the smallest pallid sturgeon measured was 683 mm in fork length, equivalent in size to an age-9 fish. The study reported three pallid sturgeon deaths out of 114 sturgeon harvested, a mortality rate of 0.026. Over two seasons, 9,371 sturgeon were collected by commercial fishers between rkm 1240 and 1422 (Bettoli et al. 2009), suggesting that 123 pallid sturgeon, or 0.67 fish rkm^{-1}, were killed per year. Annual survival in the MMR, measured when commercial take was still allowed, was 70% compared with 89-93% survival in the LMR, where commercial take was not allowed in most reaches (Killgore et al. 2007b). If we attribute this difference entirely to commercial take in the MMR and assume the difference applies only to age-8+ fish, then we can infer that 123 is 21-25% of the adult population in the study reach, leading to an adult population density estimate on the order of 3.0-3.4 age-8+ pallid sturgeon rkm^{-1}. Finally, incorporating the age structure predicted by our demographic model for the LMR, in which 48% of the population is younger than age-8 and 79% is age-3+, the estimated total population density is 4.4-5.1 age-3+ pallid sturgeon rkm^{-1}. This value falls near the 95% lower bound on river-wide age-3+ abundance reported by Friedenberg et al. (2013) and is intermediate between the low and high abundance levels investigated in the current study. This example suggests that the results of our risk analyses bracket a reality that lies between the extremes.

The Impact of Entrainment

Quantification of entrainment and its relevance to population viability are necessary to inform efforts surrounding the recovery of pallid sturgeon in the LMR (U.S. Fish and Wildlife Service 2013). Our modeling indicated that both episodic and chronic causes of entrainment mortality had the potential to contribute to meaningful declines in the abundance of pallid sturgeon in the LMR, though no level of entrainment we explored led to an elevated risk of extinction over three generations. Our volumetric estimates of entrainment could be extended to other diversion structures. For instance, the Old River Control Complex handles a maximum of roughly 20,000 cubic meters per second and diverts 30% of the flow of the Mississippi and Red Rivers into the Atchafalaya River. Our results suggest that a full accounting of entrainment through diversion structures in the LMR, including both the Old River Control Complex and the Morganza spillway, could indicate biologically significant impacts to abundance.

The draft revised recovery plan calls for population size of 5,000 adults in the LMR and Atchafalaya River (coastal plain management unit) based on rules of thumb for minimum viable population size (U.S. Fish and Wildlife Service 2013). Given the suspected lack of reproduction in the Atchafalaya River (Keenlyne and Jenkins 1993), this criterion should apply to the LMR alone. The abundance levels examined in this study included approximately 1,000 – 5,000 adults (age-8+). If the true abundance is near 1,000, then entrainment can be seen as a significant factor challenging recovery and a valid focus of management and mitigation. If the true abundance of pallid sturgeon adults in the LMR is near 5,000 or more, entrainment is not a central factor in the recovery and maintenance of the population.

Rates of episodic entrainment through the Bonnet Carré Spillway were developed from three distinct scenarios. We do not know which scenario is most likely. Episodic entrainment, in isolation, presented small risks to population viability. Only the worst-case scenario of low abundance and high entrainment presented an appreciable risk to the population, a 20% decline in median abundance. It is interesting to consider this impact retrospectively. In the worst case, abundance may have been 20% higher 60 years ago based on episodic entrainment alone. The range of uncertainty around episodic impacts is larger than the range we explored. Only the 2008 diversion event was used to establish possible entrainment rates. The magnitude and duration of diversion has varied over the spillway's historical use such that average entrainment may be higher than we estimated.

Surprisingly, the small chronic diversions posed a more substantial threat than the Bonnet Carré. Unlike our episodic entrainment estimates, entrainment levels for the chronic diversions were probabilistic with 98% coverage. It is therefore possible to assert that the intermediate entrainment rate is more likely than the high or low rates. As such, the most likely impact of chronic diversion was a 6-31% decline in median abundance. However, we included the White Ditch diversion in our study even though it is south of New Orleans, LA, in a reach of the Mississippi River where pallid sturgeon have not been found (Killgore et al. 2007a). Hence, our estimates of risk are conservative. At the low abundance level, our estimate of chronic diversion was sufficient to induce an IUCN rating of vulnerable (IUCN Standards and Petitions Subcommittee 2010) if the LMR pallid population was otherwise stable.

It is possible that mitigation efforts, such as monitoring and rescue below small diversion structures could reduce risks posed by the wetlands restoration project planned in reach B of the LMR. For instance, stranding behind diversion structures has been found to imperil the endangered green sturgeon population in the Sacramento River (Thomas et al. 2013). However, monitoring and rescue efforts focused on water impounded by diversion structures greatly reduced projected risks to the population (Thomas et al. 2013).

The envelope of median decline for combined episodic and chronic entrainment was 2-57% over 60 years, highlighting the large uncertainty associated with impacts. The effects of episodic and chronic entrainment combined multiplicatively. This result was expected given that we modeled entrainment as age-independent and population growth as density-independent. Age specificity or bias could lead to changes in age structure and reproductive potential. Density dependence could also lead to more complicated cumulative effects; chronic entrainment could reduce the population's capacity for compensatory growth following episodic events.

The effect of spatial structure on the risk of population decline was relatively small in this study. Among models utilizing the baseline dispersal rates and density-independent growth, median declines in final abundance differed by 5% or less between the uniform and observed patterns of population density. However, the difference between the spatial structures themselves was also small. We only explored minor differences in population density rather than possible variation in age structure. This choice allowed us to parameterize the model in the absence of key data on reach-specific and age-specific rates of survival and movement. Even with the similarity of the two spatial structures and their median responses to entrainment, the probability of a 30% decline was meaningfully higher for the uniform pattern in some cases.

Density dependence reduced the impact of both episodic and cumulative entrainment. However, the particular magnitude of this reduction was based on an arbitrary assumption of 5% maximum population increase per year. Our density-independent simulations are a more conservative approach to the assessment of risk in populations where the strength and form of density independence are unknown (Ferson et al. 2003). By assuming long-term stasis in abundance, our density-independent models captured the essential feature of density-dependent models while permitting maximum sensitivity to perturbations. One useful result of the density-dependent simulations, however, was their illustration of the effect of spatial structure when maximum fecundity is constrained. The higher fecundity required for maintenance of equilibrium with the observed spatial structure reduced the degree to which fecundity could further increase to compensate for entrainment.

Counterintuitively, reproduction by reach B residents would increase the projected impact of entrainment in our model. This is because entrainment would directly affect individuals with high reproductive value. If residents of reach B do not spawn, then reproductive value is only realized upon dispersal to reach CD. The resulting link between movement and reproductive value also explains the sensitivity of decline risk to age-1+ dispersal. In turn, if reach B supports spawning directly or upstream spawning migrations occur, dispersal rate will have less effect on the population-level response to entrainment.

It may be possible that the high population density in reach B associated with the observed spatial structure of the LMR population could be reduced by habitat modification upstream. Though the LMR still features a large amount of floodplain habitat (Schramm et al. 2000), flood control structures and engineering of the river bank modified flows, sedimentation patterns, and channel complexity (Baker et al. 1991) in such a way that fewer larvae may be retained in reach CD. As parameterization of our demographic model demonstrated, the drift of larvae to reach B from upstream locations is a tax on the productive capacity of the LMR population. Retention of larvae in reach CD would not only keep a larger fraction of the population associated with reproductive habitat but would also reduce the fraction of the population subject to entrainment by the high concentration of diversion structures in reach B.

Data Priorities

Demographic models are essential tools for guiding research priorities and modifying adaptive management plans (Bakker and Doak 2009). The uncertainty in our estimates of risk posed by entrainment is currently too large to support management decisions directly. While some of the uncertainty in our analysis of the impact of entrainment is attributable to intrinsic environmental variation and is therefore not reducible by further study, the majority is attributable to a lack of knowledge that could be addressed by continued research in the LMR. Estimates of abundance ranged five-fold and entrainment rates for both episodic and chronic diversions spanned more than an order of magnitude. In both cases, the true range of uncertainty is actually larger but can be reduced through continued monitoring of the population. Finally, the large sensitivity of projected risk to dispersal rate strongly suggests that the collection and synthesis of large-scale adult movement data would provide a better understanding of the relationship between management actions and recovery goals.

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Table 1.5. Derivation of age-specific fecundity, Ft, and survival St, to generate the baseline population models, in which median abundance is not expected to change through time.

Characteristic	Predictor	Expression	Parameter values	Source
L_t, fork length (mm)	Age, t (y)	$L_t = L_\infty[1 - e^{-k(t-t_0)}]$	$L_\infty = 849.6$ mm $k = 0.16$ y^{-1} $t_0 = -1.3$ y	Killgore, et al. (2007b)
M_t, mass (kg)	L (mm)	$M_t = \alpha L_t{}^\beta$	$\alpha = 10^{-9.22}$ kg/mm $\beta = 3.42$	Analysis of updated survey dataset following Killgore et al. (2007b).
E_t, eggs	M (kg)	$E_t = aM_t{}^b$	$a = 18{,}780$ eggs/kg $b = 0.91$	Fit of a to two Atchafalaya females (George et al. 2012) given the value of b for white sturgeon (DeVore 1995).
p, proportion female		$p = 0.5$		Wildhaber et al. (2007)
m_t, proportion mature	t (y)	$m_t = \Pr\left[\frac{1}{\mathrm{N}(\mu,\sigma)} < t\right]$	$\mu = 0.091$ y^{-1} $\sigma = 0.01$	Consistent with varied observations (Keenlyne 1992; George et al. 2012)
I, reproductive interval (y)		$I = 3$		Lower limit observed by Keenlyne (1992)
F_t, fecundity	t (y)	$F_t = \frac{pm_t}{I} a(\alpha L_t{}^\beta)^b S_0$		
S_0, first-year survival			$S_0 = 2.4 \times 10^{-5}$	Balances births and deaths in baseline model
S_1, survival of age-1 fish			$S_1 = 0.63$	Steffenson, et al. (2010), then adjusted to balance model
S_2, survival of age-2 fish			$S_2 = 0.75$	Hadley and Rotella (2009)
$S_3 \ldots S_{24}$, survival of fish age-3 to age-24			$S_3 .. S_{24} = 0.93$	Killgore, et al. (2007b)
S_{25}, survival of age-25+ fish			$S_{25} = 0.86$	Twice the mortality of younger adults

Table 2.5. Scenarios of pallid sturgeon entrainment explored in this study. Episodic entrainment occurred at random time intervals with a given annual probability, whereas chronic entrainment occurred every year. Per capita probabilities of entrainment in reach B depended on total take, use of the low or high estimate of population size (N), and the assumption that population density was either uniform along the lower Mississippi River's length or followed the observed pattern of catch per unit effort.

			Per Capita Entrainment Probability			
			Uniform		Observed	
Scenario	Annual Probability	Total Take	Low *N*	High *N*	Low *N*	High *N*
Episodic	0.125	18	0.022	0.004	0.014	0.003
		65	0.078	0.016	0.050	0.010
		130	0.157	0.031	0.100	0.020
Chronic	1.0	14	0.010	0.002	0.006	0.001
		28	0.034	0.007	0.021	0.004
		56	0.067	0.013	0.043	0.009

Table 3.5. Initial conditions and model parameters given estimates of female abundance and spatial structure and the assumption of a stable population. Density-dependent models made use of the maximum growth rate and carrying capacity parameters for population CD only. Population B was assumed to be supported by larval drift in the absence of local reproduction.

	Spatial Structure			
	Uniform		CPUE	
	Low *N*	High *N*	Low *N*	High *N*
Population B				
total abundance	525	2,625	825	4,125
adult abundance[a]	275	1,373	431	2,157
age-1+ dispersal[b]	0.135	0.135	0.07	0.07
relative fecundity[c]	0	0	0	0
Population CD				
total abundance	1,525	7,625	1,300	6,500
adult abundance[a]	797	3,987	680	3,399
larval dispersal	0.26	0.26	0.39	0.39
age-1+ dispersal[b]	0.046	0.046	0.044	0.044
relative fecundity[c]	1.34	1.34	1.64	1.64
$R_{max\ local}$[d]	1.035	1.035	1.025	1.025
adult carrying capacity	1,180	5,900	1,420	7,100
carrying capacity SD	118	590	142	710

[a]At the demographic model's stable age distribution, age-8+ females comprise 52.3% of the population

[b]Age-1+ dispersal rates assume an equal number of upstream and downstream migrants consistent with the structure of abundance and emigration as reported by Koch et al. (2012).

[c]There is no reproduction in population B. We assumed age structure is maintained by surplus fecundity and larval drift from population CD.

[d]The effective maximum local population growth rate of population CD is diminished by larval drift. Values given assume a maximum growth rate of 1.05 in the absence of larval drift.

Table 4.5. Median final abundance of pallid sturgeon in the lower Mississippi River under episodic entrainment after 60 years (3 generations).

		Low population estimate				High population estimate			
		Age-3+ fish entrained[a]				Age-3+ fish entrained[a]			
Age-3+ fish[b]	Spatial structure	0	18	65	130	0	18	65	130
median	uniform	1,615	1,580	1,440	1,290	8,086	7,976	7,884	7,709
	observed	1,684	1,649	1,522	1,386	8,365	8,362	8,248	8,119
% reduction from baseline median	uniform		2	11	20		1	2	5
	observed		2	10	18		0	1	3
probability of a 30% decline	uniform	0.02	0.03	0.10	0.26	0.02	0.02	0.03	0.04
	observed	0.02	0.02	0.06	0.17	0.01	0.01	0.01	0.02

[a]Entrainment is both sexes per event. Number of age-3+ fish determines the *per capita* rate of entrainment for all age classes.

[b]Abundance of females after 60 years.

Table 5.5. Median final abundance of pallid sturgeon in the lower Mississippi River under chronic entrainment after 60 years (3 generations)

		Low population estimate				High population estimate			
		Age-3+ fish entrained[a]				Age-3+ fish entrained[a]			
Age-3+ fish[b]	Spatial structure	0	8	28	56	0	8	28	56
median	uniform	1,615	1,436	1,116	813	8,086	7,907	7,452	6,912
	observed	1,684	1,531	1,224	930	8,365	8,232	7,854	7,371
% reduction from baseline median	uniform		11	31	50		2	8	15
	observed		9	27	45		2	6	12
probability of a 30% decline	uniform	0.02	0.09	0.54	0.96	0.02	0.03	0.05	0.13
	observed	0.02	0.05	0.41	0.92	0.01	0.01	0.03	0.07

[a]Entrainment is both sexes per event. Number of age-3+ fish determines the *per capita* rate of entrainment for all age classes.

[b]Abundance of females after 60 years.

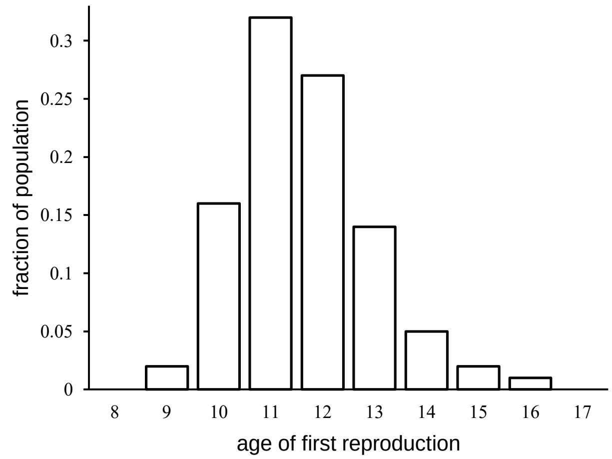


Figure 1.5. The schedule of maturation used in calculating age-specific fecundity. The mean age of first reproduction is age 11. Variance in age of first reproduction arises from the assumption that the rate of maturation has a normal distribution among individuals in the population.

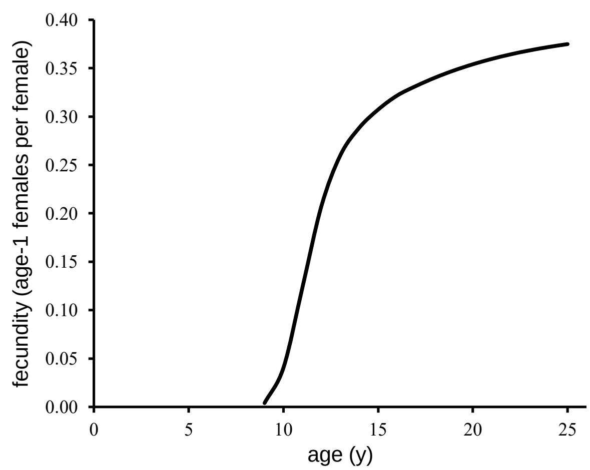


Figure 2.5. Fecundity, the number of age-1females produced per female per year, as a function of age. Values were adjusted to produce no change in median abundance over time. Calculated following the equation for F_t in Table 1.

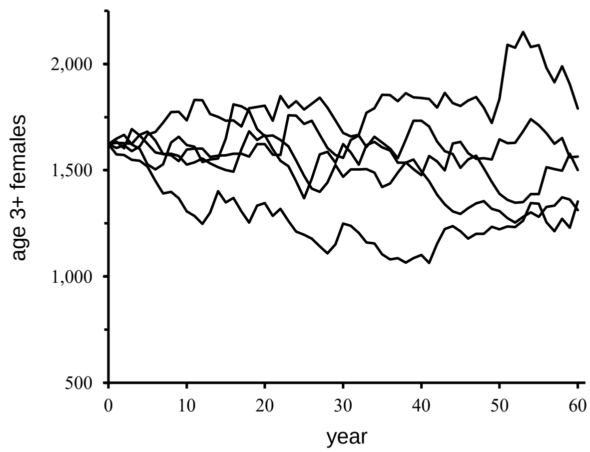


Figure 3.5. Five replicate trajectories of the baseline demographic model, in which births are expected to balance deaths. The trajectories illustrate stochastic changes in abundance of age-3+ fish in the lower Mississippi River over 60 y (~3 generations). Stochasticity includes both yearly environmental variation and demographic stochasticity. Simulations were performed using the low estimate of population density.

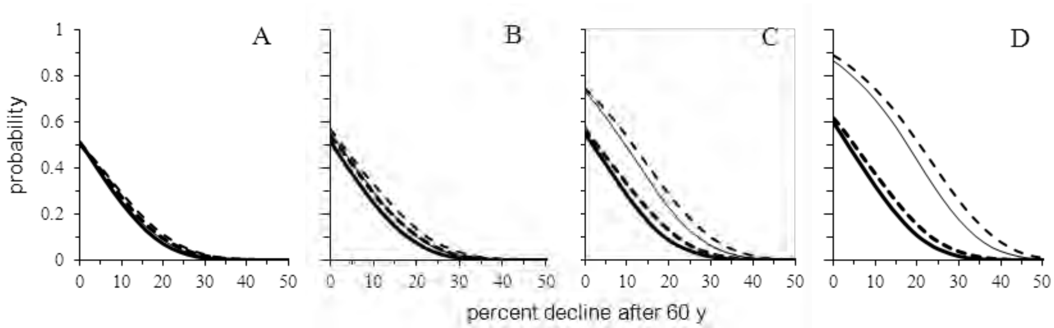


Figure 4.5. A comparison of the probability of decline after 60 y (~3 generations) with the episodic take of 0, 18, 65, or 130 age-3+ fish **(A-D**, respectively) from reach B. Line weight indicates high (heavy) or low (light) population estimate. Line style indicates uniform (dashed) or observed (solid) spatial distribution of the population.

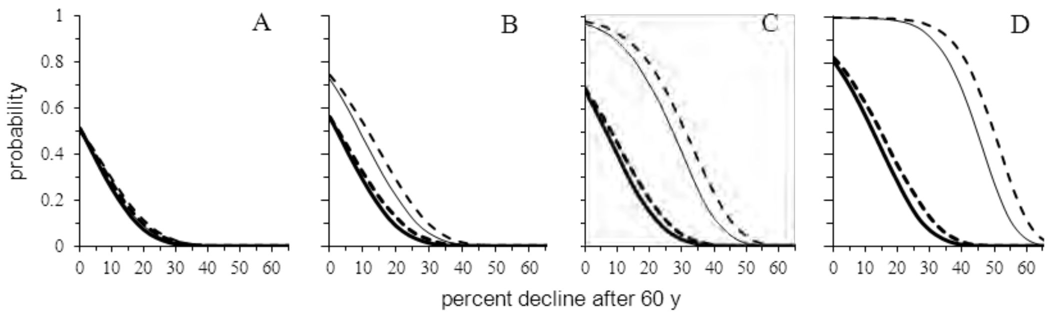


Figure 5.5. A comparison of the probability of decline after 60 y (~3 generations) with the chronic take of 0, 8, 28, or 56 age-3+ fish **(A-D**, respectively) from reach B. Line weight indicates high (heavy) or low (light) population estimate. Line style indicates uniform (dashed) or observed (solid) spatial distribution of the population.

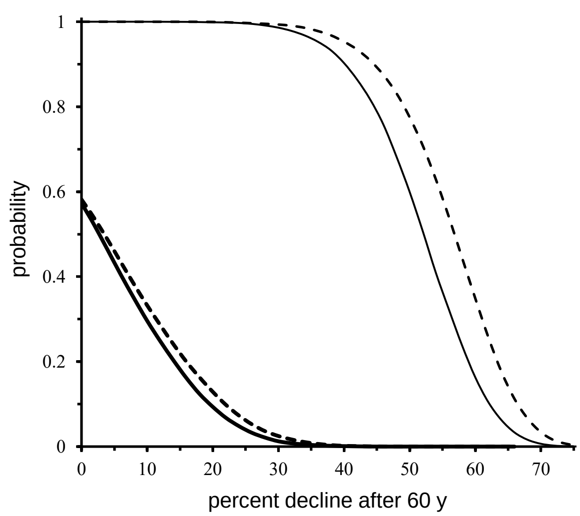


Figure 6.5. Best and worst cases of decline after 60 y given the combination of episodic and chronic take with density-independent population growth. Best case (heavy curves): high abundance estimate, episodic take of 18 and chronic take of 8 age-3+ fish. Worst case (light curves): low abundance estimate, episodic take of 130 and chronic take of 56 age-3+ fish. Line style indicates uniform (dashed) or observed (solid) population distribution.

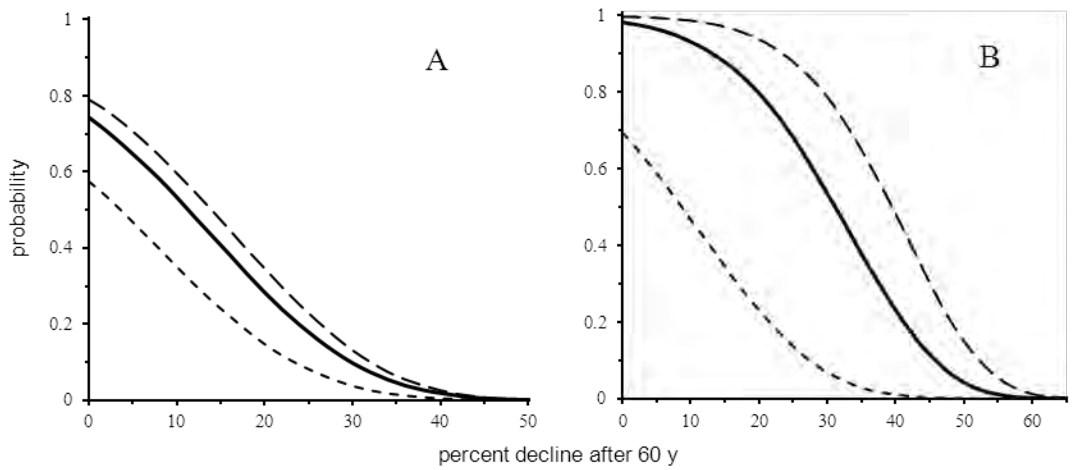


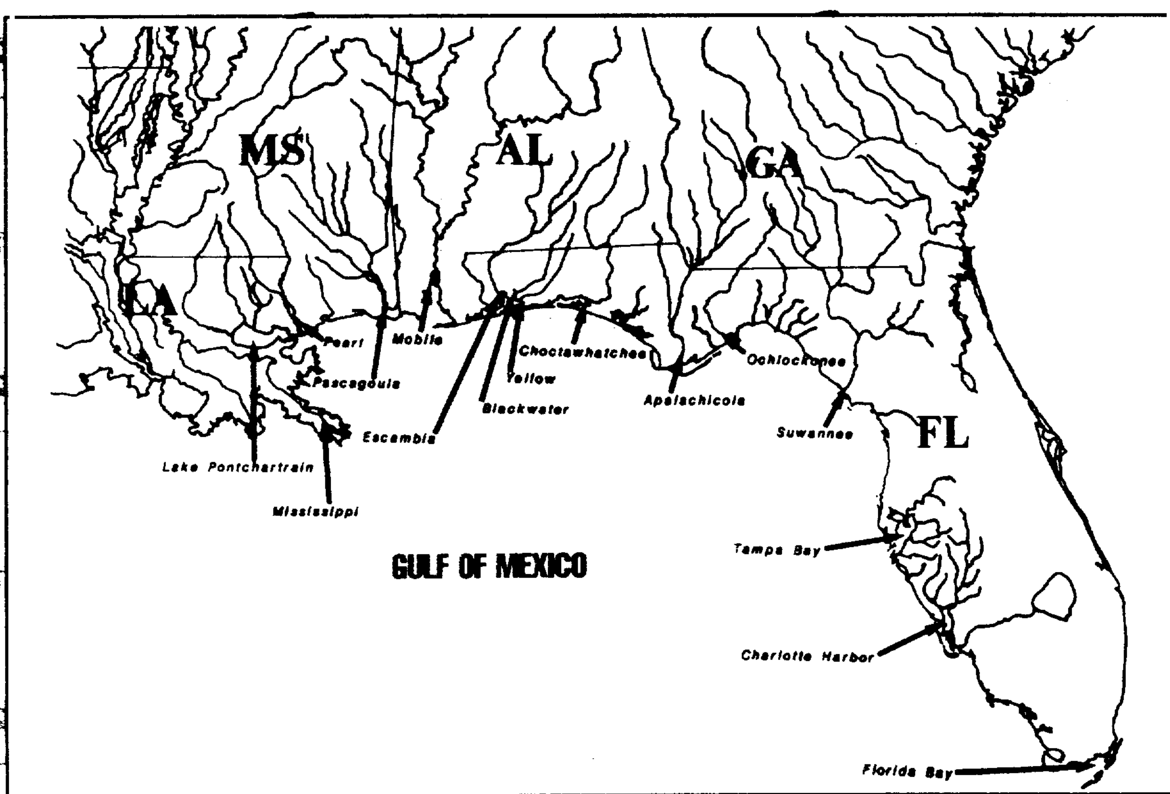
Figure 7.5. The probability of decline after 60 y given **A.** episodic take of 65 or **B.** chronic take of 28 age-3+ pallid sturgeon in reach B with density-independent population growth. All results are for the low abundance estimate and uniform spatial structure. Line style indicates standard (solid), high (long dashes), or no (short dashes) rate of age-1+ dispersal between reaches B and CD.

ATTACHMENT 6

SPECIES RECOVERY PLANS

GULF STURGEON

RECOVERY/MANAGEMENT PLAN



GULF STURGEON
(*Acipenser oxyrinchus desotoi*)

RECOVERY/MANAGEMENT PLAN

Prepared by

The Gulf Sturgeon Recovery/Management Task Team

for

Southeast Region
U.S. Fish and Wildlife Service
Atlanta, Georgia

and

Gulf States Marine Fisheries Commission
Ocean Springs, Mississippi

and

National Marine Fisheries Service
Washington, D.C.

Approved: Noreen K. Clough Date: 9/22/95
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Edwin J. Conklin
Chairman, Gulf States Marine Fisheries Commission

Approved: Rolland A. Schmitten Date: SEP 15 1995
Rolland A. Schmitten
Assistant Administrator for Fisheries, National Marine Fisheries Service

DISCLAIMER PAGE

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, sometimes prepared with the assistance of recovery teams, contractors, state agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. They represent the official position of the U.S. Fish and Wildlife Service and the National Marine Fisheries Service only after they have been signed by the Regional Director of the Fish and Wildlife Service and the Assistant Director for Fisheries of the National Marine Fisheries Service as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

LITERATURE CITATIONS

Literature citations should read as follows:

U.S. Fish and Wildlife Service and Gulf States Marine Fisheries Commission. 1995. Gulf Sturgeon Recovery Plan. Atlanta, Georgia. 170 pp.

Additional copies of this plan may be purchased from:

Fish and Wildlife Reference Service:

5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
Telephone: 301/492-6403
or 1-800-582-3421

Fee for recovery plans vary, depending upon the number of pages.

ACKNOWLEDGEMENTS

The Gulf sturgeon would not have received federal protection without the dedication and persistence of a few individuals who raised our consciousness of the plight of this prehistoric species. Alan Huff completed the first life history of Gulf sturgeon and has since been influential in shaping recovery and restoration efforts. Dr. Archie Carr realized the magnificence of this subspecies, initiating sturgeon studies on the Apalachicola and Suwannee rivers. Each of his sons helped him through the years, the last being Stephen, who has continued the studies after Dr. Carr's death. Stephen's work has resulted in a long-term commitment to the subspecies. The Carrs were funded in their efforts by The Florida Phipps Foundation founded by Mr. John H. (Ben) Phipps. The Foundation continues to support Stephen Carr's work. Mr. Jim Barkuloo, while with the U.S. Fish and Wildlife Service (FWS), was instrumental in persuading the FWS to list the species. Dr. Michael Bentzien completed the tedious procedural work to list the subspecies and has continued to support the team's efforts in preparing the Recovery Plan. The Gulf States of Louisiana, Mississippi, Alabama, and Florida provided protection for the Gulf sturgeon before the subspecies was listed, by prohibiting take of "sturgeon." The states continue to provide protection through implementation of surveys and studies on the Gulf sturgeon so that management decisions can be based on scientific data.

Current Species Status: The current population levels of Gulf sturgeon in rivers other than the Suwannee and Apalachicola are unknown, but are thought to be reduced from historic levels. Historically, the subspecies occurred in most major rivers from the Mississippi River to the Suwannee River, and marine waters of the central and eastern Gulf of Mexico to Florida Bay.

Habitat Requirements and Limiting Factors: The Gulf sturgeon is an anadromous fish which migrates from salt water into large coastal rivers to spawn and spend the warm months. The majority of its life is spent in fresh water. Major population limiting factors are thought to include barriers (dams) to historical spawning habitats, loss of habitat, poor water quality, and overfishing.

Recovery Objectives: The short-term recovery objective is to prevent further reduction of existing wild populations of Gulf sturgeon. The long-term recovery objective is to establish population levels that would allow delisting of the Gulf sturgeon in discrete management units. Gulf sturgeon in discrete management units could be delisted by 2023, if the required criteria are met. Following delisting, a long-term fishery management objective is to establish self-sustaining populations that could withstand directed fishing pressure within discrete management units.

Recovery Criteria: The short-term recovery objective will be considered achieved for a management unit when the catch-per-unit-effort (CPUE) during monitoring is not declining from the baseline level over a 3 to 5-year period. This objective will apply to all management units within the range of the subspecies. Management units will be defined using an ecosystem approach based on river drainages, but may also incorporate genetic affinities among populations in different river drainages. Baselines will be determined by fishery independent CPUE levels.

The long-term recovery objective will be considered achieved for a management unit when the population is demonstrated to be self-sustaining and efforts are underway to restore lost or degraded habitat. A self-sustaining population is one in which the average rate of natural recruitment is at least equal to the average mortality rate in a 12-year period. While this objective will be sought for all management units, it is recognized that it may not be achievable for all management units. The long-term fishery management objective will be considered attained for a given management unit when a sustainable yield can be achieved while maintaining a stable population through natural recruitment. Note that the objective is not necessarily the opening of a management unit to fishing, but rather the development of a population that can sustain a fishery. Opening a population to fishing will be at the discretion of state(s) within whose jurisdiction(s) the management unit occurs. As with the long-term recovery objective, this objective may not be achievable for all management units, but will be sought for all units.

Priority 1 Recovery Tasks:

1. Develop and implement standardized population sampling and monitoring techniques (1.3.1).

2. Develop and implement regulatory framework to eliminate introductions of non-indigenous stock or other sturgeon species (2.5.3).

3. Reduce or eliminate incidental mortality (2.1.2).

4. Restore the benefits of natural riverine habitats (2.4.5).

5. Utilize existing authorities to protect habitat and where inadequate, recommend new laws and regulations (2.3.1).

Costs ($000's) of Priority 1 Tasks:

Year	Action 1	Action 2	Action 3	Action 4*	Action 5
FY 1	59	0	125	26	29
FY 2	73	25	125	48	29
FY 3	114	0	125	48	29
FY 4	108	0	75	31	29
FY 5	108	0	25	0	0

Cost of No. 1 Priority Actions: $1,231,000

* Actual restoration costs undetermined

Total Cost of Recovery: $8,413,000

Date of Recovery: Delisting should be initiated by 2023, for management units where recovery criteria have been met.

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PREFACE

The U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) jointly listed the Gulf sturgeon as threatened under the authority of the Endangered Species Act of 1973, as amended (ESA).

The FWS prepared a Report on the Conservation Status of the Gulf of Mexico Sturgeon *Acipenser oxyrhinchus desotoi* in 1988 as a precursor to the listing process. The Gulf States Marine Fisheries Commission (GSMFC) began an initiative in late 1990 to draft a fishery management plan for the Gulf sturgeon. The drafting team (ad hoc subcommittee of the GSMFC Technical Coordinating Committee, Anadromous Fish Subcommittee), on October 1, 1991, in response to the listing, took action to draft a management/recovery plan. This plan meets the requirements of a fisheries management plan as originally begun by the GSMFC, as well as the requirements associated with an Endangered Species Act recovery plan. The plan incorporates the format that has become standard in federal endangered and threatened species recovery plans in recent years. The FWS published a "Framework for the Management and Conservation of Paddlefish and Sturgeon Species in the United States" in March 1993. This document resulted from a workshop sponsored by the FWS that was attended by representatives of other federal agencies, the states, the private aquaculture community, and academia in January 1992. This recovery plan is consistent with the framework document, and in essence, steps down the recommendations and strategies contained therein.

The plan is intended to serve as a guide that delineates and schedules those actions believed necessary to restore the Gulf sturgeon as a viable self-sustaining element of its ecosystem. Some of the tasks described in the plan are ongoing by the FWS, GSMFC, NBS, and the states of Louisiana, Mississippi, Alabama, and Florida. The inclusion of these ongoing tasks represents an awareness of their importance, and offers support for their continuation. Because of this ongoing research on the subspecies, the plan incorporates personal communications and unpublished data.

LIST OF ABBREVIATIONS

ADCNR	Alabama Department of Conservation and Natural Resources
AGS	Alabama Geological Survey
ANSTF	Aquatic Nuisance Species Task Force
CCC	Caribbean Conservation Corporation
CES	Cooperative Extension Service
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COE	U.S. Army Corps of Engineers
CWA	Clean Water Act
CZM	Office of Coastal Zone Management
EIRP	Environmental Impact Research Program
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FDEP	Florida Department of Environmental Protection
FDNR	Florida Department of Natural Resources
FERC	Federal Energy Regulatory Commission
FGFC	Florida Game and Fresh Water Fish Commission
FRTES	Fisheries Resources Trace Elements Survey
FSBC	Florida State Board of Conservation
FWS	United States Fish and Wildlife Service
GCRL	Gulf Coast Research Laboratory
GSMFC	Gulf States Marine Fisheries Commission
GSRMA	Gulf States Resource Management Agencies (TX,LA,MS,AL,FL)
LDWF	Louisiana Department of Wildlife and Fisheries
MDWFP	Mississippi Department of Wildlife, Fisheries, and Parks
MMS	Minerals Management Service
NBS\BSC	National Biological Service, Southeastern Biological Science Center
NCSU	North Carolina Cooperative Research Unit, North Carolina State University
NGO	Nongovernmental organizations
NMFS	National Marine Fisheries Service
NRCS	Natural Resources Conservation Service (formerly SCS)
OCS	Outer Continental Shelf
SCS	Soil Conservation Service
TED	Turtle Excluder Device
USGS	United States Geological Survey
WES	Waterways Experiment Station
WSRFC	Warm Springs Regional Fisheries Center

LIST OF SYMBOLS

m	meter
mm	millimeter
cm	centimeter
kg	kilogram
km	kilometers
in	inches
ft	feet
mi	mile
lb	pound
hr	hour
°F	degrees Fahrenheit
°C	degrees Centigrade
ft/s	feet per second
m/s	meters per second
m^3/s	cubic meters per second
r	correlation coefficient
SD	standard deviation
TL	total length
FL	fork length
P	probability
hectare	not abbreviated
acre	not abbreviated

I. INTRODUCTION

NOMENCLATURE

The scientific name for Atlantic sturgeon is *Acipenser oxyrinchus* Mitchill. This species consists of two geographically disjunct subspecies: the Gulf sturgeon, *Acipenser oxyrinchus desotoi*, which inhabits the Gulf of Mexico watersheds, and the Atlantic coast subspecies, *Acipenser oxyrinchus oxyrinchus*.

Gilbert (1992) discovered that the species name of the Atlantic sturgeon has been "...misspelled for over one hundred years..." as *oxyrhynchus* rather than *oxyrinchus*. Consequently, based on the rules of zoological nomenclature, *oxyrinchus* is used throughout this plan.

Other colloquial names, in addition to Gulf sturgeon, are: Gulf of Mexico sturgeon, Atlantic sturgeon, common sturgeon and sea sturgeon.

TAXONOMY

Class: Osteichthyes
    Order: Acipenseriformes
        Family: Acipenseridae
            Genus: Acipenser
                Species: oxyrinchus
                    Subspecies: desotoi

Type Specimens

The holotype was collected from the mouth of Singing River (West Pascagoula River) in Mississippi Sound off Gautier, Mississippi and is housed in the U.S. National Museum of Natural History, Washington, DC. The paratype was collected with the holotype and is deposited in the Chicago Natural History Museum (Vladykov 1955).

Current Taxonomic Treatment

The Gulf sturgeon is a member of the family Acipenseridae which inhabits the Atlantic, Gulf, Pacific and certain freshwaters of the United States (Ginsburg 1952). The family includes five members of the genus *Acipenser*, and three members of the genus *Scaphirhynchus*.

Other sturgeon likely to be found in the same waters with Gulf sturgeon include the pallid sturgeon, *Scaphirhynchus albus*, the shovelnose sturgeon, *S. platorynchus*, and Alabama sturgeon *S. suttkusi* (Rafinesque 1820; Forbes and Richardson 1908; Williams and Clemmer 1991). *Scaphirhynchus* are freshwater sturgeon that are native to the Mississippi and Mobile River systems. They formerly occurred in the upper Rio Grande River in New Mexico, but have not been recorded since 1874 (Lee et al., 1980). The fish are characterized by a flattened shovel-shaped snout and are easily distinguished from Gulf sturgeon. *Acipenser oxyrinchus desotoi* is the only anadromous sturgeon occurring in the Gulf of Mexico.

Based on morphometrics, Wooley (1985) concluded that *A. o. desotoi* is a valid subspecies. Bowen and Avise (1990) analyzed the genetic structure of Atlantic and Gulf sturgeon using mitochondrial DNA (mtDNA) restriction fragment length polymorphism analysis, and postulated that relatively recent genetic contact had occurred between the two regions because of several shared mtDNA clones and clonal arrays. However, Ong et al. (manuscript submitted) used direct sequence analysis of the mtDNA control region and found three fixed nucleotide site differences between *A. oxyrinchus* from the Atlantic and Gulf coasts. They concluded that subspecific divisions are warranted for *A. oxyrinchus*, based on fixed genetic differences between the forms, their allopatric distributions, and their morphometric and life history differences. Ong et al. also postulated that their data, and those of Bowen and Avise (1990), indicate that the reproductive isolation between *A. o. desotoi* and *A. o. oxyrinchus* occurred because of climatic fluctuations in the Pleistocene in conjunction with related changes in the size of the Florida peninsula. Further, they noted that even if the two subspecies occasionally mix in ocean waters, the finding of fixed genetic differences between them suggests that homing fidelity is high in *A. oxyrinchus*.

STATUS

The U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) designated the Gulf sturgeon to be a threatened subspecies, pursuant to the Endangered Species Act of 1973, as amended (ESA). The listing became official on September 30, 1991. As part of the listing, a special rule was promulgated to allow taking of the subspecies for educational purposes, scientific purposes, the enhancement of propagation or survival of the subspecies, zoological exhibition, and other conservation purposes consistent with the ESA. The special rule will allow conservation and recovery activities for Gulf sturgeon to be accomplished without a federal permit, provided the activities are in compliance with applicable state laws (FWS 1991a).

DESCRIPTION

Gulf sturgeon are anadromous fish with a sub-cylindrical body imbedded with bony plates or scutes. The snout is greatly extended and bladelike with four fleshy barbels in front of the mouth, which is protractile on the lower surface of the head. The upper lobe of the tail is longer than the lower lobe (Figure 1). The subspecies is light brown to dark brown in color and pale underneath (Vladykov 1955; Vladykov and Greeley 1963).

Characteristics common to both subspecies, *A. o. oxyrinchus* and *A. o. desotoi* are: Scutes strongly developed in longitudinal rows; 7 to 13 (average 9.8) dorsal shields; 24 to 35 (average 28.7) lateral shields behind dorsal fin in pairs; elongated fulcrum at base of lower caudal lobe decidedly longer than base of anal fin; head elongate; snout longer than postorbital distance in individuals up to 95.0 cm (38.0 in), but shorter than postorbital distance in older specimens (Vladykov and Greeley 1963).

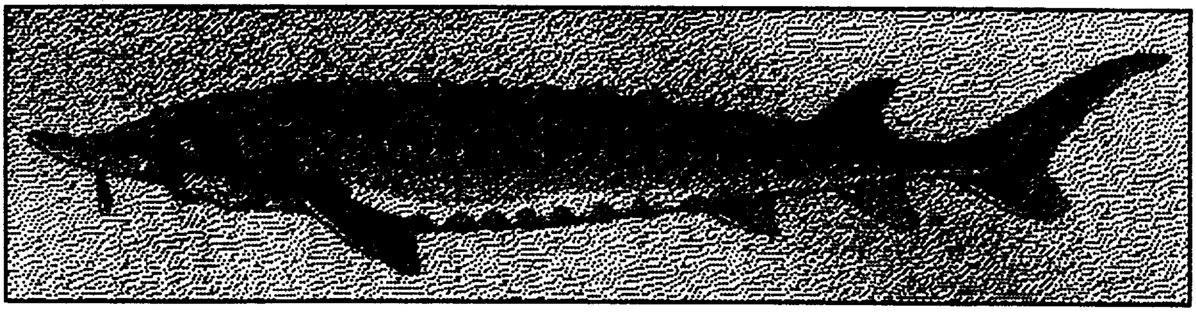

Figure 1: Gulf sturgeon *Acipenser oxyrinchus desotoi* (from Bigelow et al., 1963)

The most significant morphological characteristic to distinguish *A. o. oxyrinchus* from *A. o. desotoi* is the length of the spleen. Wooley (1985) found *A. o. desotoi* specimens had a mean spleen length versus fork length measurement of 12.3% (range 7.9 to 15.8%, SD 2.5, r = 0.212). *Acipenser o. oxyrinchus* specimens had a mean spleen length versus fork length (FL) measurement of 5.7% (range 2.8 to 8.3%, SD 1.8, r = 0.121) for a statistically significant difference ($P \leq 0.05$) and minimal overlap. He concluded that Gulf sturgeon and Atlantic sturgeon populations are allopatric and are sufficiently discrete to be considered distinct stocks for sturgeon population management.

POPULATION SIZE AND DISTRIBUTION

According to Wooley and Crateau (1985) Gulf sturgeon occurred in most major river systems from the Mississippi River to the Suwannee River, Florida and in marine waters of the Central and Eastern Gulf of Mexico south to Florida Bay (Figure 2). Comparison of historic information and current data indicates that Gulf sturgeon populations are reduced from historic levels (Barkuloo 1988). At present, Gulf sturgeon population estimates are unknown throughout its range; however, estimates have been completed for the Apalachicola and Suwannee rivers.

Extant Occurrences of Gulf Sturgeon

Offshore

A Gulf sturgeon was caught on hook and line in 1965 by Dianne Cox, a FWS employee. The 45.7-cm (18-in) Gulf sturgeon was caught in the Gulf of Mexico, 1.6 to 3.2 km (1 to 2 mi) east of Galveston Island in 6.1 m (20 ft) of water (Reynolds 1993).

The incidental catch of Gulf sturgeon in the industrial bottomfish (petfood) fishery in the north-central Gulf of Mexico from 1959 to 1963 was reported by Roithmayr (1965), based on the documentation of one juvenile specimen. The bottomfish fishery worked an area between Point au Fer, Louisiana and Perdido Bay, Florida from shore to 55 m (180 ft).

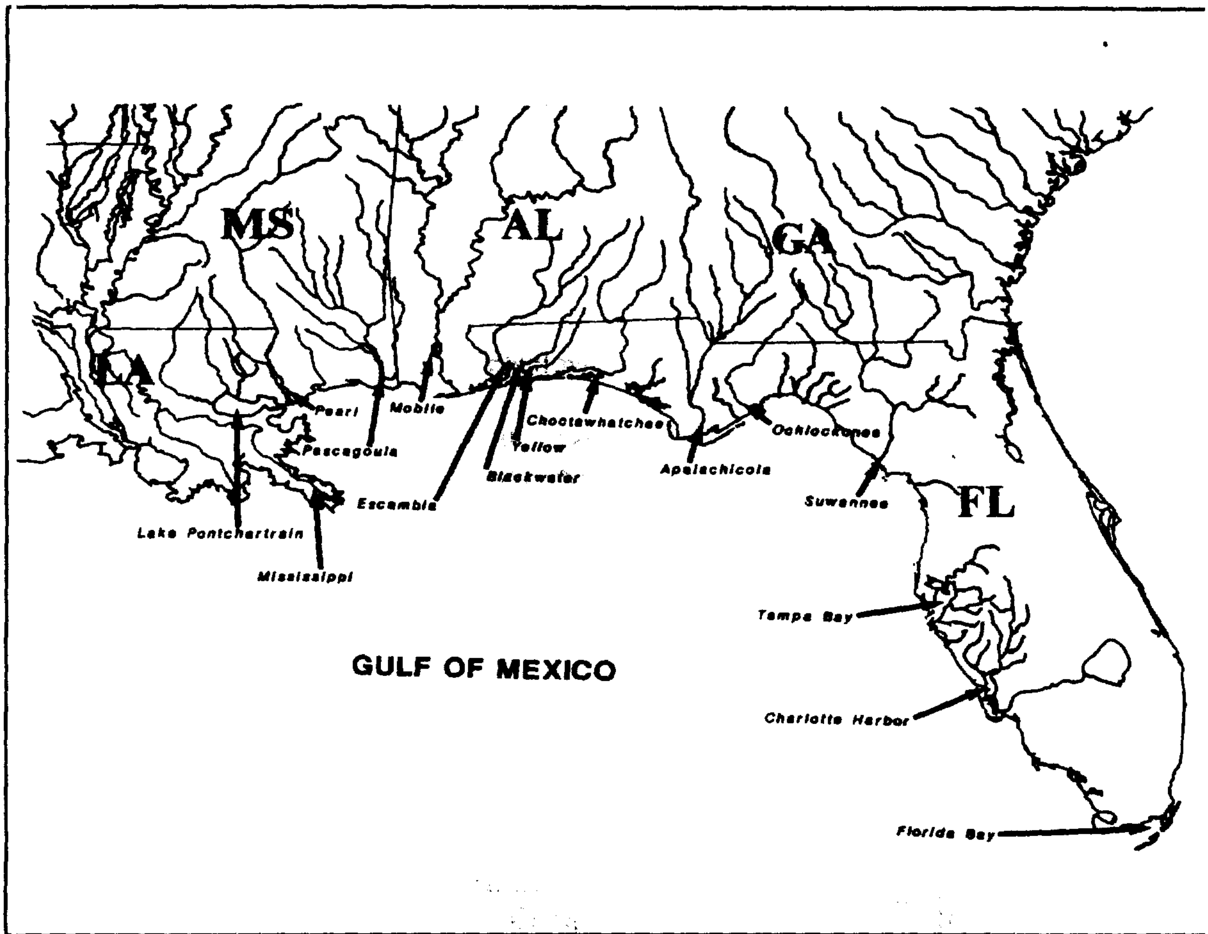

Figure 2: Range of the Gulf Sturgeon

Mermantau River Basin

Mermantau River: The Louisiana Department of Wildlife and Fisheries (1979) reported that an Atlantic sturgeon was caught by a Mr. Hugh Mhire in an otter trawl while shrimping in the Gulf off the mouth of the Mermentau River, Cameron Parish. This specimen was probably a Gulf sturgeon.

Mississippi River Basin

A photograph of a "sea" sturgeon captured at the mouth of the Mississippi River was shown in Fishes and Fishing in Louisiana (1965). Reynolds (1993) reported that a sturgeon measuring 282 cm (111.0 in) and weighing 228.2 kg (503.0 lb) was caught at the mouth of the Mississippi River at Cow Horn Reef in September of 1936.

Mississippi River: A Gulf sturgeon was caught by a commercial fisherman in the auxiliary outflow channel between river km 500.3 (river mi 311.0) of the Mississippi River and river km

16.09 (river mi 10.0) of the Red River on March 28, 1994 (G. Constant, personal communication). The Gulf sturgeon weighed 28.8 kg (63.5 lb) and was 151.2 cm (59.5 in) length and was caught in a 1.2 m (4.0 ft) hoop net.

Lake Pontchartrain Basin

Lake Pontchartrain/Lake Borgne/Rigolets: The Louisiana Department of Wildlife and Fisheries (LDWF) collected twelve Gulf sturgeon weighing 0.22 to 9 kg (0.5 to 19.8 lb) April through June of 1993 (H. Rogillio, personal communication). During a study from January 1990 to March 1993, LDWF collected and tagged 19 Gulf sturgeon weighing 0.25 to 14.5 kg (0.6 to 32.0 lb) from Lake Pontchartrain, Lake Borgne, and the Rigolets (Rogillio 1993). Commercial and sport fishermen incidentally caught 177 Gulf sturgeon measuring up to 220.0 cm (86.6 in) in length and weighing from 1.0 to 68.0 kg (2.2 to 149.9 lb) from Lake Pontchartrain from October 1991 to September 1992 (Rogillio 1993). Reynolds (1993) reported that sturgeon measuring up to 220.0 cm (86.6 in) in length and weighing up to 117.3 kg (258.0 lb) were incidentally caught by shrimp trawlers, netters and recreational anglers from 1989 to 1993 in Lake Pontchartrain. A specimen weighing 53.6 kg (118 lbs) was caught by a hook-and-line fisherman in 1986 (Sentry News 1986). Davis et al. (1970) reported that sturgeon were collected from Lake Ponchartrain during an anadromous fish survey from 1966 to 1969.

Tchefuncte River: Commercial gillnetters incidentally caught 15 Gulf sturgeon weighing from 1.0 to 18.0 kg (2.2 to 39.7 lb) between February and March 1991 in the mouth of the river (H. Rogillio, personal communication). Davis et al. (1970) reported that Gulf sturgeon were collected in trammel nets from the Tchefuncte River during an anadromous fish survey conducted from 1966 to 1969.

Tickfaw River: Davis et al. (1970) reported the collection of sturgeon in trammel nets from the Tickfaw River during an anadromous fish survey from 1966 to 1969.

Tangipahoa River: Davis et al. (1970) reported that sturgeon were collected in trammel nets from the Tangipahoa River during an anadromous fish survey from 1966 to 1969.

Amite River: Davis et al. (1970) reported catch of a sturgeon by a commercial fisherman from the Amite River. Identification of the fish was confirmed by the fisheries biologists with the Louisiana Wild Life (sic) and Fisheries Commission who were conducting an anadromous fish survey.

Pearl River: Esher and Bradshaw (1988) and Bradshaw (personal communication) gill netted a Gulf sturgeon in May 1988 in the lower Pearl River. Sixty-three Gulf sturgeon ranging from juvenile to subadult size were collected from river mile 20 of the Pearl River in 1985 (F. Petzold, personal communication). A 72.7 kg (160.3 lb) female Gulf sturgeon was caught just south of Jackson, Mississippi in 1984 by Miranda and Jackson (1987). The FWS donated a Gulf sturgeon caught by a commercial fisherman in the Pearl River at Monticello to the Mississippi Museum of Natural Science Fish Collection

(MMNS 20206) in 1982 (C. Knight, personal communication; W. McDearman, personal communication). The MDWFP measured and photographed a 119.0 kg (263.0 lb) Gulf sturgeon, 2.2 m (7.25 ft) in length taken by a commercial fisherman below the Ross Barnett Reservoir spillway in 1976 (W. McDearman, personal communication). McDearman and Stewart (personal communication) also note that in the Pearl River between Georgetown and Monticello, Mississippi, there is an area where 2 to 3 Gulf sturgeon are routinely reported by commercial fisherman every 4 to 5 years. In 1971 a Gulf sturgeon from the Pearl River was examined as part of a parasite study (N. Jordan, personal communication). Davis et al. (1970) reported the catch of Gulf sturgeon in hoop nets from the Pearl River at Highway 90 during an anadromous fish survey from 1966 to 1969. The Gulf sturgeon ranged in size from 15.2 cm (6.0 in) to 187.9 cm (74.0 in).

Middle Pearl River: Two Gulf sturgeon were collected in the Middle West Pearl River, St. Tammy Parish, Louisiana, one on March 1, 1995, and the other on March 2, 1995, by the U.S. Army Corps of Engineers, Waterways Experiment Station (WES). The Gulf sturgeon were collected in gill nets and the first sturgeon caught weighed 0.28 kg (0.62 lb) and measured 36.2 cm (14.3 in) in total length. The second Gulf sturgeon weighed 0.28 kg (0.62 lb) and measured 43.5 cm (17.1 in) in total length. Both fish were tagged with Peterson discs and released (M. Chan, personal communication).

Louisiana Department of Wildlife and Fisheries personnel collected 77 Gulf sturgeon from the west Middle Pearl River in 1994 (H. Rogillio, personal communication). The fish ranged in length from 45.7 to 165.1 cm (18 to 65 in). The majority of the fish (84 percent) ranged in length from 74.0 to 114.3 cm (29 to 45 in). The LDWF also collected 14 Gulf sturgeon weighing 1.5 to 14.5 kg (3.3 to 32 lb) in the Middle and west Middle Pearl River from June 1992 through June 1993 (H. Rogillio, personal communication). Two of those specimens were tagged with radio tags. The LDWF also collected 13 Gulf sturgeon weighing 0.27 to 4.3 kg (0.6 to 9.5 lb) in the Middle Pearl River (Drumhole) from April to May 1992 (Rogillio 1993). Commercial fishermen caught one Gulf sturgeon weighing 45.0 kg (99.2 lb) in the Middle Pearl River in February 1991.

Bogue Chitto: Three Gulf sturgeon were also captured by LDWF in the Bogue Chitto River below the Bogue Chitto sill in 1993. The Gulf sturgeon weighed from 2.9 to 4.5 kg (6.5 to 14.5 lb) (H. Rogillio, personal communication).

East Pearl River: Biologists with the FWS gill netted a Gulf sturgeon from the Mikes River, a tributary to the East Pearl River during a fishery survey in the spring of 1992. The fish was 0.7 m (2.3 ft) in length (P. Douglas, personal communication). Davis et al. (1970) reported that one sturgeon was collected in a trammel net from the East Pearl River on November 1, 1968 during an anadromous fish survey conducted from 1966 to 1969.

West Pearl River: Commercial fishermen caught five Gulf sturgeon weighing from 0.1 to 0.3 kg (0.22 to 0.66 lb) in the West Pearl River in October 1990 (H. Rogillio, personal communication).

Mississippi Sound

Bradshaw (personal communication) reported three tag returns from Gulf sturgeon that were incidentally caught by shrimpers working in Mississippi Sound during the fall of 1985. Bradshaw originally collected these Gulf sturgeon from river km 32 (river mi 20) on the Pearl River earlier in 1985. He also noted finding three dead Gulf sturgeon incidentally caught by gillnetters in the western part of the Sound and revived another Gulf sturgeon a gillnetter had caught "on" Horn Island in 1989. Five Gulf sturgeon from Mississippi Sound near Horn Island were examined as part of a parasite study (N. Jordan, personal communication). Of the five sturgeon, one was examined in each of the years 1973, 1976, and 1977, and two in 1982. One Gulf sturgeon [Gulf Coast Research Laboratory (GCRL) #1711] was incidentally caught in a shrimp trawl off the east end of Deer Island in Mississippi Sound in November 1966 in approximately 5.5 m (18 ft) of water. The Gulf sturgeon had a total length (TL) of 75.2 cm (29.6 in). Near this same location J.Y. Christmas (personal communication) reported catching one Gulf sturgeon (GCRL #28) with a TL of 55.2 cm (21.7 in) while sampling with a shrimp trawl in March 1960.

Biloxi Bay

One Gulf sturgeon was incidentally caught in a shrimp trawl in Biloxi Bay off Marsh Point on November 19, 1960 (GCRL #337). The fish was 55.5 cm (22.0 in) TL.

Pascagoula River Basin

Pascagoula Bay: Shepard (personal communication) caught two Gulf sturgeon at the mouth of Bayou LaMotte during the winters of 1991 and 1992 while gillnetting for the J.L. Scott Marine Education Center (GCRL). Reynolds (1993) reported commercial fishermen collecting Gulf sturgeon in and near the mouth of the Pascagoula River in the late 1980's and early 1990's. Shepard (personal communication) reports catching nine Gulf sturgeon from the mouth of the West Pascagoula River while gillnetting from 1983 to 1984. All but one of the sturgeon were caught at the mouth of Bayou LaMotte. The ninth fish was captured near the Sandalwood Canal. One Gulf sturgeon from the mouth of the Pascagoula River was examined in 1970 as part of as part of a parasite study conducted by GCRL (N. Jordan, personal communication).

Pascagoula River: Murphy and Skaines (1994) reported collection of seven Gulf sturgeon in the lower three miles of the Pascagoula River from April to June 1993. Two were radio tagged and released. The fish ranged in length from 46.4 to 111.8 cm (18.3 to 44.0 in) and from 0.8 to 10.4 kg (1.8 to 22.9 lb) in weight. Miranda and Jackson (1987), collected a 78.2 cm (30.8 in) Gulf sturgeon in June 1987 during 30 net-nights from the river. Three Gulf sturgeon were examined from the Pascagoula River as part of a parasite study conducted by GCRL. One was examined in 1978, the second in 1982 and the third in 1984 (N. Jordan, personal communication).

Chickasawhay River: Miranda and Jackson (1987) reported a catch of a 56.7 kg (125.0 lb) Gulf sturgeon in 1985 from the Chickasawhay River, which is a tributary of the Pascagoula River.

Leaf River: Murphy and Skaines (1994) reported that one of two fish radio-tagged from the lower Pascagoula River in May 1993 was located twice in September of that year. The last documented location of the fish was in the Leaf River three miles downstream from McLain, Mississippi approximately 123.8 km (77.0 mi) from its site of capture.

West Pascagoula River: Two Gulf sturgeon from the West Pascagoula River were examined in 1973 and 1979 as part of a parasite study conducted by GCRL (N. Jordan, personal communication). In December 16, 1964, a Gulf sturgeon (GCRL #4501) was collected by T.D. McIlwain in Big Lake off the West Pascagoula River. The sturgeon weighed 0.24 g (0.52 lb) and was 45.6 cm (18.0 in) TL. The water temperature was 13.9°C (57.0°F) with a salinity of 1.1 ppt.

Mobile River Basin

Mobile Bay: A live Gulf sturgeon was picked up on the shoreline of Bayou LaBatre by a fisherman on March 8, 1993 (F. Parauka, personal communication). The fish was 127 cm (50 in) long and weighed 12.5 kg (27.5 lb). The fish was held for observation at the Dauphin Island Sealab until a FWS biologist measured, weighed, radio-tagged, and collected genetic tissue samples and released it into Mobile Bay a day later. Efforts to locate the sturgeon again were unsuccessful. In July 1972 approximately one hundred Gulf sturgeon were observed at the mouth of the Blakeley River in eastern Mobile Bay feeding in shallow water (Vittor 1972). The sturgeon were approximately .91 m (3 ft) in length.

Mobile River: A Gulf sturgeon about 150 cm (59.1 in) long was sighted in the Mobile River near the head of Mobile Bay on October 3, 1992 by an Alabama Department of Conservation and Natural Resources (ADCNR) Marine Resources Division employee. There is a mounted specimen of a juvenile Gulf sturgeon at the Roussos Restaurant in Mobile, Alabama (J. Roussos, personal communication). The specimen is approximately 45.7 to 50.8 cm (18 to 20 in) TL and was collected in 1985 or 1986. The specimen was caught in a shrimp trawl in the Mobile River, presumably at the north end of Mobile Bay.

Tensaw River: The ADCNR reported that a commercial fisherman incidentally caught a 180 cm (70.9 in) Gulf sturgeon in the mouth of the Tensaw River in September 1991 (W. Tucker, personal communication). M. Mettee (personal communication) reported a 180 cm (70.9 in) Gulf sturgeon was incidentally netted and released in the Tensaw River in April 1986 by a commercial fisherman.

Blakeley River: Commercial gillnetters incidentally caught Gulf sturgeon in the Blakely River during the fall from 1989 to 1991.

Tombigbee River: A specimen caught in June 1987 upstream of Coffeeville on the Tombigbee River was verified by an Alabama Geological Survey (AGS) biologist as *Acipenser* (M. Mettee, personal communication). In 1977 a Gulf sturgeon from the Tombigbee River was examined as part of a parasite study (N. Jordan, personal communication). Incidental catches of Gulf sturgeon still occur annually from the Tombigbee River in the remaining riverine habitat below Coffeeville dam (J. Duffy, personal communication).

Alabama River: Incidental catches of Gulf sturgeon still occur annually from the Alabama River in the remaining riverine habitat below Claiborne dam (J. Duffy, personal communication).

Pensacola Bay Basin

Pensacola Bay: A 56.0 cm (22.0 in) TL Gulf sturgeon was collected in Pensacola Bay on January 20, 1978 (Collection No. 10319, Florida Department of Environmental Protection, FDNR).

Escambia River: Two Gulf sturgeon were collected, tagged and released in the Escambia River about 1.6 km (1.0 mi) downstream of highway 184 bridge in September 1994 by the FWS (F. Parauka, personal communication). The fish weighed 15.5 and 20.7 kg (34.0 and 45.5 lb). Incidental catches of Gulf sturgeon have been reported for the Escambia River (G. Bass, personal communication). Recreational anglers reported that prior to 1980 they would see as many as 10 Gulf sturgeon jumping in the river but now it is rare to see even one fish jump during a fishing trip (Reynolds 1993). Prior to a Florida law prohibiting sturgeon fishing in 1984, a limited commercial fishery existed on that river (National Marine Fisheries Service 1987).

Conecuh River: Annual sightings are reported from the Conecuh River in south central Alabama (J. Duffy, personal communication).

Blackwater River: Three Gulf sturgeon were collected in the Blackwater River during a Florida Game and Fresh Water Fish Commission (FGFC) striped bass netting project in March 1991. The fish weighed from 5.0 to 12.0 kg (11.0 to 26.5 lb) (FGFC, unpublished data).

Yellow River: Eighteen Gulf sturgeon were collected, tagged and released in the Yellow River below Boiling Lake in July 1993 by the FWS (F. Parauka, personal communication). The fish weighed from 5.8 to 63.6 kg (12.7 to 140.0 lb). Gulf sturgeon were collected in the Yellow River during a 1961 to 1962 survey by FGFC (1964). Commercial landings were occasionally reported prior to the 1984 fishing prohibition (J. Barkuloo, personal communication).

Choctawhatchee Bay Basin

Santa Rosa Sound: The U.S. Environmental Protection Agency (EPA) reported a 23 kg (50 lb) Gulf sturgeon washed up on the beach in Santa Rosa Sound near Navarre, Florida in 1988 (F. Parauka, personal communication).

Choctawhatchee Bay: Four Gulf sturgeon were collected by FDEP biologists on April 27, 1993 from Jolly Bay at the eastern end of Choctawhatchee Bay. The sturgeon ranged in length from 41.2 to 81.9 cm (16.22 to 32.2 in).

Choctawhatchee River: Fifty adult and subadult Gulf sturgeon were collected, tagged and released at the mouth of the Choctawhatchee River in April 1994 by the North Carolina Cooperative Research Unit, North Carolina State University (NCSU) and the FWS (Potak et al. 1995). Twenty-five of the fish were equipped with radio tags. The fish weighed from 2.5 to 72.7 kg (5.5 to 160.3 lb) and ranged in length from 73.8 to 192.0 cm (29.1 to 75.6 in). Twenty-seven Gulf sturgeon were captured, tagged, and released in the Choctawhatchee River between Howell Bluff and Rocky Landing in 1988, 1990, and 1991 by the FWS (FWS 1988, 1990, 1991b). The fish weighed from 4.5 to 52.3 kg (9.9 to 115.3 lb). In addition, a 0.13 kg (0.29 lb) specimen caught by an angler downstream from Caryville, Florida in 1991 was tagged and released by the FWS (FWS 1991b). Three Gulf sturgeon weighing from 17.0 to 26.0 kg (37.5 to 57.3 lb) were collected in the upper Choctawhatchee River below its confluence with Pea River at Geneva, Alabama in August 1991 by the FWS (FWS, unpublished data). Annual sightings are reported from the Choctawhatchee River in south central Alabama (J. Duffy, personal communication).

Pea River: Three Gulf sturgeon 91.0 to 213.0 cm (35.8 to 83.9 in) in length were collected by the AGS during March 1992 about 1.0 to 3.0 km (0.62 to 1.86 mi) in the Pea River above its confluence with the Choctawhatchee River (M. Mettee, personal communication). Annual sightings are reported from the Pea River in south central Alabama (J. Duffy, personal communication).

Apalachicola, Chattahoochee, Flint River Basin

Apalachicola Bay: A 34.0 kg (74.8 lb) Gulf sturgeon was caught by a commercial fisherman in a shrimp trawl in Apalachicola Bay in November 1989 (F. Parauka, personal communication). The fish was taken to the Apalachicola National Estuarine Reserve for observation and was later tagged and released at the point of capture by the FWS. A 34.5 kg (76.0 lb) Gulf sturgeon was captured, tagged and released in Apalachicola Bay, south of Hwy 98 bridge in March 1988. Also, in March 1987, a 34.0 kg (74.6 lb) Gulf sturgeon was captured, tagged and released in Apalachicola Bay, north of Hwy 98 bridge (F. Parauka, personal communication). Incidental captures by commercial shrimpers and gill net fishermen in Apalachicola Bay were noted by Wooley and Crateau (1985) and reported by Swift et al. (1977).

Apalachicola River: The FWS Panama City, Florida Field Office has monitored the Apalachicola River Gulf sturgeon population since 1979. Three-hundred and fifty Gulf sturgeon were collected below Jim Woodruff Lock and Dam (JWLD), tagged and recaptured from May through September, 1981 through 1993. The number of fish staying below the dam in the summer was estimated using a modified Schnabel method. Fish smaller than 45.0 cm (17.7 in) TL were excluded because of sampling bias caused by net selectivity. Since 1984, the estimated annual number of fish ranged from 96 to 131 with a mean of 115 (FWS 1990, 1991b, 1992). A 145 cm (57.1 in) FL specimen was captured by FDEP (FSBC 640008) on October 28, 1970 in the river. The FGFC (1964) collected Gulf sturgeon during their anadromous fish survey conducted from 1954 to 1964.

A report of the U.S. Commission on Fish and Fisheries (1902) indicated the Apalachicola River provided the largest and most economically important commercial sturgeon fishery in Florida in 1901. Archie Carr (personal communication) noted that 32 families commercially fished for Gulf sturgeon in the mid-1940's. A commercial fishery continued until the late 1970's with only a few families. Sport fishing for Gulf sturgeon in the spring, and to a lesser extent in the fall, in some of the deeper holes in the Apalachicola River below the JWLD produced fish up to 73 kg (160.9 lb) and 2.3 m (7.5 ft) long (Tallahassee Democrat 1958, 1963, 1969).

Brothers River: Archie Carr (1978 and personal communication) began studying Gulf sturgeon in the Apalachicola River in 1975 and caught only eight sturgeon in 23 days of set-netting in Brothers Creek.

Flint River: Swift et al. (1977) noted a report of a 209 kg (460.8 lb) specimen from the Flint River near Albany, Georgia before 1950, prior to the completion of JWLD in 1957.

Ochlockonee River Basin

Ochlockonee River: Four Gulf sturgeon weighing from 2.0 to 4.0 kg (4.4 to 8.8 lb) were collected in the lower Ochlockonee River at the mouth of Womack Creek in June 1991 (FWS/Panama City and National Biological Survey/Southeastern Biological Service Center-Gainesville (NBS/SBSC-G), unpublished data). Gulf sturgeon were commercially fished in the vicinity of Hitchcock Lake in Wakulla County (Swift et al., 1977; Florida Outdoors 1959). The fish were shipped to the town of Apalachicola for processing and sale to the New York City area. Commercial landings comparable to the Apalachicola River fishery were noted in 1901 (U.S. Commission on Fish and Fisheries 1902). However, most commercial fishing for Gulf sturgeon in the river ended in the early 1970's (F. Parauka, personal communication).

Suwannee River Basin

Suwannee River: The Suwannee River appears to support the most viable Gulf sturgeon population among the coastal rivers of the Gulf of Mexico (Huff 1975). The Caribbean Conservation Corporation (CCC) has captured, marked, and released 1,670 spring migrating Gulf sturgeon at the river mouth since 1986. Based on the recapture of marked fish, the annual estimated population size ranged between 2,250 to 3,300 for Gulf sturgeon averaging about 18 kg (39.7 lb) (Carr and Rago, unpublished data). An ongoing complementary study by the NBS/BSC-G (unpublished data) has captured, marked, and released about 1,500 subadults, most of which were less than 15 kg (33.1 lb), throughout the river from March 1988 through March 1992. This river supported a limited commercial Gulf sturgeon fishery from 1899 (U.S. Commission on Fish and Fisheries 1902) until 1984 when the State of Florida prohibited harvest and possession.

Tampa Bay Basin

Tampa Bay: A commercial netter incidentally caught and released a Gulf sturgeon 56.4 cm (1.8 ft) in length, one mile west of Redington Beach near St. Petersburg in December 1992 (Reynolds 1993). Before this time, the most recent Gulf sturgeon catch reported from Tampa Bay was a 144 cm (56.7 in) FL female weighing 25.8 kg (56.9 lb), collected on December 11, 1987 near Pinellas Point (FDEP fish collection records, no collection number). Tampa Bay was the location of the first recorded significant sturgeon fishery on the Gulf of Mexico coast, lasting only three years (U.S. Commission on Fish and Fisheries 1902). The fishery began in 1886-1887 with a catch of 1,500 fish yielding 2,268 kg (5,000 lb) of roe. Two thousand fish and 2,858 kg (6,300 lb) of roe were marketed in 1887-1888. The fishery ended after the 1888-1889 season when only seven sturgeon were caught. Sturgeon catches have been reported sporadically since 1890.

Charlotte Harbor Basin

Charlotte Harbor: A 3.0 kg (6.6 lb) Gulf sturgeon was captured by a commercial mackerel net fisherman near the mouth of Charlotte Harbor on January 29, 1992 (R. Ruiz-Carus, personal communication). The sturgeon was caught on a sand bar near Boca Grande Pass, 2.4 to 3.0 m (7.9 to 9.8 ft) in depth. While specific information was given for this fish, the fishermen related that two or three sturgeon of the same size were released alive from the same net set near Boca Grande Pass. Two other specimens have been reported from Charlotte Harbor (University of Florida/Florida State Museum (UF/FSM) 35332; FSBC 18077), one of which is a 24.3 kg (53.6 lb) specimen now mounted at the Florida Marine Research Institute, FDEP, St. Petersburg, Florida.

BIOLOGICAL CHARACTERISTICS

Habitat

Gulf sturgeon are classified as anadromous, with immature and mature fish participating in freshwater migrations (Huff 1975; Carr 1983; Wooley and Crateau 1985; S. Carr, unpublished data; J. Clugston, unpublished data). Anecdotal information, gillnetting, and biotelemetry have shown that subadults and adults spend eight to nine months each year in rivers and three to four of the coolest months in estuaries or Gulf waters. It appears that Gulf sturgeon less than two years old remain in riverine habitats and estuarine areas throughout the year. Many Gulf sturgeon in the Suwannee River spend summer months near the mouths of springs and cool-water rivers (Foster 1993; S. Carr, unpublished data). The substrate of much of the Suwannee River is sand and limerock, especially in those areas near springs and spring runs.

Wooley and Crateau (1985) reported that Gulf sturgeon in the Apalachicola River utilized the area immediately downstream from JWLD from May through September. The area occupied consisted of the tailrace and spillway basin of JWLD and a large scour hole below the lock. During high flow periods in the late spring when water was passing through open water control gates at JWLD, Gulf sturgeon would congregate in the turbulent flow, often suspended just below the water surface. During the summer, Gulf sturgeon concentrated in the large scour hole below the lock and in the area of the dam spillway basin. This area represented the deepest available water within 25 km (15.5 mi) down-river of the JWLD. Mean total distance moved by Gulf sturgeon during this time was only 0.4 km (0.25 mi). In all cases Gulf sturgeon did not move more than 0.8 km (0.5 mi) from May through September. The area consisted of sand and gravel substrate, water depths ranged from 6.0 to 12.0 m (19.7 to 39.4 ft) with a mean depth of 8.4 m (27.6 ft) and velocities ranged from 60.0 to 90.0 cm/s (2.0 to 3.0 ft/s) with a mean velocity of 64.1 cm/s (2.1 ft/s). Because of the scarcity of historical biological data pertaining to the Gulf sturgeon in the Apalachicola River it is impossible to ascertain whether the area observed as a summer congregation area represents specific historic habitat. It may be the best alternative habitat type available to Gulf sturgeon whose migration upstream was blocked by the construction of JWLD in 1957.

The U.S. Army Corps of Engineers (COE) conducted surveys in this area in November 1991 and October 1992, to characterize flows associated with a strong cross current at the lock approach. In November 1991, velocities were measured at a depth 0.06 and 0.24 m (0.2 and 0.8 ft) of the water column, with velocities ranging from 0.19 to 0.67 m/s (0.61 to 2.19 ft/s) during normal powerhouse generation (two turbines on line with trash gate open). The follow-up survey in October 1992 included an additional measurement within the large scour hole below the lock at a depth within 0.6 m (2 ft) of the bottom. Velocities ranged from 0.08 to 0.92 m/s (0.25 to 3.01 ft/s) for normal powerhouse generation (with or without the trash gate open; with velocities at the bottom of the scour hole ranging from 0.11 to 0.37 m/s (0.36 to 1.2 ft/s) (COE 1993; COE 1994).

The Brothers River, a tributary entering the lower Apalachicola River at river km 19.3 (river mi 12.0) appears to be a staging area for Gulf sturgeon leaving the river (Odenkirk 1989). This was a favorite location for commercial Gulf sturgeon netting in past years (J. Fichera, personal communication). The Brothers River is a sluggish river with deep holes, swampy banks, and a sand and rock bottom. Wooley and Crateau (1985) characterized the habitat as having a mean depth of 11.0 m (36.1 ft), water depths ranged from 8.0 to 18.0 m (26.2 to 59.0 ft) and velocities ranged from 0.58 to 0.75 m/s (1.9 to 2.46 ft/s) with a mean velocity of .60 m/s (1.97 ft/s).

Swift et al. (1977) reported that local fishermen believed that Gulf sturgeon spawning occurred in June in the deeper holes and "lakes" along the rivers. Swift also reported that Gulf sturgeon were caught by sport fisherman from deep holes in the Apalachicola River below Jim Woodruff Dam during the spring and fall in the late 1950's to the late 1960's.

The WES reported the river conditions during collection of two Gulf sturgeon from the west Middle Pearl River on March 1, 1995. The conditions for at the surface and in 7.62 m (25 ft) of water were: temperature of 15.3°C (59.6°F) and 15.3°C (59.5°F); conductivity of 68 μmho's/cm; dissolved oxygen of 9.09 and 8.80 mg/l; pH of 6.64 and 6.57; and turbidity at the surface of 32 NTU (M. Chan, personal communication).

Bradshaw (personal communication) noted that 62 of 63 of the Gulf sturgeon collected from the East Pearl River at river km 32.2 (river mi 20) in 1985 were from one location, a deep, 12.2 m (40 ft) hole. He also reported that another Gulf sturgeon was captured at the same location in 1988.

Swift et al. (1977) noted that young Gulf sturgeon were reportedly captured in shrimp trawls in Apalachicola Bay. Muddy, soft bottom substrates, the dominant habitat of the Bay, comprise about 78% of the open water zone (Livingston 1984). Wooley and Crateau (1985) reported one Gulf sturgeon was captured 3.2 km (2.0 mi) from the mouth of Apalachicola River in the Bay in approximately 2 m (6.6 ft) depth over a mud substrate. Several Gulf sturgeon were collected from Gulf waters adjacent to Apalachicola Bay (Wooley and Crateau 1985). One Gulf sturgeon was caught 1.2 km (.75 mi) south of Cape St. George in 6 m (19.7 ft) of water and another Gulf sturgeon was captured 1.6 km (1.0 mi) south of Cape San Blas in 15 m (49.2 ft) of water. Limited stomach analyses from Suwannee and Apalachicola River Gulf sturgeon indicate that mud and sand bottoms and seagrass communities are probably important marine habitats for Gulf sturgeon (Mason and Clugston 1993).

Migration and Movement

The movements of Gulf sturgeon in the Apalachicola, Suwannee, Pearl, and Choctawhatchee rivers have been and are being monitored by ultrasonic and radio telemetry and by conventional fish sampling gear (Foster 1993; Carr 1983; Wooley and Crateau 1985; Odenkirk 1989; Rogillio 1993; Clugston et al., in press; Potak et al. 1995; S. Carr, unpublished data; Odenkirk et al., unpublished manuscript; F. Parauka, personal communication; H. Rogillio, personal communication). In general, subadult and adult Gulf sturgeon began to migrate into rivers from the Gulf of Mexico as river temperatures increased to about 16 to 23°C (60.8 to 75.0°F). They continued to immigrate through early May, but most arrive when temperatures reach 21°C. Gulf sturgeon have been collected as far upstream as river km 221 (river mi 137.3) in the Suwannee River. In the Suwannee River, most radio-tracked Gulf sturgeon appeared to settle into four 3.0 to 15.0 km (1.9 to 9.3 mi) long reaches of the river during the summer (Foster 1993). Upstream migration in the Apalachicola River is blocked at river km 171 (river mi 106.3) by the JWLD. Nearly all radio-tracked Gulf sturgeon remained in the dam tailrace during the summer (Wooley and Crateau 1985; Odenkirk 1989).

Wooley and Crateau (1985) reported that of 99 Gulf sturgeon tagged below JWLD, Apalachicola River, 6 were incidentally captured by shrimp trawlers during the fall season in Apalachicola Bay and the adjacent Gulf of Mexico. Bradshaw (personal communication) notes three Gulf sturgeon he collected and tagged in 1985 from the East Pearl River at river km 32.2 (river mi 20) that were incidentally caught by shrimpers in Mississippi Sound in the fall of that year. One Gulf sturgeon, a 53.0 cm (20.9 in) FL individual, was caught near the west tip of Cat Island, a distance of 64.6 km (40 mi) from the release point on the river.

Subadult and adult Gulf sturgeon in the Suwannee and Apalachicola Rivers generally began downstream migration in late September and October. Wooley and Crateau (1985) found that the Gulf sturgeon at the JWLD began their downstream migration in late fall when the temperature dropped to 23°C (73.4°F). Most return to the estuary or the Gulf of Mexico by mid-November to early December. In the Suwannee River, young Gulf sturgeon from about 0.3 to 2.5 kg (0.7 to 5.5 lb) remained at the river mouth during the winter and spring and were the only Gulf sturgeon captured during December, January and early February over a three year period from late 1987 to 1991 (Clugston et al. 1995). Based on mark-recapture data, these young fish did not appear to venture far into the Gulf of Mexico. Tagging (J. Clugston, unpublished data) and other life history studies (Huff 1975) found small Gulf sturgeon at river distributaries indicating that they were spawned in the Suwannee River.

Radio telemetry studies on the Choctawhatchee River conducted by NCSU in the summer of 1994, found that 25 tagged Gulf sturgeon did not distribute themselves uniformly throughout the river and did not occupy the deepest or coolest water available (Potak et al. 1995). Most fish were concentrated in relatively shallow straight stretches of the river. Of the 25 fish, 23 remained within two primary summer holding areas in the middle to lower river. They were found outside the main channel, where water velocities were less than the maximum available. Most of the fish were in water depths of 1.5 to 3.0 m (4.9 to 9.9 ft) and substrates were silt or clay.

Tagging and radio telemetry studies conducted by the LDWF during 1993 and 1994 showed subadult and adult Gulf sturgeon frequented or moved between specific areas from May through September. The most southern site is known as the Drum Hole on the west Middle Pearl River to the upper and lower Fridays Ditch on the west Middle Pearl River. Telemetry data showed movement of fish between Fridays Ditch to the West Pearl River at Powerline and Yellow Lake. Movement was also observed from Gulf sturgeon tagged from the Boque Chitto River below the sill at the canal and Lake Pontchartrain at Bayou Lacombe (H. Rogillio, personal communication).

Three sonic-tagged Gulf sturgeon were tracked into saline water and monitored in Apalachicola Bay for one to four hours in late October 1987. In November 1989, a Gulf sturgeon was monitored in Apalachicola Bay for 72 hours and tracked for 30.0 km (18.6 mi) (FWS 1988, 1989). Four Gulf sturgeon were similarly tracked in late October 1991 outside the Suwannee River and remained for about a week in water depths of 3.0 m (9.8 ft) and 5.0 km (3.1 mi) offshore in an area of mud bottom (Carr, unpublished data).

Gulf sturgeon tagging studies in the Apalachicola and Suwannee rivers demonstrate the high probability of recapture in the same river in which the fish were tagged. Between 1986 to 1992, approximately 3,750 Gulf sturgeon were tagged in the Suwannee River, and of nearly 700 recaptures, all but two were recovered in the Suwannee River. Those two recaptures occurred in the Apalachicola River and offshore near Tarpon Springs, Florida. From 1981 to 1993, a total of 350 Gulf sturgeon were tagged in the Apalachicola River. Of those, 160 were recaptured in the Apalachicola River, while six individuals were recaptured in the East Pass of the Suwannee River (S. Carr, unpublished data) and one was recaptured in the Ochlockonee River (F. Parauka, personal communication). Of those six individuals recaptured in the Suwannee River, three were recaptured the following year in the East Pass. Radio-tracking further suggests that individuals return to the same area of the river inhabited the previous summer (Foster 1993; Carr, unpublished data; FWS/Panama City, unpublished data).

Small Gulf sturgeon were noted to move southward along the western Florida coast to Florida Bay during the winters of 1957, 1959, and 1962 (D. Robins in personal communication to Wooley and Crateau 1985). Several sturgeon, estimated at 60 cm (23.6 in) FL, were also collected in fish traps in Government Cut, Miami, Florida during the winters of 1957, 1959, and 1962 (D. Robins, personal communication). Vladykov examined one of the specimens internally and determined it to be *A. o. desotoi*. These occurrences may have been in response to unusually low winter temperatures.

Stocks

Stabile et al. (unpublished manuscript) used RFLP analysis of mitochondrial DNA (mtDNA) of Gulf sturgeon collected from six geographically disjunct drainages along the Gulf of Mexico. The river systems included the Suwannee, Apalachicola, Ochlockonee, Blackwater, and Choctawhatchee rivers in Florida and the Pearl River in Louisiana/Mississippi. Their preliminary data analysis indicates that there are significant differences among Gulf sturgeon stocks. They found the most notable difference existed between the Choctawhatchee River samples and samples from other Gulf of Mexico rivers. In addition, the results indicated a break between the Apalachicola/Suwannee river populations and populations to the west of the Apalachicola River. Further, their data suggest that Gulf sturgeon display region-specific affinities and may exhibit river-specific fidelity.

Stabile et al. (unpublished manuscript) also indicated population-level polymorphisms using direct sequence analysis in sturgeon from the Gulf coast rivers. They found that Gulf sturgeon analyzed from the Pearl River exhibited haplotypes that were different from all other Gulf coast samples. Polymorphisms at other sites indicated possibly useful markers for discriminating sturgeon from the Choctawhatchee and Yellow rivers. No significant differences of mtDNA haplotypes were found among Gulf sturgeon from the eastern Gulf coast. However, these results are considered tentative because of the small sample size.

Food Habits

In the Suwannee River, stomachs of Gulf sturgeon 38 to 188 cm (15.0 to 74.0 in) FL caught in commercial gill nets 10.0 m (32.8 ft), 24.5 cm (9.4 in) stretch fished in the lower river in East Pass contained digested aquatic plant material interspersed with crab hard parts (probably blue crab, *Callinectes sapidus*). The relative abundance of crab parts was greater in stomachs of migrants entering the river in spring and usually absent from those exiting in fall (Huff 1975). Gammaridean amphipods were primarily found in smaller schooled Gulf sturgeon <82.0 cm (32.3 in) caught with trammel nets in shallow water 1.0 to 2.0 m (3.3 to 6.6 ft) in depth over a sand bank at the river's mouth (Alligator Pass). These prey species are associated with sandy substrates. Other food items included isopods (*Cyathura burbanki*), midge larvae, mud shrimp (Callianassidae), one eel (*Moringua* sp.), and unidentifiable animal or vegetable matter. Huff concluded that these small Gulf sturgeon occupied a different habitat than larger Gulf sturgeon harvested in the gill net fishery.

Mason and Clugston (1993) studied the food habits of Gulf sturgeon on the Suwannee River from 1988 to 1990. In the spring, immigrating subadult and adult Gulf sturgeon collected from the river mouth contained gammarid, haustoriid, and other amphipods, polychaete and oligochaete annelids, lancelets, and brachiopods. However, once in fresh water, these Gulf sturgeon did not eat as evidenced by the presence of only a greenish-tinged mucus in their guts during June through October. Stephen Carr (unpublished data) found in the Suwannee River that immigrating, sexually mature Gulf sturgeon were mainly empty of food; however, of food items present, brachiopods and mud shrimp dominated. By contrast, a 13.6 kg (30.0 lb) Gulf sturgeon was captured by bait trawlers on Red Bank Reef three miles from the mouth of the Suwannee River in spring 1986. Its stomach contained six species of lugworm, two species of clam, five species of crustacea, an echinoderm (sand dollar), an unidentifiable marine worm and two dozen lancelets (S. Carr, unpublished data). Mason and Clugston (1993) found that small Gulf sturgeon (0.5 to 4.0 kg) (1.1 to 8.8 lb) collected at the river mouth during the winter and early spring contained amphipod and isopod crustaceans, oligochaetes, polychaetes, and chironomid and ceratopogonid larvae. Although the guts of these young Gulf sturgeon contained small amounts of food as they migrated upstream to about river km 55 (river mi 34), they too contained only a detrital mass and were essentially empty in the freshwater reaches during the summer and fall. It remains unclear why most subadult and adult Gulf sturgeon feed for three to four months in a marine environment and enter fresh water where they do not feed for the following eight or nine months.

Growth

Huff (1975) used cross sections of pectoral fin rays to estimate the age of 631 Gulf sturgeon collected from the Suwannee River. Because back calculation using fin ray sections was not possible, mean fork lengths for fish ages 1 through 17 were calculated (Figure 3). Mean fork length at age 1 was approximately 35.0 cm (13.8 in) and increased to approximately 145.0 cm (57.1 in) at age 17.

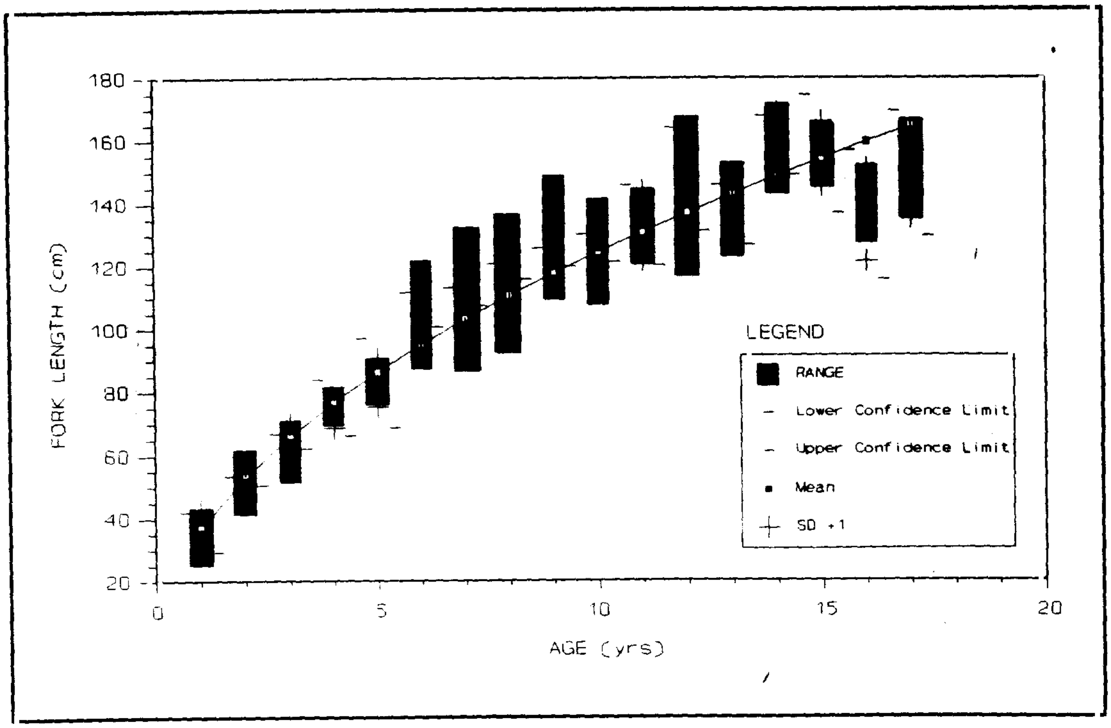

Figure 3: Length-range diagram and regression line,
Gulf sturgeon age groups 1 to 17, from 1972 to 1973 (Huff 1975)

Cross sections of pectoral fin rays were also used to estimate the age of 76 Gulf sturgeon collected from the Apalachicola River, Florida from 1982 to 1990 (Jenkins, unpublished manuscript). Fish ranged from 2 to 28 years old with lengths and weights ranging from 47.0 to 227.0 cm (18.5 to 89.4 in) and 0.2 to 90.7 kg (0.4 to 200.0 lb). Fin rays from four fish exhibited possible spawning belts. Average growth was 24.0 cm (9.4 in) per year for fish two to five years old, and 8.0 cm (3.1 in) per year to the age of eight. Fish marked and later recaptured exhibited similar large growth variations which may be the result of sexual dimorphism. The time of annulus formation was in the late summer and fall, which is a period of weight loss according to mark-recapture studies.

Carr (1983) found that on the average, marked Gulf sturgeon from the Suwannee River gained 30% of body weight in one year. He also noted that little or no growth was seen when recapture occurred during the same season and a little weight was lost by some. Wooley and Crateau (1985) noted that Gulf sturgeon 80.0 to 114.0 cm (31.5 to 44.9 in) FL tagged in early summer in the Apalachicola River below JWLD and subsequently recaptured in the same area in July and September exhibited weight losses of 4% to 15% or 0.5 to 2.3 kg (1.1 to 5.1 lb). Gulf sturgeon from 75.5 to 101.0 cm (29.7 to 39.8 in) FL tagged in September and recaptured the following year between May and September, after spending the winter period feeding in Apalachicola Bay and/or the Gulf of Mexico, showed weight gains of 35% to 137% or 4.3 to 10.2 kg (9.5 to 22.5 lb). These growth rates are considered normal for young Gulf sturgeon.

The recapture of 229 marked fish provided an opportunity to calculate seasonal growth rates of Gulf sturgeon in the Suwannee River (Clugston et al. 1995). It appears that Gulf sturgeon gain weight only during the winter and spring while in marine or estuarine waters and lose weight during the eight to nine month period while in fresh water. In general, Gulf sturgeon weighing between 7.0 kg (15.4 lb) and 27.0 kg (59.5 lb) grew about 11.0 cm (4.3 in) and gained 2.0 to 3.0 kg (4.4 to 6.6 lb) per year. In nearly all cases, however, fish that were marked and recaptured during the same summer lost weight. Those recaptures that spanned the three or four months that most fish were in the Gulf of Mexico increased in weight. Likewise, the young fish collected at the mouth of the river during the winter and spring and recaptured during the same period increased in weight. Lengths and weights were monitored for two Gulf sturgeon hatched and reared for 17 months under laboratory conditions (Mason et al., 1992). In the first year these fish grew to 71.9 cm (28.3 in) and 63.4 cm (25.0 in) in total length and to weights of 1.9 kg (4.2 lb) and 1.4 kg (3.1 lb). After 17 months they grew to 84.6 cm (33.3 in) and 78.7 cm (31.0 in) and to 3.1 kg (6.7 lb) and 2.7 kg (6.0 lb). These two fish received special treatment, and their growth in the laboratory may not represent growth of wild fish. Nevertheless, the data represent the first measured growth of young Gulf sturgeon and provide insight into the species' growth potential.

Reproduction

Timing, location and habitat requirements for Gulf sturgeon spawning are not well documented. Most subadult and adult Gulf sturgeon ascend coastal rivers from the Gulf of Mexico from mid-February through April when some adults are sexually mature and in ripe condition. Studies conducted on the Apalachicola River resulted in the only known collection of wild Gulf sturgeon larvae. Two larvae were collected at river km 168 (river mi 104.2); one on May 11, 1977 (Wooley et al., 1982) and one on May 1, 1987 (Foster et al., 1988). At the time of the 1977 collection, the surface water temperature was 23.9°C (75.0°F), water depth 4.2 m (13.78 ft), flow 365.0 m^3/s (12,888.0 ft^3/s), and velocity of .67 m/s (2.2 ft/s). During the 1987 collection the surface water temperature was 21.6°C (70.9°F), water depth 4.2 m (13.8 ft), flow 437.0 m^3/s (15430.0 ft^3/s), velocity not measured. The larva collected in 1977 was estimated to be 1 to 2 days old while the other larva was estimated to be a few hours old. A third larva was collected on April 3, 1987 at river km 18.7 (river mi 11.6) at a water temperature of 16.1°C (61.0°F), water depth 7.9 m (25.9 ft), flow not measured, and velocity .96 m/s (3.2 ft/s). The larva was estimated to be about 1 to 1.5 days old (FWS 1988).

Huff (1975) spent considerable time using anchored plankton nets to collect Gulf sturgeon eggs and larvae in the Suwannee River but was unsuccessful. However, two Gulf sturgeon eggs were collected in the river on April 22, 1993 (Marchant and Shutters, unpublished manuscript). The eggs were collected in water depths of 5.5 m and 7.3 m (18.0 ft and 24.0 ft) and water temperature 18.3°C (65.0°F) at river km 215 (river mi 134.2), just downstream of the confluence of the Alapaha River. Additional eggs were collected during late March and April 1994 at river km 201 to 221 (river mi 124.9 to 137.3) when water temperatures ranged from 18.8°C to 20.1°C (65.8°F to 68.2°F)(Smith and Clugston, unpublished manuscript). From 1988 through 1992, Gulf sturgeon investigations were conducted throughout the Suwannee River using plankton nets, small-mesh trap nets, trawls and gill nets, and electrofishing equipment. The smallest Gulf sturgeon collected was a 30.6 cm (12.0 in) specimen weighing 85.0 g (0.2 lb) at river km 215.0 (river mi 133.6) on December 3, 1991 (Clugston et al. 1995).

Stephen Carr and F. Tatman (unpublished data) found that 15 ultrasonic-tagged gravid females were associated with springs between river kms 32.0 and 145.0 (river mi 19.9 and 90.1) in the Suwannee River. The bottom habitats surrounding the springs consist mainly of rock. Their consistent association with these springs has led to Carr's speculation that spawning occurs in these areas.

Remnant reproductive populations may still occur in many small and large rivers draining into the Gulf where Gulf sturgeon have historically ranged. Infrequent anecdotal reports and incidental captures of small Gulf sturgeon indicate that reproduction is occurring in tributary rivers. Small Gulf sturgeon are closely associated with the river basin where they were spawned (river-specific affinity). This has been demonstrated in the Suwannee River and Apalachicola River/Bay distributaries, by the occurrence of similar size Gulf sturgeon in similar depths, and on similar substrate. Any analogous occurrence of small Gulf sturgeon suggests that a reproducing population remains nearby.

Spawning Age

Huff (1975) found that sexually mature females ranged in age from 8 to 17 years and sexually mature males from 7 to 21 years in the Suwannee River. The youngest ripe female specimen and the oldest immature female were age 12. The youngest ripe male specimen was 9 years old and the oldest immature male was age 10. Jenkins (unpublished manuscript) estimated a ripe male captured from the Suwannee River in 1990 to be six to seven years old.

Fecundity

Chapman et al. (1993) reported that three mature Gulf sturgeon had 458,080, 274,680, and 475,000 eggs and were estimated to have an average fecundity of 20,652 eggs/kg (9,366 eggs/lb). Smith et al. (1980) estimated that Atlantic sturgeon weighing 50.0 and 100.0 kg (110.2 and 220.5 lb) would yield over 400,000 and 1,000,000 eggs, respectively.

Gulf sturgeon eggs are demersal and adhesive (Vladykov 1963; Huff 1975; Parauka et al., 1991; Chapman et al., 1993). The eggs are globular and vary in color from gray to brown to black. Smith et al. (1980) reported that Atlantic sturgeon eggs ranged in size from 2.5 to 3.0 mm (0.10 to 0.12 in) in diameter. Parauka et al., (1991) found that eggs from Gulf sturgeon averaged 2.10 and 2.20 mm (0.08 to 0.09 in) in diameter.

Reproduction in Hatcheries

Hormone-induced ovulation and spawning of Gulf sturgeon was accomplished in 1989 at a portable hatchery located on the Suwannee River and at the Welaka National Fish Hatchery in

Florida (Parauka et al., 1991). The project was a joint effort involving the FWS, CCC, and University of California, Davis. The initial spawning produced 5,000 fry for fishery research. In 1990, 1991, and 1992, the University of Florida, the FWS, and CCC again successfully induced spawning and produced about 60,000 fry for fish culture programs. Hatching time for the artificially spawned Gulf sturgeon eggs ranged from 85.5 hr at 18.4°C (65.1°F) to 54.4 hr at about 23.0°C (73.4°F) (Figure 4) (Parauka et al., 1991). Also, at temperatures ranging from 15.6 to 17.2°C (60.1 to 63.0°F) and 19.5 to 21.0°C (67.1 to 69.8°F), eggs hatched in 95 and 65 to 70 hr, respectively (FWS 1991b). Chapman et al. (1993) reported that artificially spawned Gulf sturgeon eggs incubated at 20°C (68°F) hatched in 3.5 days. Hatching time for Atlantic sturgeon eggs has been reported to be 94 hr at 20.0°C (68.0°F) (Dean 1893), 121 to 140 hr at 16.0 to 19.0°C (60.8 to 66.2°F) (Smith et al., 1980) and 168 hr at 17.8°C (64.0°F) (Vladykov and Greeley 1963). One-hour-old Gulf sturgeon larvae, hatched under artificial conditions on the Suwannee River in 1989, ranged in length from 0.66 to 0.71 cm (0.26 to 0.28 in) with a mean length of 0.69 cm (0.27 in) (Parauka et al., 1991). Hatching success ranged from 5 to 10%.

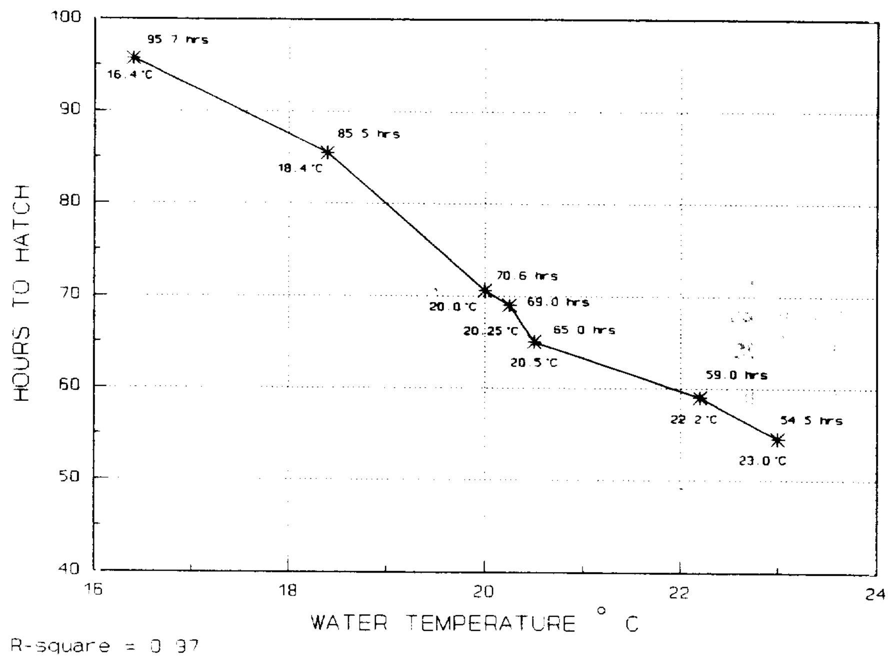

Figure 4: Gulf sturgeon egg incubation periods
at different mean water temperature (F. Parauka et al., 1991; FWS 1991b).

Predator/Prey Relationships

Van Den Avyle (1984) noted there was little written regarding competitors and predators of sturgeon. He pointed out that many fish species live in the same waters as sturgeon and that there is the possibility for competition with other bottom dwelling species. In fresh water, benthic feeders could compete with young sturgeon or feed directly on eggs and larvae. Competition with Gulf sturgeon for food or space in the marine environment is unknown. Scott and Crossman (1973) speculated that the sturgeon's "size and protective plates protect it from most predaceous fishes and its habitat and secretiveness from other predators."

Parasites and Disease

Fish lice *Argulus stizostethi*, an ectoparasitic copepod, have occasionally been observed on the opercula and gill filaments and in the gut of Gulf sturgeon collected in fresh and estuarine water. The numbers noted were not significant (Mason and Clugston 1993; F. Parauka, personal communication). Endoparasites, such as nematodes, trematodes, and leeches were noted in the guts of Gulf sturgeon (Mason and Clugston 1993). Five species of helminth parasites and one parasitic arthropod have been identified in Atlantic sturgeon from the St. Johns River, New Brunswick (Appey and Dadswell 1978). No detrimental effects from these parasites were noted in these studies.

The shovelnose sturgeon serves as host for glochidia of three mussel species. Rates of glochidial infestation on fish gills are typically low, but thought not to be detrimental to the host (R.S. Butler, personal communication). Huff (1975) reported tumor-like growths on several Gulf sturgeon ovaries from the Suwannee River. Macroscopic tumors were found from 7.5% of gill-netted females in Fall 1972, 3.5% of females in Spring 1973, and 4.6% of females in Fall 1973. Examination of this material revealed two types of growth (Harshbarger 1975). One was a perifollicular pseudocyst (surrounding follicles) filled with proteinaceous fluid often containing viable oocytes. The other type was a parafollicular serous cyst (a true separate fluid-filled cyst) containing denser proteinaceous fluid. Both types are considered subclinical, having little or no effect on adjacent organs, general ovarian development, fecundity, or spawning behavior. Microscopic slides (RTLA nos. 979 and 980) containing this material were accessioned by the Registry of Tumors in Lower Animals, Smithsonian Institution (Huff 1975). Moser and Ross (1993) reported the capture of six Atlantic sturgeon from the Brunswick River, North Carolina from June to September 1991 and in April 1992. Three of the specimen were in poor condition with abnormalities characterized by deformed mouths, lesions of the ventral buccal region and/or lesions around the eye. Oral, buccal, and ventral lesions or ulterations are common signs of poor water quality. Veterinarians examined another sturgeon from the Brunswick River that died without external evidence of disease and found the liver and heart tissues to be in poor condition.

FACTORS CONTRIBUTING TO THE DECLINE AND IMPEDIMENTS TO RECOVERY

Many members of the family Acipenseridae, including Gulf sturgeon, virtually disappeared throughout their ranges at the turn of the 20th century. Their decline was likely caused by over-exploitation and exacerbated by damming of rivers and other forms of habitat destruction and water quality deterioration, among other factors (Birstein 1993; Huff 1975; Barkuloo 1988; McDowall 1988; Smith and Clugston, unpublished manuscript).

Exploitation

The Gulf sturgeon was heavily fished because of the high value of its eggs used to produce caviar and its flesh for smoking (Carr 1983; J. Barkuloo, personal communication). Sturgeon also provided isinglass, a semi-transparent gelatin prepared from the swim bladder and used in jellies, wine and beer clarification, special cements, and glues. Directed commercial fishing contributed to the depletion of sturgeon populations. Aperiodic commercial landing statistics are available from 1887 to 1985 for Gulf sturgeon (Huff 1975; Futch 1984; Barkuloo 1988). Commercial landings data for the Suwannee River are available for 1981 to 1984 (Tatman, unpublished data). These records show that the only consistent fisheries for Gulf sturgeon occurred in west Florida. There was a directed fishery in Alabama, while there is no record of a directed commercial fishery in Mississippi, only incidental catches. Davis et al., (1970) notes a minor commercial fishery for Gulf sturgeon in the Lake Pontchartrain and its tributaries during the late 1960's.

Recreational and subsistence fishing may have contributed to population declines. A "snatch-hook" recreational fishery was popular on the Apalachicola River, Florida, during the late 1950's to 1960's (Burgess 1963; Swift et al., 1977) and continued until 1984 when the State of Florida enacted protective measures.

Incidental Catch

Incidental catch of Gulf sturgeon in other fisheries has been documented (Wooley and Crateau 1985; D. Mowbray, personal communication; H. Rogillio, personal communication). Incidental captures by commercial shrimpers and gill net fishermen in Apalachicola Bay were noted by Wooley and Crateau (1985) and reported by Swift et al. (1977). Such catches have also occurred in Mobile Bay, Tampa Bay, and Charlotte Harbor (J. Roussos, personal communication; FDEP, unpublished data). The FWS caught a small Gulf sturgeon in St. Andrew Bay while gill-net collecting for seatrout for contaminant analysis in 1986 (M. Brim, personal communication). Gulf sturgeon are occasionally caught in Gulf coast rivers on set-hooks targeting catfish (J. Duffy, personal communication). Captures of young Gulf sturgeon have been reported in blue crab traps in the Suwannee River estuary (F. Tatman, personal communication). The incidental catch of Gulf sturgeon in the industrial bottomfish (petfood) fishery in the north-central Gulf of Mexico from 1959 to 1963 was reported by Roithmayr (1965). The bottomfish fishery worked an area between Point au Fer, Louisiana and Perdido Bay, Florida from shore to water depths of about 55 m (180 ft). Hastings (1983) and Moser and Ross (1993) report capture and disruption of spawning migrations of shortnose and Atlantic sturgeon in commercial gill nets targeted for shad in the Cape Fear River, North Carolina.

The LDWF records indicate 177 Gulf sturgeon were incidentally captured and reported by commercial fishermen in southeastern Louisiana during 1992 (H. Rogillio, personal communication). Forty-four of these Gulf sturgeon were delivered to the LDWF field office or held until LDWF employees could secure them. Specimens were generally held in captivity for 1 to 7 days by the fishermen. These sturgeon were then measured, weighed, tagged and released by departmental personnel. Seventy-six Gulf sturgeon were captured in trawls, 10 in wing nets, and 91 in gill nets. A mortality of less than 1% was noted. This percentage is based on 177 Gulf sturgeon incidentally captured by commercial fishermen and 51 Gulf sturgeon captured by LDWF personnel during a Gulf sturgeon status survey.

Bradshaw (personal communication) reported three tag returns from Gulf sturgeon he collected in early 1985 which were incidentally caught by shrimpers in Mississippi Sound during the fall of that year. He also noted finding three dead Gulf sturgeon incidentally caught by gillnetters in the western part of the Sound and revived another Gulf sturgeon a gillnetter had caught "on" Horn Island in 1989.

Entrainment of *Acipenser guldenstadti* and *A. stellatus* larvae during dredging operations has been assessed by Veshchev (1982) in the lower Volga River, Russia. He concluded that hydraulic dredging operations caused significant mortality of sturgeon larvae in the Caspian basin.

Hastings (1983) reported anecdotal accounts of adult sturgeon being expelled from dredge spoil pipes while conducting a study on shortnose sturgeon on the Atlantic coast. Whether the "adult sturgeon" was an Atlantic or shortnose sturgeon was not indicated in the report.

Habitat Reduction and Degradation

Gulf sturgeon have evolved within Gulf coast drainages that exhibit seasonal patterns of high and low flows, temperature regimes, sedimentation, and other physical factors. Provision of these essential life requirements are part of and dependent on a fully functioning ecosystem.

Dams have limited sturgeon access to migration routes and historic spawning areas (Boschung 1976; Murawski and Pacheco 1977; Wooley and Crateau 1985; McDowall 1988) (Table 1). While sturgeon are able to pass some water control structures, low-head dams, or sills during high water, these structures can create barriers that preclude normal migration. An example of complete migration restriction occurred in the St. Andrew Bay system, Bay County, Florida. A newspaper account from 1895 reports sturgeon were caught at the head of North Bay in upper St. Andrew Bay (Womack 1991). The account notes that an average of three sturgeon a day were caught and 90.7 kg (200 lb) of fish had been smoked and on sale for $0.10 per lb. The FGFC collected four Gulf sturgeon 173.0 to 201.5 cm (68.1 to 79.3 in) in length from Bear Creek, a tributary to Econfina Creek which drains into North Bay, in May of 1961. A dam was placed across North Bay in 1962 preventing anadromous fish migration, and no reports of Gulf sturgeon from above the dam have been reported since that time. Not only was migration to the creeks cutoff, but approximately 2024 hectares (5,000 acres) of estuarine habitat was converted into a fresh water lake.

Another example of complete restriction to Gulf sturgeon migration is the JWLD on the Apalachicola River. Swift et al. (1977) noted a report of a Gulf sturgeon from the Flint River near Albany, Georgia prior to 1950. Huff (1975) noted Gulf sturgeon migrated 322 km

Table 1: Examples of reduction in available river habitat due to dam, water control structure, or sill construction.

River/Watershed	Total River Length	Location of Impediment	Percent Habitat Remaining
St. Andrew Bay Drainage Bear Creek, Lower Econfina Creek, upper North Bay (now known as Deer Point Lake)	11 km (6.8 mi)	Deer Point Dam County Rd 2321	0%
Apalachicola, Chattahoochee, Flint River Basin (to the fall line)	790 km (491 mi)	JWLD river km 172 (river mi 107)	22%
Mobile Bay Drainage Basin Alabama River	1691 km (1051 mi)	Claiborne Dam river km 130 (river mi 81)	8%
Tombigbee River	988 km (614 mi)	Coffeeville Dam river km 121 (river mi 75)	12%
Pearl River	772 km (480 mi)	Ross Barnett Dam (RBD) river km 486 (river mi 302)	63%
During low water conditions		Pools Bluff Sill river km 78.3 (river mi 48.7)	10%
Bogue Chitto River (during low water conditions)	217 km (135 mi)	Boque Chitto Sill river km 6.4 (river mi 4)	3%
Amite River	274 km (170 mi)	control weir river km 40.7 (river mi 25.3)	15%

(200 mi) upstream in the Apalachicola-Chattahoochee-Flint river system before the dam construction in 1957. There are numerous anecdotal reports of Gulf sturgeon in the Flint and Chattahoochee rivers prior to construction of JWLD (Swift et al. 1977). In spite of many tagging studies conducted on the Apalachicola River, no tags have been returned as a result of Gulf sturgeon moving upstream of JWLD, nor does evidence exist that the Gulf sturgeon passes though the lock system (A. Carr, personal communication; U.S. Fish and Wildlife Service, personal communication). The COE (1978) acknowledged that the dam on the Apalachicola River adversely affect Gulf sturgeon by impeding upstream migration.

An example of barriers that limit movement is found in the Pearl River basin above the Pools Bluff and Bogue Chitto Sills. Gulf sturgeon have been reported to be incidentally collected above the Pools Bluff Sill as far north as the Ross Barnett Reservoir spillway as late as 1984 (J. Stewart, personal communication; R. Jones, personal communication; W. McDearman, personal communication; R. Bowker, personal communication). Based on gauge data (COE, personal communication), the duration of water depths allowing passage of Gulf sturgeon over the sills is limited at the Bogue Chitto Sill and less restrictive at the Pools Bluff Sill (Table 2). It appears Gulf sturgeon movement above the sills is also possible through cutoffs that have developed since the construction of the Pearl River navigation canal (H. Poitevint, personal communication). However, Gulf sturgeon migration is entirely prevented above Jackson, Mississippi by the Ross Barnett Dam at river km 515 (river mi 320). Jones (personal communication) reports that Gulf sturgeon were historically found above this area. He notes the capture of a 154.2 kg (340 lb) female Gulf sturgeon 2.3 m (7.5 ft) from the river 32 km (20 mi) north of Jackson in 1942.

Navigation activities including dam construction, dredging, dredged material, and other maintenance actions could adversely affect Gulf sturgeon habitats depending on the location and timing of the activity. Elimination of deep holes and alterations of rock substrates result in loss of habitat for the Gulf sturgeon in the Apalachicola River (Carr 1983; Wooley and Crateau 1985). At Rock Bluff, river km 148.8 (river mi 92.5), this deep, rocky area frequently used by Gulf sturgeon was filled with dredged spoil material drifting downstream from a within bank disposal site at river km 150 (river mi 93) during routine maintenance dredging. This caused Gulf sturgeon to cease use of this area as a regular habitat (Carr 1983, J. Barkuloo, personal communication). The within bank disposal site is no longer used. Essential habitats of young-of-the-year Gulf sturgeon are unknown, so the impacts of dredging on early life stage habitats of Gulf sturgeon are difficult to assess.

Table 2: Duration Data on Lower Pearl River Sills (COE, personal communication).

Depth Over Sill (m)	Percent Equaled or Exceeded	
	Pools Bluff Sill[1]	Bogue Chitto Sill[2]
.3 m (1.0 ft)	100	90
.61 m (2.0 ft)	70	25
.9 m (3.0 ft)	48	10
1.2 m (4.0 ft)	35	-
1.5 m (5.0 ft)	28	-
1.8 m (6.0 ft)	24	-
2.1 m (7.0 ft)	18	-

[1]Duration based on gauge data for Pearl River at Bogulusa, Louisiana
[2]Duration based on gauge data for Bogue Chitto River at Sun, Louisiana

The entrenchment of the Apalachicola River's streambed due to the trapping of sediments in Lake Seminole, has been attributed to the construction of JWLD (COE 1986). The effects entrenchment occurred in the upper third of the river from the base of the dam to the vicinity of Blountstown, Florida. The streambed elevation lowering was also exacerbated by deepening rock sills, cutting out river bends, and repeated dredging to maintain the channel. This has resulted in elimination of some habitats that had been available to Gulf sturgeon during the summer months prior to the construction of JWLD and navigation channels. For example, as a result of streambed degradation, access to spring-fed tributary creeks has been reduced during low water periods. A cooperative effort by the COE and FGFC removed sedimentation and debris from a midstream spring below the JWLD, navigation km 170.6 (navigation mi 106.0) in January 1994. In addition, the COE obtained environmental clearances and unertook habitat restoration action by the removal of sediments at the mouth of Blue Spring Run, navigation 157.7 (river mi 98.0) in May, 1994.

Cool water habitats are thought to be important to Gulf sturgeon during the summer. Cool-water habitats in streams can be significantly reduced or even eliminated by decreased groundwater levels (Lynn Torak, personal communication). Springs emanating from the streambed originate in the groundwater-flow system and are regulated by relative differences in stream stage, spring-discharge elevation, and groundwater level. Decreased groundwater levels in the vicinity of streams, caused by pumping or climatic variation, can reduce springflow that provides cool-water habitats for the Gulf sturgeon during summer months. Pumping or climate-induced groundwater-level declines can reduce the groundwater component of streamflow (baseflow) in addition to and in the absence of springs. For example, a study in the Albany, Georgia area by Torak et al. (1993) indicates that about 74% of water pumped from the Upper Floridan aquifer in November 1985, approximately 79 million gallons a day, would have discharged to the Flint River under predevelopment conditions. The Flint River is generally unregulated and has a major spring-fed flow component that, in comparison with the Chattahoochee River, contributes the larger share of flow to the Apalachicola River during low-flow periods. The Chattahoochee River is a regulated stream that derives its flow predominantly from surface runoff. Consequently, the Chattahoochee River contributes the major portion of flow to the Apalachicola River during mean- to high-water events. Base-flow of the Flint River has been reduced since the early 1970s, mainly from groundwater and surface water irrigation withdrawals (Leitman et al. 1993). The analysis by Leitman et al. (1993) indicates that the Flint River's percent contribution to the Apalachicola River decreases, instead of increasing as would be expected as the flow in the Apalachicola River decreases. Several springs and spring runs along the upper Apalachicola and Flint Rivers have already exhibited greatly reduced flow or have ceased flowing during periods of drought. If these cool water habitats are important and are reduced in size or eliminated at critical periods of summer, Gulf sturgeon could be subjected to increased environmental stress.

Contaminants may also contribute to population declines. Experiments have shown that DDT and its derivatives and toxaphene are toxic to fish in minute quantities (Johnson and Finley 1980; White et al. 1983). Twelve Gulf sturgeon were collected from the Apalachicola, Suwannee, Choctawhatchee rivers, Ochlockonee Bay and the Gulf of Mexico near Cape San Blas, Florida, at various times between 1985 to 1991. This specimens were analyzed for pesticides and heavy metals (Bateman and Brim 1994). The Gulf sturgeon ranged in size from 1.8 to 49.0 kg (4.0 to 108.0 lb). Concentrations of arsenic, mercury, DDT metabolites, toxaphene, polycyclic aromatic hydrocarbons, and aliphatic hydrocarbons high enough to warrant concern were detected in individual fish. Specific sources of contamination were not identified. Suwannee River Gulf sturgeon had higher concentrations of arsenic in liver samples than Apalachicola River fish. However, Apalachicola River Gulf sturgeon had higher liver mercury concentrations. Organochlorine pesticides were also highest in fish from the Apalachicola River.

Organochlorines enter the environment as pesticides or industrial waste products. Use of most of these compounds has been prohibited because of effects on nontarget species and suspected carcinogenicity in humans and wildlife. Effects include reproductive failure, reduced survival of young, or physiological alterations which can affect the ability of the fish to withstand stress (White et al. 1983). Levels of DDT and derivative compounds in the samples were found at low concentrations in all Gulf sturgeon tissues, however, DDD and/or DDE was detected in 84% of the samples (Bateman and Brim 1994). In addition, amounts detected in reproductive tissue, while relatively low (range non-detect to 4.02 ppm), could affect Gulf sturgeon reproduction because DDT compounds are known to be estrogenic (Fox 1992). Like DDT, toxaphene is persistent in the environment and biomagnifies through the food chain. Toxaphene was the most heavily used insecticide after prohibition of DDT in the 1970s. Toxaphene was detected in four fish, all from the Apalachicola River. The level of toxaphene in the roe of one specimen was 14.00 ppm wet weight and exceeded the Food and Drug Administration (FDA) action level of 5.00 ppm for fish for human consumption. The highest level in muscle tissue (0.48 ppm) fell below the FDA action level for human consumption (Bateman and Brim 1994). Toxaphene is more toxic to fishes than DDT compounds (Johnson and Finley 1980) and has been shown to impair reproduction, reduce growth in adults and juveniles, and alter collagen formation in fry, resulting in "broken back syndrome" (Mayer and Mehrle 1977).

Polycyclic aromatic hydrocarbons (PAH), primarily from petroleum products, are known to be carcinogenic, cocarcinogenic and tumorigenic. Concentrations found in the ovarian tissue sample (total PAH 410 ppb; Apalachicola River) and eggs (total PAH 409 and 815 ppb; Suwannee River) could adversely affect development and survival of some percentage of eggs, larval, and juvenile fish (Bateman and Brim 1994). Aliphatic hydrocarbons are components of oils, fuels, and other petroleum products. Two or more aliphatic compounds were detected in all tissue samples of the Gulf sturgeon. Hall and Coon (1988) stated that it is likely that any animal with demonstrated petroleum hydrocarbon residues in the tissues has suffered effects of the pollutant (Bateman and Brim 1994).

Arsenic is used in herbicides, insecticides, and fungicides and can be toxic to fish in certain metabolic forms. The metal was detected in 92% of the Gulf sturgeon samples, however the metabolic form was not identified. The arsenic concentrations detected in all of the muscle tissue samples were greater than the FDA action limit of 0.50 ppm for swine muscle tissue (Bateman and Brim 1994).

Mercury, predominantly found as methylmercury in fish fillets, is highly toxic and was detected in 87% of the Gulf sturgeon samples. The mercury concentrations in muscle tissue were well below the Florida limited consumption advisory (0.50 ppm) and the FDA consumptive use action level (1.00 ppm) but, almost all tissue samples exceeded the predator protection limit of 0.10 ppm recommended by Eisler (1987) for the protection of fish-eating birds. However, the mercury levels of the Gulf sturgeon in the study were well below those reported by Armstrong (1979) for other fish species, to cause either chronic inability to catch food, rolling from side to side or acute toxicity.

Cadmium, a known teratogen, carcinogen, and probable mutagen was detected in 42% of the Gulf sturgeon samples. The concentrations were in the low to normal range for muscle and liver tissue when compared to fish species in the Fisheries Resources Trace Elements Survey (FRTES) of the NMFS (Bateman and Brim 1994). Low levels of lead were detected in 8%.

Culture and Accidental or Intentional Introductions

Where viable wild populations exist or sturgeon possibly can be reintroduced, the potential harm from incidental or accidental introduction of non-endemic species is a threat to the genetic integrity and biodiversity of entire ecosystems. The likelihood of these introductions increases dramatically where imports and culture of exotic species is allowed or facilitated, and even where laws or regulations exist which prohibit release of non-endemic species. Accidental releases from culture facilities and intentional releases by aquarists tiring of their hobby is a frequent occurrence. Schwartz (1972, 1981) identifies bibliographic citations of hybrid combinations between species of sturgeons (Acipenseridae). Therefore, an introduction, for example, of white sturgeon from the Pacific coast into Gulf river systems could potentially do great harm to Gulf sturgeon stocks.

An introduction has already occurred in Alabama. A white sturgeon, 50.1 cm (1.6 ft) TL, was caught by a commercial fisherman on a trotline in Lake Weiss, about 2.4 km (1.5 mi) south of Cedar Bluff, Alabama in 1989 (M. Pierson, personal communication). Lake Weiss is part of the upper Coosa River system flowing through Georgia and Alabama. In 1992 a white sturgeon, 96.0 cm (3.15 ft) TL, was caught by a fisherman in the Coosa River east of Birmingham (Sun Herald 1992). This sturgeon was caught about 100 km (62.1 mi) downstream from the 1989 capture. The white sturgeon is thought to have been accidentally released from a private fish hatchery located adjacent to the Coosa River in Georgia. The State of Georgia confiscated the white sturgeon from the hatchery in 1990.

A controversial fishery management problem revolves around the issue of hatchery stocks' adversely affect wild stocks. Hatchery technology has been employed for salmon in the Pacific Northwest for well over thirty years, but salmon stocks in many river systems have recently experienced significant declines. Biologists and many opponents of the hatchery programs attribute these declines on loss of genetic diversity caused by hatchery programs. Proponents of hatcheries argue that the basis of the problem is failure to protect habitat, manage water resources, control harvest, and prevent environmental contamination, among other factors.

These problems and failures may continue to contribute to reductions in stocks of Gulf sturgeon. The problems are readily evident and appropriate actions should be taken to correct them before or in conjuction with introduction of hatchery stock.

Other

Finally, life history characteristics of Gulf sturgeon may complicate and protract recovery efforts. Gulf sturgeon cannot establish a breeding population rapidly because of the long period they require to achieve sexual maturity. Further, Gulf sturgeon appear to be river-specific spawners, although immature Gulf sturgeon occasionally exhibit plasticity in movement or occurrence among Gulf basin rivers. Therefore natural repopulation may be non-existent or very low by Gulf sturgeon migrating from other rivers.

Fishery Management Jurisdiction, Laws, and Policies

The take of Gulf sturgeon is prohibited in the state waters of Louisiana, Mississippi, Alabama, and Florida. Section 6(a) of the ESA provides for extended cooperation with states for the purpose of conserving threatened and endangered species. The Departments of the Interior and Commerce may enter into cooperative agreements with a state, provided the state has an established program for the conservation of a listed species. The agreements authorize the states to implement the authorities and actions of the ESA relative to listed species recovery. Specifically, the states are authorized (1) to conduct investigations to determine the status and requirements for survival of resident species of fish and wildlife (this may include candidate species for listing), and (2) to establish programs, including acquisition of land or aquatic habitat or interests for the conservation of fish and wildlife. Federal funding is also provided to states under the agreements to implement the approved programs. All four of the above mentioned states have entered into Section 6 agreements with the FWS. More detailed descriptions of pertinent agencies, laws, and regulations are provided in Appendix A.

CONSERVATION ACCOMPLISHMENTS

Caribbean Conservation Corporation/Phipps Florida Foundation

1. Initiated tagging of Gulf sturgeon in 1975, using monel tags, in the Apalachicola and Suwannee Rivers which resulted in evidence of home-river fidelity, yearly growth rates, in-river weight loss, and an estimate of population size.

2. Initiated telemetry studies of Gulf sturgeon in 1976, providing evidence of the importance of the Floridian Aquifer to Gulf sturgeon ecology and in-river site fixity.

3. Initiated consultations which resulted in prohibition of take of Gulf sturgeon in the State of Florida.

Gulf States Marine Fisheries Commission

1. Initiated a Gulf sturgeon interjurisdictional fishery management plan in 1990 which evolved into the Gulf Sturgeon Recovery Plan.

National Biological Service, Southeastern Biological Science Center, (BSC-G formerly U.S. Fish and Wildlife Service), Gainesville, Florida

1. Since 1987 conducted comprehensive population and life history studies of Gulf sturgeon in the middle and lower Suwannee River, Florida, in cooperation with the CCC.

2. Facilitated survival and abundance estimates for Gulf sturgeon in the Suwannee River by FWS Resource Analysis Branch using CCC long-term data.

4. Developing relational database on physical, chemical, and biological characteristics of the Suwannee River for use with geographic information system (GIS) software.

5. Evaluating habitat characteristics in areas Gulf sturgeon are known to occupy during the summer months.

6. Conducted studies on movement of hatchery reared Gulf sturgeon released into the Suwannee River.

7. Conducted feasibility study for offshore sonic tracking of Gulf sturgeon.

8. Initiated field sampling in Tampa Bay and the Waccasassa, Steinhatchee, and Ochlockonee rivers to determine presence of Gulf sturgeon and evaluate existing habitat.

9. Provided an analysis of food habits of subadult and adult Gulf sturgeon in the Suwannee River.

10. Provided an assessment of the water quality of the Suwannee River and impacts of natural and human-induced disturbances on the food resources of the Gulf sturgeon.

11. Instituted and maintained a voucher specimen reference collection of Gulf sturgeon foods and provided expert assistance in identification of food organisms.

12. Devised and tested methods for culture of key foods used to rear Gulf sturgeon; amphipod crustaceans, brandling worm, West-African nightcrawler, blackworm, and tubificid oligochaetes.

13. Participated in first artificial spawning of the Gulf sturgeon at a temporary streamside facility in 1989-1991 and in 1992-1993 at the NBS\BSC.

14. Provided the first documented growth of Gulf sturgeon fed natural foods in a laboratory from fry stage to 17 months.

15. Conducted food preference study on cultured juvenile Gulf sturgeon comparing survivorship and growth between live and commercially prepared foods.

16. Identified critical thermal maximum and preferred temperature for cultured juvenile Gulf sturgeon.

17. Conducted investigations into plasma osmotic and metabolic responses to a wide range of experimental salinities.

18. Evaluating the retention rate of passive integrated transponders (PIT tags) and coded wire tags in cultured Gulf sturgeon.

State of Alabama

Alabama Department of Conservation and Natural Resources

1. Established a regulation in 1972 prohibiting all take of sturgeon within the jurisdiction of the State of Alabama.

2. Conducted literature search and field survey in 1991 and 1992 to determine historic and current status of Gulf sturgeon and possible reasons for apparent decline.

3. Conducted sampling of juvenile Gulf sturgeon on the Alabama River from 1990-1992.

4. Conducted feasibility work in 1992 regarding the use of ADCNR's Claude Peteet Mariculture Center in Gulf Shores, Alabama, as a Gulf sturgeon hatchery for the Mobile system.

Alabama Geological Survey

1. Conducted Gulf sturgeon sampling in the Alabama, Mobile, Conecuh, and Choctawhatchee river systems.

State of Florida

Florida Department of Environmental Protection (formerly Florida Department of Natural Resources

1. Conducted an anadromous fish survey, including Gulf sturgeon, in 1970-1971.

2. Completed the first life history study of Gulf sturgeon in the Suwannee River, Florida from 1972-1973.

3. Conducted a status review of Gulf sturgeon in Florida waters in 1984, and recommended prohibition of all take of the species within the jurisdiction of the State of Florida.

Florida Game and Fresh Water Fish Commission

1. Completed F10-R Anadromous Fish Study from 1964-1967.

2. In 1987 listed the Atlantic sturgeon as a Species of Special Concern in: Official list of endangered and potentially endangered fauna and flora in Florida. Florida Game and Fresh Water Fish Commission. 19 pp.

3. In conjuction with the COE, Mobile District, removed sedimentation and debris from a midstream spring below the JWLD on the Apalachicola River, navigation km 170.6 (navigation mi 106.0), to restore important thermal refuge habitat for the Gulf sturgeon and other anadromous species in January 1994.

Florida Marine Fisheries Commission

1. Established a regulation in 1984 prohibiting all take of sturgeon within the jurisdiction of the State of Florida.

University of Florida

1. Artificial propagation of Gulf sturgeon 1991-1995.

State of Mississippi

Gulf Coast Research Laboratory

1. Distributed Gulf sturgeon posters at boat ramps and other appropriate locations during 1992 in order to acquire information and reports on Gulf sturgeon sightings.

Mississippi Department of Wildlife, Fisheries, and Parks

1. Established a regulation in 1974 prohibiting all take of sturgeon within the jurisdiction of the State of Mississippi.

2. Listed the sturgeon as an endangered species in 1974.

3. Conducted Gulf sturgeon investigation and documentation in the Pascagoula River during 1993.

Mississippi State University

1. Documented Gulf sturgeon presence in the lower Pearl River in 1985 and 1988.

2. Documented incidental catches of Gulf sturgeon in Mississippi in 1989.

3. Investigated and documented Gulf sturgeon in the Pascagoula River in 1993.

<u>State of Louisiana</u>

Louisiana Department of Wildlife and Fisheries

1. Initiated a survey in 1990 to assess the status of Gulf sturgeon in Louisiana waters.

2. Initiated a radio-tracking project in 1992 on Gulf sturgeon in the Pearl River drainage and continuing into 1994.

3. Established a computerized data base in 1991 on all pallid and Gulf sturgeon sightings and captures in Louisiana and continues to be updated as needed.

4. Conducted Gulf sturgeon tagging using T-bar and monel tags beginning in 1992 and ongoing in 1994.

5. Collected blood and tissue samples for genetic analysis beginning in 1991 and ongoing in 1994.

6. Established a regulation in 1990 prohibiting all take of sturgeon within the jurisdiction of the State of Louisiana.

<u>State of Texas</u>

Texas Parks and Wildlife Department

1. Conducted sampling for sturgeon in the Rio Grande in 1992 - 1993.

2. Documented historic distribution of sturgeon in Texas.

<u>U.S. Army Corps of Engineers, Mobile District, Mobile, Alabama</u>

1. Restored access into Battle Bend Cutoff on the Apalachicola River, approximate river km 46.3 (river mi 28.8) in 1987.

2. Conducted flow/velocity studies below the JWLD to document velocities in Gulf sturgeon habitat areas during low flow conditions during November 1991 and October 1992, as

part of a Biological Assessment associated with the Jim Woodruff Powerhouse Major Rehabilitation Evaluation Report.

3. In conjuction with the FGFC, removed sedimentation and debris from a midstream spring below the JWLD on the Apalachicola River, navigation km 170.6 (navigation mi 106.0), to restore important thermal refuge habitat for the Gulf sturgeon and other anadromous species in January 1994.

4. Obtained environmental clearances and undertook action to restore habitat for the Gulf sturgeon and other anadromous species by removal of sediments at the mouth of Blue Spring Run, Apalachicola River, navigation km 157.7 (river mi 98.0) in March 1994, under the Department of the Army/National Oceanic and Atmospheric Administration Cooperative Agreement to Create and Restore Fish Habitat.

5. Initiated Anadromous Fish Hatchery Reconnaissance Study in 1987.

6. During January 1994, the COE proposed that the Waterways Experiment Station (WES) consider in the FY 1995 Environmental Impact Research Program (EIRP) a proposal to document issues affecting the protection of sturgeon related to O&M activities in North American rivers. This proposal was submitted because of similar concerns expressed by other COE divisions and districts that operation and maintenance (O&M) projects may impact sturgeon populations. It is also proposed to quantify responses of sturgeon to broad ranges of relevant physical conditions so that risk from O&M activities can be predicted. Districts will be surveyed for specific issues on sturgeon and the scope of problems will be defined. The District has been informed from COE headquarters that funds are available for WES to initiate efforts in FY 1995.

U.S. Army Corps of Engineers, Vicksburg District, Vicksburg, Mississippi

1. Funded a study conducted by WES on Gulf sturgeon in the Pearl River during 1994 and 1995.

U.S. Fish and Wildlife Service

Fisheries Resources Office, Panama City Field Office, Florida

1. First documented in-river habitat usage of Gulf sturgeon in 1977.

2. First documented Gulf sturgeon spawning in the Apalachicola River, Florida in 1977.

3. Investigated methods of externally marking Gulf sturgeon beginning in 1981.

4. Documented the movement of Gulf sturgeon in the Apalachicola River using radio and sonic telemetry devices beginning in 1982.

5. Estimated the Gulf sturgeon population size in the Apalachicola River below JWLD beginning in 1983.

6. Reviewed and validated the morphometric characteristics used in the taxanomic separation of Gulf and Atlantic sturgeon in 1985.

7. Developed field techniques and equipment which aided in the handling of Gulf sturgeon in 1985.

8. Investigated the age structure of Gulf sturgeon in the Apalachicola River by utilizing cross-sections from pectoral fin rays beginning in 1986.

9. Initiated artificial propagation of Gulf sturgeon in 1989.

10. Collected samples for and funded genetic studies on Gulf sturgeon throughout their range beginning in 1990.

11. Collected samples for and funded contaminant tissue analyses of Gulf sturgeon from the Apalachicola and Suwannee rivers, Florida beginning in 1990.

12. Initiated a program through news releases and information posters to document Gulf sturgeon sightings (past and present) from Tampa Bay, Florida to the Mississippi River in 1992.

13. Funded development of a dual radio-sonic telemetry tag in 1992.

14. Compiled and maintained a directory/data base of sturgeon and paddlefish researchers beginning in 1992.

17. Produced a report entitled Gulf Sturgeon Sightings, Historic and Recent - a Summary of Public Responses in 1993.

18. Conducted field investigations to develop a population model for the Gulf sturgeon and to delineate riverine habitat requirements in 1993 and 1994, in cooperation with the NBS, North Carolina Cooperative Fish and Wildlife Research Unit.

Ecological Services, Panama City, Florida

1. Funded preparation of an information report on the Gulf sturgeon, entitled: Gulf of Mexico Sturgeon, *Acipenser oxyrhynchus* (Vladykov), Information. 1980. Unpublished. 15 pp. J.L. Hollowell.

2. Completed a document entitled: Report on the Conservation Status of the Gulf of Mexico Sturgeon *Acipenser oxyrhynchus desotoi* in 1988.

3. **Prepared report entitled, Reconnaissance Report on the Feasibility of Constructing an Anadromous Fish Hatchery Apalachicola River, Florida for the COE, Mobile District in 1989.**

4. **Initiated the proposal to list the Gulf sturgeon under the ESA.**

5. Coordinated development of Gulf Sturgeon Management/Recovery Plan from 1992 to 1995.

Ecological Services, Jacksonville, Florida

1. Prepared the listing package to list the Gulf sturgeon as a threatened species under the ESA (listed September 30, 1991 in conjuction with the Department of Commerce-NOAA).

Ecological Services, Jackson, Mississippi

1. Produced a Mobile River Basin Aquatic Ecosystem Recovery Plan in 1995.

Warm Springs Regional Fisheries Center, Georgia

1. Developed Gulf sturgeon artificial feeding program in 1989.

Welaka National Fish Hatchery, Florida

1. Hormone induced spawning of Gulf sturgeon beginning in 1989.

2. Developed Gulf sturgeon artificial feeding program in 1989.

Gulf Coast Fisheries Coordination Office, Ocean Springs, Mississippi

1. Participated as a technical advisor in development of the Gulf sturgeon Management/Recovery Plan from 1992 to 1995

Memorandum of Understanding (MOU) on Implementation of the Endangered Species Act.

Fourteen federal agencies including the COE, NMFS, FWS, NPS, DOD, MMS, CG and EPA signed the MOU in September of 1994. The purpose of the MOU was to establish a general framework for cooperation and participation among the agencies in accordance with responsibilities under the ESA. The agencies are to work together along with appropriate involvement of the public, states, Indian Tribal governments, and local governments, to achieve the common goal of conserving species listed as threatened or endangered under the ESA by protecting and managing their populations and the ecosystems upon which those populations depend. The cooperating federal agencies involved in recovery of the Gulf sturgeon will now be able to work closer together under the umbrella of this MOU.

II. RECOVERY AND FISHERY MANAGEMENT

OBJECTIVES AND CRITERIA

Objectives constitute those results that are desired to be attained through implementation of the Recovery Plan. Criteria are those factors that define how attaining the objective will be pursued, and what will constitute sucess.

1. Short-term Objective: The short-term recovery objective is to prevent further reduction of existing wild populations of Gulf sturgeon within the range of the subspecies. This objective will apply to all management units within the range of the subspecies. Ongoing recovery actions will continue and additional actions will be initiated as needed.

   Criteria:

   A. Management units will be defined using an ecosystem approach based on river drainages. This approach may also incorporate genetic affinities among populations in different river drainages.

   B. A baseline population index for each management unit will be determined by fishery independent catch-per-unit-effort (CPUE) levels.

   C. Change from the baseline level will be determined by fishery independent CPUE over a three to five year period. This time frame will be sufficient to detect a problem and to provide trend information. The data will be assessed annually.

   D. The short-term objective will be considered achieved for a management unit when the CPUE is not declining (within statistically valid limits) from the baseline level.

2. Long-term Objective A: The long-term recovery objective is to establish population levels that would allow delisting of the Gulf sturgeon by management units. Management units could be delisted by 2023 if the required criteria are met. While this objective will be sought for all management units, it is recognized that it may not be achievable for all management units.

   Criteria:

   A. The timeframe for delisting is based on known life history characteristics including longevity, late maturation, and spawning periodicity.

   B. A self-sustaining population is one in which the average rate of natural recruitment is at least equal to the average mortality rate over a 12-year period (which is the approximate age at maturity for a female Gulf sturgeon).

C. This objective will be considered achieved for a management unit when the population is demonstrated to be self-sustaining and efforts are underway to restore lost or degraded habitat.

3. Long-term Objective B: This is a long-term fishery management objective to establish, following delisting, a self-sustaining population that could withstand directed fishing pressure within management units. Note that the objective is not necessarily the opening of a management unit to fishing, but rather, the development of a population that can sustain a fishery. Opening a population to fishing will be at the discretion of state(s) within whose jurisdiction(s) the management unit occurs. As with Long-term Objective A, this objective may not be achievable for all management units, but will be sought for all units.

Criteria:

A. All criteria for delisting must be met.

B. This objective will be considered attained for a given management unit when a sustainable yield can be achieved while maintaining a stable population through natural recruitment.

C. Particular emphasis will be placed on the management unit that encompasses the Suwannee River, Florida, which historically supported the most recent stable fishery for the subspecies.

These objectives and criteria are preliminary. After better identification of population status and evaluation of the adequacy of the habitat to support self-sustaining populations, these objectives and criteria may be revised. The criteria stated above will be more quantitatively defined through identification of management units and through population assessments in those individual management units.

OUTLINE FOR RECOVERY ACTIONS ADDRESSING THREATS

Recovery Outline Narrative

1.0 **Determine essential ecosystems, identify essential habitats, assess population status, and refine life history investigations in management unit rivers.**

As an initial step to enhance the long-term recovery of populations of Gulf sturgeon, collection of basic biological information is essential. Without a clear understanding of life history requirements, recovery efforts are severely hampered. Presently, lack of information in the marine environment and sparse information in the riverine environment make it difficult to adequately census populations or to implement appropriate recovery actions. Studies to provide this information should be conducted as soon as possible.

1.1 Identify essential habitats important to each life stage in river basin and contiguous estuarine and neritic waters.

Investigations are needed to locate and describe the micro- and macrohabitat characteristics critical for recovery and maintenance of the Gulf sturgeon. Radio and ultrasonic tracking studies of juveniles and adults will help determine movements and habitat utilization over time. Emphasis should be placed on tracking Gulf sturgeon in the estuarine and marine environment where it is believed that most feeding and growth occurs, and where the least information is available. Spawning areas and larval and post-larval movements and distribution within rivers must be determined. When a sufficient number of animals has been monitored and distributions identified, habitat characterization studies can be used to better define essential habitat requirements. Significant ecosystems for the recovery of the Gulf sturgeon will be identified once essential habitats are defined in riverine, estuarine, and marine environments

1.1.1 Conduct and refine field investigations to locate important spawning, feeding, and developmental habitats.

Gulf sturgeon have been successfully tracked with radio and ultrasonic transmitters in riverine systems. These studies have been limited to a very few locations, and usually for a short time spans. Multi-year tracking studies in the estuarine and marine environment have never been accomplished. Knowledge of spawning areas, developmental habitat requirements and feeding requirements are essential to the recovery of Gulf sturgeon in all river basins across the range of the species. Tracking studies appear to be the best way to initially locate important habitat. Technological advances in telemetry should facilitate long-term tracking studies to provide the needed information. The FWS and NBS should expand their efforts to identify and inventory essential habitats of Gulf sturgeon. The Gulf states resource management agencies should continue or initiate studies to identify essential habitats in their respective states. The CCC should continue their multi-year monitoring program on the Suwannee River. New field work by other researchers such as universities and non-government organizations (NGOs) should incorporate this research need into their plans. The NMFS should work with FWS and NBS to identify marine habitats used by adult Gulf sturgeon during winter migration. The MMS should seek funding to obtain this information because of the potential for impacts to the Gulf sturgeon from outer continental shelf oil and gas operations and other non-energy mineral mining activities.

1.1.2 Characterize riverine, estuarine, and neritic areas that provide essential habitat.

When areas of utilization have been delineated (Task 1.1.1), characterization of these habitats should be conducted. Characteristics of the areas regarding particular life history requirements of Gulf sturgeon at various life stages must be determined. Among the parameters that may be important include substrate, depth, instream flow, current, pH, temperature, turbidity, and food availability. The Gulf states resource management agencies, FWS, NMFS, NBS, CCC, NGOs, and universities should refine their studies or surveys to provide these data.

1.2 Conduct life history studies on the biological and ecological requirements of little known or inadequately sampled life stages.

Because of the difficulty in collecting eggs, larvae, and adequate numbers of Gulf sturgeon less than a year old, essentially nothing is known about requirements of these life stages in the wild. Year-class strength is established during these stages, and water temperature, salinity, flow, turbidity, and other factors affect survival rates. As outlined in Task 1.1, intensive field investigations must be initiated to locate and characterize habitats used by early life stages. Likewise laboratory studies on wild and cultured Gulf sturgeon must be conducted to evaluate habitat requirements and tolerances. The University of Florida, NBS, and FWS should expand ongoing investigations into the biology and ecology of Gulf sturgeon. Non-fatal sampling techniques to examine stomach contents need to be determined. Diet studies of fish captured in estuaries should be expanded. Diet of Gulf sturgeon captured offshore (neritic environments) should also be evaluated, not only to assess food preferences, but also to determine habitat use.

It is known that subadult and adult Gulf sturgeon spend winters feeding in estuarine and marine waters. Little is known about specific areas and habitat requirements. Ultrasonic techniques should be improved and studies conducted to document marine habitats frequented by Gulf sturgeon. Identified habitats must be described by depth, water quality, substrate, and food availability. The FWS and NBS should continue ongoing marine habitat investigations of Gulf sturgeon. The NMFS should initiate marine habitat investigations of Gulf sturgeon.

1.3 Survey, monitor, and model populations.

Intensive field investigations have concentrated on Gulf sturgeon life history in the Suwannee and Apalachicola rivers in Florida. Additionally, long-term monitoring of Gulf sturgeon in these systems has resulted in reliable population estimates with which population models are being developed. Outside these systems, few studies have been conducted on the Gulf sturgeon. Information such as distribution, relative abundance, age structure and other biological information should be compiled to identify baseline population status and identify index monitoring sites to evaluate success of recovery and management programs.

1.3.1 Develop and implement standardized population sampling and monitoring techniques.

The assessment of Gulf sturgeon populations Gulfwide are essential to develop and evaluate recovery and management efforts. Standardized programs to address size, age and sex composition, and stock size must be developed so that the condition of each stock can be evaluated over time and compared with those in other river systems. Government agencies, NGOs, and universities investigating Gulf sturgeon should participate in a coordinated effort to develop standardized sampling and monitoring techniques and conduct appropriate programs. Standard operating procedures will facilitate application of statistical data set comparisons between various Gulf coast river systems. In addition, fishery management/recovery decisions could be more accurately formulated with uniform data collection and reporting procedures. The FWS should take the lead in coordinating, preparing and distributing a standardized sampling and monitoring protocol document. The Gulf states resource management agencies should evaluate the status of populations of Gulf sturgeon in their streams and coastal waters. The FWS and NBS in conjunction with other researchers should verify current aging techniques for Gulf sturgeon.

1.3.2 Develop population models.

Modeling is needed to better assess fishery restoration and management options. Capture-recapture models can estimate survival, abundance and recruitment of Gulf sturgeon. Population models should be developed to forecast the future condition of Gulf sturgeon populations and provide estimates on potential rates of recovery. Appropriate models will also help identify future research needs. The FWS and NBS should continue to take the lead in formulating peer accepted population models for the Gulf sturgeon.

1.4 Continue experimental culture of Gulf sturgeon.

Successful artificial propagation of Gulf sturgeon was first accomplished in 1989. Additional work is still needed to refine culture techniques, develop handling and holding procedures for fry and broodstock, maintaining genetic diversity of broodstock, research nutritional requirements and initiate fish health management. In addition, research is needed to document the optimum chemical and physical parameters necessary for maintaining growth and survival of Gulf sturgeon under artificial and natural conditions.

1.4.1 Continue culture of Gulf sturgeon.

State, federal, and NGOs should continue to develop culture techniques for Gulf sturgeon in accordance with the Gulf Sturgeon Hatchery Guidelines, Hatchery Manual for White Sturgeon protocols addressed in the Gulf Sturgeon Recovery Plan, and state and federal laws and regulations. Efforts should be directed towards filling data gaps (i.e. hormone dosages and types, incubation temperatures, egg de-adhesion methods, broodstock reproductive staging, elimination of stress related to capture, handling, and holding, among other factors).

1.4.2 Identify the physical, chemical and biological parameters necessary to maintain growth, health and survival of Gulf sturgeon reared under artificial conditions.

Studies are needed to determine the optimum water quality conditions necessary to maintain growth and survival of fry and fingerlings. In addition, nutritional requirements and artificial feeding methods need to be identified. Research is required to document carrying capacity for various fish rearing facilities, and hauling densities of fry and fingerlings. The FWS, researchers, and universities should continue to implement additional studies to address this need. Also, the FWS should take the lead in providing updated information on artificial propagation of Gulf sturgeon.

1.4.3 Identify and test internal and external markers or techniques useful for differentiation of wild and hatchery-produced Gulf sturgeon.

The identification of non-genetic internal and external markers to differentiate between wild and hatchery-produced Gulf sturgeon is important in the development and regulation of hatchery programs. Unique markers (i.e. PIT tags, coded wire tags, and chemical marking) could allow investigators, law enforcement officers, and others to distinguish hatchery-reared fish from wild stocks. In addition, these markers or techniques may be used in selective enhancement programs and provide a means to evaluate introductions. The FWS and other researchers should continue to investigate and develop useful internal and external markers or techniques.

1.5 Identify genetic characteristics of wild and hatchery-reared Gulf sturgeon.

Research is needed to determine whether or not significant genetic differences exist among Gulf sturgeon from throughout the range of the subspecies. Determining whether genetic differences exist among populations is essential to ensure successful recovery and management of the subspecies. Genetically distinct management units may be identified and could affect reintroduction and/or population augmentation.

1.5.1 Conduct a Gulfwide genetic assessment to determine geographically distinct management units.

Determination of the genetic structure for Gulf sturgeon is essential in formulating future management decisions for the subspecies. It is important that sound restoration efforts of Gulf sturgeon address the genetic structure of the subspecies in order to identify and maintain genetic integrity and diversity. Mitochondrial DNA analysis of Gulf sturgeon should be continued with emphasis placed on obtaining Gulf sturgeon tissues and/or blood from the following river systems:

1. Pascagoula River, Mississippi.
2. Mobile and Alabama rivers, Alabama.
3. Ochlocknee River, Florida.
4. Escambia River, Florida.

A genetic tissue bank should be established and curated where state or federal agencies deposit tissue or blood for genetic analysis. The Gulf states resource management agencies, universities, NGOs, NBS, FWS, and other Gulf sturgeon researchers should establish tissue collection protocol and insure that tissue samples are collected whenever possible.

1.5.2 Assess the potential to develop genetic markers to differentiate wild and hatchery-produced Gulf sturgeon.

The development of genetic markers for differentiating between wild and hatchery produced Gulf sturgeon may be important in the development and regulation of hatchery programs. A unique genetic marker could allow investigators, law enforcement officers, and others to distinguish hatchery reared fish from wild stocks. In addition, hatchery stocks possessing a different genetic mark from wild fish may be used in selective enhancement programs and provide a means to evaluate their introductions. The FWS and NMFS should continue to investigate the potential of viable genetic markers.

2.0 Protect individuals, populations, and their habitats.

In efforts to recover listed species, protection is the most obvious initial step. By virtue of their endangered or threatened status, species may not be able to sustain continuing losses of individuals, and steps should be taken immediately to eliminate any known preventable take. Initial measures to protect individuals, populations, and their habitats can be strengthened or reduced as new information is collected.

2.1 Reduce or eliminate unauthorized take.

Under the ESA, take means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." "Harm" in the definition of "take" in the ESA means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. "Harm" in the definition means an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. In the case of the Gulf sturgeon, the immediate concern is with lethal or injurious take by non-directed fisheries. Directed fisheries for listed species are prohibited by virtue of the listing. However, a number of fisheries targeting other species use fishing gear that take Gulf sturgeon.

2.1.1 Increase effectiveness and enforcement of state and federal take prohibitions.

Directed take of the Gulf sturgeon is prohibited under the ESA and laws or regulations of Louisiana, Mississippi, Alabama, and Florida. All states within the geographic distribution of the Gulf sturgeon have cooperative agreements with the FWS that require enforcement of federal endangered species laws. Both federal and state officials are empowered to enforce prohibitions on the take of Gulf sturgeon. Appropriate steps should be taken to support and enhance enforcement activities related to restoration and protection of Gulf sturgeon. The Gulf states resource management agencies should evaluate their enforcement programs and if needed, implement appropriate enhancements or actions. The FWS and NMFS should insure that during ESA section 7 consultations, incidental take is stipulated to provide full protection of the species.

On July 1, 1975, the Atlantic sturgeon (*Acipenser oxyrinchus*, including the Gulf sturgeon) was included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The effect of this listing is that CITES permits are required before international shipment may occur.

2.1.2 Reduce or eliminate incidental mortality.

Incidental catch and mortality of Gulf sturgeon is a difficult or cryptic problem to address because it requires a knowledge of effort and catch composition in a variety of different fisheries. Gear types used in many fisheries are capable of capturing Gulf sturgeon, and it is essential that the magnitude of the problem in each fishery is known before effective steps can be taken to reduce or eliminate mortality. A limited observer program may be needed to evaluate the amount/extent of incidental take or mortality in some fisheries and navigation-related and other activities. When problem fisheries or other activities have been identified, gear or equipment modifications, seasonal restrictions, limited gear or equipment deployment times, and other measures may be employed to reduce mortality of Gulf sturgeon and allow the affected fisheries or other activities to continue to operate.

If incidental take is found to be related to any fishery, the NMFS and the Gulf states should promulgate adequate regulations that protect the Gulf sturgeon from such incidental take. The NMFS should also evaluate Turtle Excluder Devices (TEDs) in commercial shrimp nets to determine if they are effective in allowing Gulf sturgeon to escape from trawls. If they are not effective, funding should be sought to investigate the appropriate gear technology. The NMFS should also fund an observer program, enforcement of regulations, and other necessary actions which reduce or eliminate incidental take of Gulf sturgeon during fishing operations.

In addition, the NMFS and FWS in cooperation with the responsible federal agency should develop methodologies that would cause Gulf sturgeon to avoid areas during navigation-related (includes O&M) activities, Clean Water Act (CWA) Sections 10 and 404, or other construction activities. The NMFS and FWS should assure that the objective of ESA section 7 consultation is to reduce or eliminate incidental take during such activities. As an example, section 7 consultation for a dredging project may result in the COE permitting the activity to occur only during seasons when Gulf sturgeon are not present in the action area.

2.2 Identify and eliminate known or potentially harmful chemical contaminants, and water quantity and water quality problems which could impede recovery of Gulf sturgeon.

Chemical contaminants, water quantity, and water quality factors may have contributed to the decline or are limiting the recovery of Gulf sturgeon. These factors include pesticides (organochlorines), metals (lead, mercury, etc.), industrial byproducts, temperature, pH, suspended solids, dissolved oxygen, water depth, and water velocity. Review of existing data and information is necessary to refine or identify the chemical and water quality and quantity requirements of Gulf sturgeon.

An information search for each management unit or coastal habitat area regarding potential types of chemical contaminant loading, including chemicals from point sources, agriculture, silviculture, industrial activities and urbanization, should be conducted. Existing chemical contaminant field evaluation reports (water, sediment or biota studies) should be examined and the information utilized to make decisions related to field sampling and chemical analysis. Field sampling of water, sediments, and sentinel and/or surrogate species should be conducted, as necessary, to fill critical information gaps. State agencies in Louisiana, Mississippi, Alabama, and Florida, with assistance from the Environmental Protection Agency (EPA) and FWS should collect existing information and provide an assessment report with recommendations. The FWS should provide coordination between the federal and state agencies as needed, compile state reports, and identify a consensus priority listing of chemical contaminant sources that may have impacts on Gulf sturgeon in the river systems. The EPA "Priority Pollutants" for each management unit or habitat area should be assessed by chemical analyses for Gulf sturgeon and other benthic species. The FWS and EPA, using the compiled contaminant data, should prepare the list and conduct necessary analyses.

2.2.1 Identify potentially harmful chemical contaminants and water quality and quantity changes associated with surface water restrictions.

A comprehensive inventory of river basins with existing surface water restrictions is needed to document physical and biological impacts that may negatively affect recovery and management of Gulf sturgeon. The GSMFC, FWS, and COE should coordinate preparation of this inventory with GSMFC taking the lead for final product completion.

2.2.2 Identify and eliminate potentially harmful point and non-point sources of chemical contaminants.

Significant point sources and high-impact non-point source areas of contaminant introductions should be identified. Appropriate actions to reduce or eliminate the contaminants should be taken. With the results of 2.2.1, EPA and state agencies in Louisiana, Mississippi, Alabama, and Florida should take actions to enforce existing regulations or promulgate new ones.

2.2.3 Assess selected contaminant levels in Gulf sturgeon from management units.

Gulf sturgeon tissue analyses should be conducted to evaluate selected chemical contaminants. Appropriate actions should be taken to reduce or eliminate contaminant sources. The EPA should take the lead in efforts to reduce or eliminate identified contaminant sources through their regulatory authorities. The EPA could also assist state agencies in Louisiana, Mississippi, Alabama, and Florida in enforcement of state regulations. During the Triennial Review of state water criteria, EPA should ensure that the states have incorporated adequate water quality standards to protect the Gulf sturgeon and its benthic habitat.

Routine, standardized inspections should be conducted on all incidental catches of Gulf sturgeon (alive or dead) for the presence of gross lesions, tumors or other abnormalities to focus evaluation on chemical contaminants.

Histopathological examinations of liver tissue for cases of incidental Gulf sturgeon mortalities should be conducted to detect the presence of cellular abnormalities or carcinogenic cells.

Chemical analyses of selected tissues should be conducted from incidental mortalities of Gulf sturgeon. The FWS should take the lead in developing protocol to collect samples, conduct training if necessary, process samples for analyses, and prepare summaries of results. Wherever possible, Gulf state resource management agencies should conduct similar analyses.

Appropriate surrogate species should be utilized to better define bio-accumulation of contaminants in particular river basins. An extrapolation formula for estimating potential chemical contaminant impacts to Gulf sturgeon should be developed. The FWS and EPA should lead the efforts to identify appropriate surrogate species, conduct bio-accumulation studies, and develop an extrapolation formula. Appropriate peer review should be conducted during formula development.

2.2.4 Identify and eliminate known and potential impacts to water quantity and quality associated with existing and proposed developments, agricultural uses, and water diversions in management units.

Domestic and industrial effluent, rural and urban run-off, and inter- and intra-water diversions affect the clarity, pH, biological oxygen demand, nutrient and contaminant composition, temperature, sediment loads, and seasonal quantity of river waters. A comprehensive inventory of known or potential problem areas associated with these factors is needed. Once identified, actions to reduce or eliminate problems and promote wise land use should be taken. With the results of 2.2.1, EPA and Gulf states resource management agencies should take actions to enforce existing regulations or promulgate new ones.

Water quality and sediment factors resulting from point and nonpoint sources may negatively affect Gulf sturgeon habitat. Examples include total dissolved solids, suspended solids, turbidity, siltation, pH, temperature, and changes in sediment types. Studies to assess the effect of river water and sediment quality should be conducted to determine the habitat suitability for Gulf sturgeon.

2.2.5 Assess the relationship between groundwater pumping and reduction of groundwater flows into management units, and quantify loss of riverine habitat related to reduced groundwater in-flows.

Groundwater diversions which affect flows into management unit rivers should be identified. The loss of riverine groundwater flows attributed to diversions should be quantified and its effect on Gulf sturgeon evaluated. The U. S. Geological Survey (USGS) should take the lead in implementing appropriate studies including modelling. The Tri-State Study for the Alabama-Tallapoosa-Coosa and Apalachicola-Chattahoochee-Flint river basins funded by the COE and Alabama, Georgia, and Florida should incorporate an effort to provide a preliminary assessment of the effects of groundwater pumping into the groundwater scope of work plan.

2.2.6 Conduct studies to determine the effects of known chemical contaminants in water from management unit rivers on Gulf sturgeon or a surrogate species.

After identification of priority contaminants, physiological and behavioral responses of Gulf sturgeon life stages to long-term exposures to such chemicals should be determined. In particular, newly fertilized eggs, Gulf sturgeon larvae, and juvenile Gulf sturgeon should be tested. The EPA should work with the FWS to conduct bioassays of water from the management unit rivers to determine effects on Gulf sturgeon.

2.3 Develop a regulatory and/or incentive framework to ensure that essential habitats, streamflow, and groundwater in-flows are protected.

Where existing laws and regulations are inadequate to meet recovery objectives, appropriate state and federal agencies should propose new incentives, laws, and/or regulations.

2.3.1 Utilize existing authorities to protect habitat and, where inadequate, recommend new incentives, laws, and regulations.

The ESA provides for the protection and recovery of the Gulf sturgeon and its habitats. Likewise individual Gulf states have regulations and laws for that purpose. Adequate funding levels must be provided to enforce existing protection measures and laws. Federal and state natural resource law enforcement programs are understaffed and underbudgeted to adequately enforce laws protecting the Gulf sturgeon and its habitats. Even with adequate funding, existing authorities may be inadequate to fully protect the Gulf sturgeon and its habitats. Adoption of new incentives, laws or regulations may be necessary to ensure the recovery of the species. Protection measures should be based on the biological requirements of the subspecies and not political boundaries. The FWS should ensure protection of the Gulf sturgeon through the ESA section 7 consultation process with other federal agencies including the COE (federal projects, Section 10/404 permits), MMS (OCS oil and gas lease sales), EPA (National Pollutant Discharge Elimination System permits, Triennial Review).

2.3.2 Identify, protect and/or acquire appropriate land or aquatic habitats on an ecosystem approach.

Habitat components of the Gulf sturgeon which provide essential life requirements should be considered as part of and dependent on a fully functioning ecosystem . These ecosystems should be protected and/or acquired. The Gulf states resource management agencies, FWS, and NMFS should seek appropriate avenues of funding and take action to acquire, manage, and protect identified significant habitats or their ecosystems as appropriate.

For example, spawning habitats should receive maximum protection from disturbance. In order to protect specific habitats, the ecosystem where it occurs also requires protection. Thus, protection of spawning habitats of the Apalachicola River would include the upper 20 km (12.4 mi) of the river and its surrounding basin components. Another example includes the maintenance of habitats such as the springs that occur in the Suwannee River. To protect these springs, it is essential to maintain other ecosystem components including upstream water quality, groundwater flows and quality, and adjacent floodplains.

2.4 Restore, enhance, and provide access to essential habitats.

Gulf sturgeon have evolved within Gulf coast drainages exhibiting seasonal patterns of high and low flows, temperature regimes, sedimentation, and other physical factors which historically may have been much different than those which exist today. The restoration and enhancement of some river and stream habitats, particularly benthic habitat, within the historical range of the Gulf sturgeon may be necessary before its recovery is successful. Within some drainages, man's alterations (mainstem dams, low-head diversions) may be preventing Gulf sturgeon from gaining access to important habitats essential to some aspect of its life history. If such structures are identified as impeding migration or preventing access to critical habitats, action should be taken to restore the natural hydrography or provide a viable bypass route around the structure.

2.4.1 Identify dam and lock sites that offer the greatest feasibility for successful restoration of and to essential habitats (i. e., up-river spawning areas).

Mainstem and low-head diversion dams that are known to be impeding potentially viable Gulf sturgeon populations from reaching historically essential habitats need to be identified. The extent of important habitat types upstream from such structures (e.g., potential spawning sites and summer refugia) should be evaluated.

The GSMFC should take the lead in identifying these sites throughout the Gulf states and preparing summary and recommendations. Federal and non-federal permitted dams should be identified. The COE, FERC, and entities such as the Pearl River Valley Water Supply District should investigate ways of mitigating impacts of federal and private water resource projects or permitted activities on Gulf sturgeon populations.

2.4.2 Evaluate, design, and provide means for Gulf sturgeon to bypass migration restrictions within essential habitats.

The structures preventing upstream migrations to essential habitats should be modified or removed to allow for Gulf sturgeon passage. Specific modifications will depend on the type of obstruction, river hydrology and the importance of the habitat to the recovery of the species in that particular ecosystem. Studies regarding Gulf sturgeon behavior may be required to assist in development and design of fish passages. Modifications which provide for both up- and downstream travel by large and small fish need be considered.

First, an assessment of existing modifications should be conducted. The assessment should consider the effectiveness of the modification for use by other migratory species such as shad and striped bass. Designs should be solicited from engineering and environmental consultants. Passage structures which show promise must be evaluated to document the relative degree of usage by Gulf sturgeon. The NMFS, COE, NBS, FWS, and Federal Energy Regulatory Commission (FERC) should investigate the use of potential passage structures and initiate action or studies to assess the structure's effectiveness for Gulf sturgeon passage.

2.4.3 Operate and/or modify dams to restore the benefits of historical flow patterns and processes of sedimentation.

The operating schedules of the dams need to be evaluated to determine if water releases are benefiting the life history requirements of the Gulf sturgeon. The operations of existing structures found to be detrimental to the life cycle of Gulf sturgeon should be evaluated to determine if modifications to approximate historical flow and sedimentation patterns are possible. The COE and FERC in coordination with the GSMFC, Gulf states resource management agencies, FWS, and NMFS should identify potential modifications to and/or operations of dams and initiate action or studies to assess the feasibility for implementation.

2.4.4 Identify potential modifications to specific navigation projects to minimize impacts which alter riverine habitats or modify thermal or substrate characteristics of those habitats.

Navigation projects that have altered or modified the thermal characteristics or natural substrates of rivers should be evaluated to determine if modifications to approximate historical conditions are possible. The COE should assist the FWS in its efforts to define and protect Gulf sturgeon spawning and other essential habitats in federal project areas. The COE should study, seek funding, implement or take appropriate remedial actions to rectify navigation projects where feasible.

2.4.5 Restore the benefits of natural riverine habitats.

Dams and channel modifications have reduced habitat diversity within the range of the Gulf sturgeon. Diversity of riverine habitat (e.g., main channel, side channel, backwater and braided channel) promotes a corresponding faunal diversity. The Gulf sturgeon evolved in natural riverine settings where such diversity was prevalent. Gulf sturgeon survival could be expected to be compromised if the benefits of riverine habitat diversity are not restored. The FWS should work with the COE to identify ways to restore and protect natural river habitat diversity.

2.4.6 Seek optimum consistency between the purposes of federal and state authorized reservoirs, flood control projects, navigation projects, hydropower projects, and federal and state mandated restorations of fish populations.

Many water projects, such as hydropower and flood control dams and navigation activities, are authorized by state and federal governments for their respective purposes. Also, there are many state and federal programs authorized to restore declining fish populations. Examples include species listed under the ESA, anadromous fisheries addressed under the Anadromous Fish Conservation Act, and coastal fisheries addressed under the Interjurisdictional Fisheries Act and the Magnuson Fisheries Conservation and Management Act.

All government authorized and proposed projects and mandates should be reviewed in order to evaluate the potential to achieve recovery of Gulf sturgeon. The GSMFC should facilitate a multi-agency effort to identify project mandates and prepare a summary and recommendation report in partnership with the appropriate state and federal agencies. Recommendations should be forwarded to each of the States of Louisiana, Mississippi, Alabama, and Florida's State legislature and congressional delegation.

2.5 Maintain genetic integrity and diversity of wild and hatchery-reared stocks.

Major conservation issues that must be addressed by this recovery program relative to health of stocks, genetic conservation of stocks and displacement of stocks. A major concern in any stock restoration and enhancement program is the potential impact of introduced fish on existing wild stocks. This impact can affect wild stocks by a variety of mechanisms:

1. Disease and parasite transfer.
2. Behavioral and ecological interference.
3. Genetic consequences of interbreeding, reduction in gene flow, introduction of strains susceptible to disease.

Problems resulting from failure to protect habitat, to control fishing pressure, to ensure correct management of water resources, to control environmental contamination, and to effectively manage other parameters have contributed to reductions in stocks of Gulf sturgeon. These problems are readily evident and appropriate actions can be taken to correct them. At this point, the potential adverse effects of initiating a stocking program are unknown. The potential effects of initiating any stocking program should be evaluated. An experimental hatchery and strictly limited release program to the wild is prudent until such time as stocking has been thoroughly evaluated.

2.5.1 Evaluate the need to stock hatchery-produced Gulf sturgeon considering habitat suitability and current population status.

An assessment of whether stocking hatchery-produced fish will benefit the overall recovery of the Gulf sturgeon is paramount to the future development of Gulf sturgeon hatchery programs. An evaluation of whether the rivers to be stocked have suitable habitat to support the stocked fish, natural reproduction, and any progeny should be conducted. The recovery of the subspecies cannot be based on a "put and take" Gulf sturgeon fishery. Government agencies, NGOs, and universities investigating Gulf sturgeon should conduct an evaluation of each river system that is under consideration for stocking on the ability of the system, at its current status, to support the stocked fish and assure that natural reproduction can occur. Only ongoing improvements to the river systems should be included in the analyses. Each of the Gulf states resources management agencies should evaluate the river systems in their states. The FWS should take the lead in coordinating the assessment and preparing a summary finding report. No stocking should be conducted without approval by appropriate state agencies.

If it is determined that there is a need for stocking, the stocking should be secondary to other recovery efforts that identify essential habitats and emphasize habitat restoration. The COE should continue to work with the FWS in efforts to construct a permanent hatchery on the Apalachicola River to help in the restoration and maintenance of the Apalachicola River Gulf sturgeon population if it is determined that stocking is necessary for recovery of the subspecies.

2.5.2 Develop policy and guidelines for hatchery and culture operations related to stocking.

Raising hatchery produced fish to a size large enough to overcome lack of suitable habitat increases survival. Also, at larger sizes, these fish can be tagged and recovered, enabling assessment of the efficacy or success of the stocking effort. Peer review and evaluation of a particular stocking effort should be included in any proposal to release hatchery-reared Gulf sturgeon. Gulf states resource management agencies, GSMFC, FWS, NMFS, NGOs, universities, and other involved researchers should prepare a hatchery and culture operations plan relating to stocking policy/guidelines. The FWS should take the lead in coordinating, seeking peer review, and completing the document.

2.5.3 Develop and implement a regulatory framework to eliminate accidental and intentional introductions of non-indigenous stock or other sturgeon species.

Release of hatchery-reared fish without a program of monitoring does not fulfill government's role as a steward of renewable natural resources. Monitoring and systematic assessment of stocks will assist in determining the impact of accidental and intentional releases of non-indigenous stock or other sturgeon species. This recovery plan recognizes that it is irresponsible to intentionally release fish without review or concurrence from the recovery team or coordinator, and therefore undocumented intentional releases should not occur. In the case of federal agencies who undertake actions that may affect a listed species (stock introductions), consultation with FWS and/or NMFS is required under section 7 of the ESA.

At a minimum, the recommendations of the Aquatic Nuisance Species Task Force (ANSTF) which was established under the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 should be conducted. The task force developed recommendations regarding direct introductions and indirect, accidental release from public and private sector facilities. All State agencies within the subspecies' range and GSMFC, FWS, NBS, NMFS, NGOs, universities, and other involved researchers should prepare a consensus policy regarding introduction of non-indigenous sturgeon stocks into the range of Gulf sturgeon in accordance with the options or actions identified by the ANSTF to reduce risks and adverse consequences associated with introductions. States should implement necessary actions for promulgating regulations consistent with the policy.

3.0 Coordinate and facilitate exchange of information on Gulf sturgeon conservation and recovery activities.

Any research and/or management activities on fish species which transcend jurisdictional boundaries must be coordinated. Management and recovery actions must be consistent across the range of the subspecies in order to be effective. Gulf sturgeon recovery efforts will be enhanced by the coordination of activities and exchange of information regarding the biology and management of all sturgeon species.

3.1 Coordinate research and recovery actions.

Coordination activities involving state and federal resource management agencies, NGOs, and universities with an interest in the Gulf sturgeon should be conducted at least every two years. Such coordination will provide for studies and management plans which will reduce duplication of effort, enhance cooperation, and optimize agency manpower and funding. The FWS and GSMFC should take the lead in conducting the coordination activities.

3.2 Develop an effective communication program or network for obtaining and disseminating information on recovery actions and research results.

All recovery participants including state and federal agencies, NGOs, and universities working on Gulf sturgeon are strongly urged to publish research findings in technical publications. Unpublished reports (gray literature), bibliographies, and available data on Gulf sturgeon should be compiled and published or otherwise made available to all participants. Acquiring, disseminating, and maintaining information regarding Gulf sturgeon recovery activities should be centralized. The FWS should take the lead in collecting and centralizing information regarding Gulf sturgeon recovery activities.

In order to ensure effective communication among the various entities involved in Gulf sturgeon research, recovery and management, a newsletter should be developed and disseminated on a regular basis. This newsletter would provide all interested parties with the most up-to-date information regarding progress toward achieving the goals of the Recovery Plan. The FWS should take the lead in preparing, printing, and disseminating the newsletter and coordinating with other existing sturgeon newsletters.

3.3 Develop a non-scientific constituency and public information program directed toward enhancing recovery actions.

In order for Gulf sturgeon recovery actions to be successful, the general public must be aware of such actions and understand the need for them. An information and education program must be developed to inform the public of the causes of the decline of Gulf sturgeon, to increase the public's awareness, understanding, and involvement in Gulf sturgeon recovery efforts and to promote wise use of land in watersheds. Educational materials such as brochures, newspaper and magazine articles, publications, posters, and slide and television presentations, among others, must be produced and disseminated to target audiences, such as commercial and recreational fishermen, boaters, and civic organizations. The Gulf states resource management agencies, FWS, NBS, and NMFS should seek funding for the development of educational material for dissemination to the public. The FWS or GSMFC should take the lead in coordinating this effort providing a centralized location for storage of information if necessary.

4.0 Implement recovery program.

Existing budgets of involved agencies and other parties are not capable of fully funding the Gulf sturgeon recovery plan. Competition for funding under the ESA is intense, partly due to the low level of appropriations to the program and the increasing number of listed species. In order to assure that actions which would result in recovery of the Gulf sturgeon are implemented, funding for activities must be secured and a designated lead recovery office must be identified. Involvement of NGOs, and universities should be solicited.

4.1 Designate and fund a Gulf sturgeon recovery lead office.

Funding to support a FWS recovery lead office must be identified to coordinate a multi-agency, multi-disciplinary recovery implementation committee. The lead office should document all research, recovery, and management information and plans. Work would be combined with other FWS duties. The lead office should be in a location which facilitates coordination with all Gulf sturgeon activities. The lead office should be funded until the Gulf sturgeon is considered recovered according to the Recovery Plan.

4.2 Seek funding for Gulf sturgeon recovery activities.

The recovery lead office, with support from involved agencies, NGOs, universities, and the public should seek to bring high visibility to the need for funding of Gulf sturgeon recovery activities. Funding strategies to acquire Congressional appropriations and other funding sources should be developed. The recovery lead office should facilitate this effort and coordinate a unified funding package for Gulf sturgeon recovery activities in the southeast.

4.3 Implement projects or actions which will achieve recovery plan objectives.

Based on the recovery plan, a series of specific projects will be identified which could bring about improvements in the habitat or stock condition of Gulf sturgeon in specific river systems throughout the range of the species. Projects should be submitted to the appropriate agencies or funding sources for consideration. The Gulf states resource management agencies should be given first opportunity to implement the identified projects, through joint efforts with FWS, NBS, NMFS, universities, NGOs, or other interested researchers.

4.4 Develop and implement a program to monitor population levels and habitat conditions of known populations in the management units as well as newly discovered, introduced, or expanding populations.

The status of the subspecies and its ecosystems should be monitored to assess any progress toward recovery while recovery actions are ongoing and following completion of actions. A standardized assessment program should be designed by a multi-agency group coordinated by the recovery lead office and the GSMFC. The Gulf states resource management agencies, federal agencies, universities, NGOs, and other researchers should conduct an annual assessment of the management unit population levels in their area of responsibility or as appropriate. The recovery lead office should maintain, collate, and review the assessments preferably on an annual basis but at least every two years. This information should be summarized for distribution and used in the Congressionally required biennial species status reports.

5.0 Monitor recovery program.

A recovery plan benefits a species only if it is implemented. The plan and its implementation must be strong enough to provide adequate guidance to species managers but be flexible enough so that it may be changed or revised to recover the species. In addition, the FWS and NMFS are required by Congress to track the status of all listed species and the implementation of recovery plans, financial expenditures for each species or clusters of species, and status of recovered species.

5.1 Assess overall success of the recovery program and recommend action.

The recovery program must be evaluated periodically to determine if it is making progress in achieving recovery objectives and to recommend future actions. These actions could include changes in recovery objectives, continuing or increasing protection, implementing new measures, revising recovery plans and recommending delisting. The recovery program should be preferably evaluated annually but at least biennially. The recovery lead office should be responsible for collection of the required information and preparation of the Congressional reports. As part of this effort, the lead office should prepare standardized reporting forms so that the affected parties can easily provide the necessary information. Reporting requirements should continue for five years after the delisting of the Gulf sturgeon.

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III. IMPLEMENTATION SCHEDULE

The Implementation Schedule indicates task priorities, task numbers, task descriptions, duration of tasks, potential or participating parties, and lastly, estimated costs (Table 3). These tasks, when accomplished, will bring about the recovery objectives for the Gulf sturgeon as discussed in Part II of this plan.

Parties with authority, responsibility, or expressed interest to implement a specific recovery task are identified in the Implementation Schedule. When more than one party has been identified, the proposed lead party is indicated by an asterisk (*). The listing of a party in the Implementation Schedule does not imply a requirement or that prior approval has been given by that party to participate or expend funds. However, parties willing to participate will benefit by being able to show in their own budget submittals that their funding request is for a recovery task which has been identified in an approved recovery plan and is therefore part of the overall coordinated effort to recover the Gulf sturgeon. Also, Section 7(a)(1) of the ESA directs all federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species.

Following are definitions to column headings and keys to abbreviations and acronyms used in the Implementation Schedule:

Task Number & Task: Recovery tasks as numbered in the recovery outline. Refer to the Narrative for task descriptions.

Priority Number: All priority 1 tasks are listed first, followed by priority 2 and priority 3 tasks.

Priority 1 - All actions that must be taken to prevent extinction or to prevent the subspecies from declining irreversibly in the foreseeable future.

Priority 2 - All actions that must be taken to prevent a significant decline in subspecies population/habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery (or reclassification) of the species.

Task Duration: Years to complete the corresponding task. Study designs can incorporate more than one task, which can reduce the time needed for task completion.

Underway - Task already being implemented.

Continuing - Task necessary until recovery.

Responsible or Participating Party: Federal or state government agencies or universities (party) with the responsibility and/or capability to fund or carry out the corresponding recovery task.

FWS Region - FWS Regions (only states in the Gulf sturgeons's range are listed)
- 2 - Albuquerque (Texas)
- 4 - Atlanta (LA, MS, AL, FL)

FWS Program - Division or program of the FWS
- FF- Fisheries
- FRO- Fisheries Resources Office
- ES- Ecological Services
- LE- Law Enforcement
- WNFH- Welaka National Fish Hatchery
- WSRFC- Warm Springs Regional Fisheries Center
- GCFCO- Gulf Coast Fisheries Coordination Office

Other Federal Agencies
- COE - U.S. Army Corps of Engineers
- EPA - U.S. Environmental Protection Agency
- MMS - Minerals Management Service
- NMFS - National Marine Fisheries Service
- FERC - Federal Energy Regulatory Coummission
- NBS - National Biological Service/Southestern Biological Science Center Gainesville, FL
- NRCS - Natural Resources Conservation Service

State Agencies
- GSRMA - Gulf States Resource Management Agencies
  - Louisiana Department of Wildlife and Fisheries
  - Mississippi Department of Wildlife, Fisheries, and Parks
  - Alabama Department of Conservation and Natural Resources
  - Florida Department of Environmental Protection
  - Texas Parks and Wildlife Department
- CES - Cooperative Extension Service (all GSRMA)

Other Parties
- GSMFC - Gulf States Marine Fisheries Commission
- CCC - Caribbean Conservation Corporation
- UF - University of Florida

Cost Estimates: Estimated fiscal year cost, in thousands of dollars, to complete the corresponding task. The costs associated with a task or party represent the estimated dollar amount to complete the task and are not necessarily the fiscal responsibility of the associated party.

Study designs can incorporate more than one task, which when combined can reduce the cost from when tasks are conducted separately. Cost for implementing "continuing" recovery tasks are in excess of what is displayed for the five years in the schedule.

Comments: Additional information if appropriate.

TABLE 3. IMPLEMENTATION SCHEDULE FOR GULF STURGEON RECOVERY ACTIONS

GULF STURGEON RECOVERY IMPLEMENTATION SCHEDULE

Priority	TASK #	TASK DESCRIPTION	TASK DURATION (YEARS)	RESPONSIBLE PARTY: FWS Region	RESPONSIBLE PARTY: FWS Program	RESPONSIBLE PARTY: OTHER	FY 1 FWS	FY 1 Other	FY 2 FWS	FY 2 Other	FY 3 FWS	FY 3 Other	FY 4 FWS	FY 4 Other	FY 5 FWS	FY 5 Other	COMMENTS
1	1.3.1	Develop and implement standardized population sampling and monitoring techniques	underway	4	FF* FRO-PC	NBS* GSRMA COE	1 6	30 20 2	1 20	30 20 2	7 40	30 32 5	1 40	30 32 5	1 40	30 32 5	Tasks 1.1.1, 1.3.1, 2.5.1, and 1.5.1 can be conducted concurrently
1	2.5.3	Develop and implement a regulatory framework to eliminate acidental and intentional introductions of non-indigenous stock or other sturgeon species	1	4	FF FRO-PC* ES-PC GCFCO	NBS* GSRMA GSMFC UF			5 8 2 2	2 4 1 1							Some of this effort will be dependent on the outcome of 2.5.1
1	2.1.2	Reduce or eliminate incidental mortality	underway continuing	4	FRO-PC* ES	GSMFC* GSRMA NMFS	15	15 20 75	15	15 20 75	15	15 20 75		75		25	Majority of funding for fish excluder devices & sampling protocols
1	2.4.5	Restore the benefits of natural riverine habitats	underway continuing	4	ES FRO-PC GCFCO	NBS COE GSRMA	2 2 2	2 10 8	10 2 2	2 20 12	10 2 2	2 20 12	20 5 3	3			Wk funded under existing programs. Actual restoration costs undetermined.
1	2.3.1	Utilize existing authorities to protect habitat and where inadequate, recommend new incentives, laws, and regulations	underway continuing	4	ES* GCFCO	EPA* COE GSRMA GSMFC	5 3	5 5 8 3	5 3	5 5 8 3	5 3	5 5 8 3	5 3	5 5 8 3			Section 7 consultation conducted with existing program funds
2	2.1.1	Increase effectiveness and enforcement of state and federal take prohibitions	continuing	4	LE FF* ES*	NMFS* GSRMA*	75	75 180	75	75 180	75	75 180	75	75 180	75	75 180	Sec 7 consultation will be conducted under existing programs. Add. monitoring or law personnel may be necessary
2	1.1.1	Conduct and refine field investigations to locate important spawning, feeding, and developmental habitats	underway continuing	4	FF FRO-PC* GCFCO	NBS* GSRMA COE CCC UF	1 5 1	20 60 5 10 1	1 58 1	20 60 5 10 1	1 70 2	20 80 5 10 2	1 70 2	20 80 5 12 2	1 70 5	20 80 5 12 5	Tasks 1.1.1, 1.3.1, 2.5.1, and 1.5.1 can be conducted concurrently

ESTIMATED FISCAL YEAR COSTS ($000)

TABLE 3. (continued). IMPLEMENTATION SCHEDULE FOR GULF STURGEON RECOVERY ACTIONS

GULF STURGEON RECOVERY IMPLEMENTATION SCHEDULE

PRIORITY	TASK #	TASK DESCRIPTION	TASK DURATION (YEARS)	RESPONSIBLE PARTY			ESTIMATED FISCAL YEAR COSTS ($000)										COMMENTS
				FWS		OTHER	FY 1		FY 2		FY 3		FY 4		FY 5		
				Region	Program		FWS	Other	FWS	Other	FWS	Other	FWS	Other	FWS	Other	
2	1.1.2	Characterize riverine, estuarine, and neritic areas that provide essential habitat	underway continuing	4	FRO-PC*	NBS* CCC GSRMA COE	5	15 2 28 5	20	15 2 28 5	70	15 3 40 5	70	15 3 40 5	10	15 3 40 5	Tasks 1.1.1 and 1.1.2 can be conducted concurrently
2	1.2	Conduct life history studies on the biological and ecological requirements of little known or inadequately sampled life stages	underway continuing	4	FRO-PC*	NBS* CCC GSRMA	5	25 2 28	20	25 2 28	20	25 3 40	40	25 3 40	40	25 3 40	Tasks 1.1.1 and 1.1.2, and 1.2 can be conducted concurrently
2	2.2.1	Identify potentially harmful chemical contaminants and water quality and quantity changes associated with surface water restrictions	3	4	ES-PC*	EPA GSRMA	25	10 40	15	10 100	75						Cost and time to complete year 2 efforts will be dependent on information collection in year 1.
2	2.2.2	Identify and eliminate potentially harmful point and non-point sources of chemical contaminants	4	4	ES-PC	EPA* GSRMA NRCS			20	10 28	25	15 40	25		25		
2	2.4.6	Seek optimum consistency between the purposes of federal and state authorized reservoirs, flood control, navigation, and hydropower projects and federal and state mandated restorations of fish populations	continuing	4	ES GCFCO	GSMFC* FERC COE NMFS				10		5		5		5	Most agency related wk., funded under existing programs

TABLE 3. (continued). IMPLEMENTATION SCHEDULE FOR GULF STURGEON RECOVERY ACTIONS

GULF STURGEON RECOVERY IMPLEMENTATION SCHEDULE

PRIORITY	TASK #	TASK DESCRIPTION	TASK DURATION (YEARS)	RESPONSIBLE PARTY: FWS		RESPONSIBLE PARTY: OTHER	ESTIMATED FISCAL YEAR COSTS ($000): FY 1		FY 2		FY 3		FY 4		FY 5		COMMENTS
				Region	Program		FWS	Other	FWS	Other	FWS	Other	FWS	Other	FWS	Other	
2	2.4.1	Identify dam and lock sites that offer the greatest feasibility for successful restoration of and to essential habitats	1	4	ES-PC FRO-PC	GSMFC* COE GSRMA			5 2	15 10 20							
2	2.4.4	Identify potential modifications to specific navigation projects to minimize impacts which alter riverine habitats or modify thermal or substrate characteristics of those habitats.	underway continuing	4	ES FRO-PC GCFCO	FERC* COE* NMFS GSRMA GSMFC	5 5 5	10 10 2 8 5	5 5 5	10 10 2 8 5	2 2 2	5 5 2 4 2					Some funding under existing programs. Proj. mod. costs undetermined and may require Congress. author. & non-federal sponsor
2	4.3	Implement projects or actions which will achieve recovery plan objectives	underway continuing	4	FF FRO-PC	GSRMA* NGOs											Individual project funding ID elsewhere in schedule
2	4.2	Seek funding for Gulf sturgeon recovery activities	underway continuing	4	ES* GCFCO	NBS GSMFC GSRMA											Funded under existing programs
2	2.2.4	Identify and eliminate known and potential impacts to water quantity and quality associated with existing and proposed developments, agricultural uses, and water diversions in management units	continuing	4	ES	NBS EPA* GSRMA NRCS	2	2 2 8	10	5 20 8	75	5 20 8	75	5 20	75	20	Amount of effort will be determined by outcome of task 2.2.1
2	2.2.5	Assess the relationship between groundwater pumping and reduction of groundwater flows into management units, and quantify loss of riverine habitat related to reduced groundwater in-flows	2	4	ES	USGS* GADNR						252		125			Mostly funded under the Tri-state Comp Study- AL,GA,FL

TABLE 3. (continued). IMPLEMENTATION SCHEDULE FOR GULF STURGEON RECOVERY ACTIONS

GULF STURGEON RECOVERY IMPLEMENTATION SCHEDULE

PRIORITY	TASK #	TASK DESCRIPTION	TASK DURATION (YEARS)	RESPONSIBLE PARTY			ESTIMATED FISCAL YEAR COSTS ($000)										COMMENTS
				FWS		OTHER	FY 1		FY 2		FY 3		FY 4		FY 5		
				Region	Program		FWS	Other	FWS	Other	FWS	Other	FWS	Other	FWS	Other	
3	2.5.1	Evaluate the need to stock hatchery-produced Gulf sturgeon considering habitat suitablity and current population status	underway	4	FF FRO-PC ES-PC GCFCO	NBS GSRMA	1 1 1 1	5 8	1 3 1 1	10 8	1 5 2 1	10 4	1 10 2 1	10 4	1 10 2 1	10 13	Tasks 1.1.1, 1.3.1, 2.5.1, and 1.5.1 can be conducted concurrently
3	1.5.1	Conduct a Gulfwide genetic assessment to determine geographically distinct management units	underway	4	FF* FRO-PC GCFCO	NBS GSRMA NGOs	15 8 2	1 3 1	15 48 1	1 100 1							Majority of samples and analyses completed 1995. Will continue to completion.
3	2.2.3	Assess selected contaminant levels in Gulf sturgeon from management units	underway continuing	4	FF* ES*	EPA* GSRMA	15		30	10 20	30	10 20	10	5 20			Study on adult fish across FL panhandle completed 1994. Study on juvenile fish, Suwannee River completed 1995.
3	1.3.2	Develop population models	underway continuing	4	FF FRO-PC	NBS NMFS GSRMA NGOs	5 15	15 2 8 2	5 5	15 2 8 2	20						
3	4.1	Designate and fund a Gulf sturgeon recovery lead office	continuing	4	ES* FF		7 3		7 3		7 3		7 3		7 3	7 3	Majority of funding provided under other recovery actions
3	1.4.1	Continue culture of Gulf sturgeon	underway	4	WNFH WSRFC* FRO-PC	NBS LDWF ADNCR UF	3 2 1	2 3 3 5	23 25 10	2 3 3 5	23 25 10	2 5 5 5	23 25 10	2 5 5 10	23 25 10	2 5 5 10	

TABLE 3. (continued). IMPLEMENTATION SCHEDULE FOR GULF STURGEON RECOVERY ACTIONS

GULF STURGEON RECOVERY IMPLEMENTATION SCHEDULE

PRIORITY	TASK #	TASK DESCRIPTION	TASK DURATION (YEARS)	RESPONSIBLE PARTY			ESTIMATED FISCAL YEAR COSTS ($000)										COMMENTS
				FWS		OTHER	FY 1		FY 2		FY 3		FY 4		FY 5		
				Region	Program		FWS	Other	FWS	Other	FWS	Other	FWS	Other	FWS	Other	
3	2.2.6	Conduct studies to determine the effects of known chemical contaminants in water from management units on Gulf sturgeon or a surrogate species	4	4	ES-PC* WNFH WSRFC	EPA NBS			75 5	10 5	75 5	10 5	75		75		WNFH & NBS may provide specimens for the studies
3	2.4.3	Operate and/or modify dams to restore the benefits of historical flow patterns and processes of sedimentation	underway continuing	4	ES FRO-PC GCFCO	FERC* COE* NMFS GSMFC											Some funding under existing programs. Project mod. costs undeterm. May require Congress. authority & non-federal sponsor.
3	2.3.2	Identify, protect, and/or acquire appropriate land or aquatic habitats on an ecosystem approach	underway continuing	4	FF FRO-PC ES-PC* GCFCO RW	NBS NMFS GSRMA NGOs											ID conducted with other studies. Land acquis. & water rights costs undeterminable.
3	2.4.2	Evaluate, design, and provide means for Gulf sturgeon to bypass migration restrictions to essential habitats	continuing	4	ES FF	FERC* COE* NMFS				10 10		25 25		25 25		25 25	FWS & NMFS funded under exist. progs. Studies conducted or infrastructure funded by COE & FERC. May req. Congress. auth. & non-fed sponsor.
3	3.1	Coordinate research and recovery actions	continuing	4	ES* FF GCFCO	NBS GSMFC*	5	5	10 5 5	2 15	5	5	10 5 5	2 15	5	5	Funding for biennial workshops
3	2.5.2	Develop policy and guidelines for hatchery and culture operations related to stocking	2	4	FF FRO-PC* ES-PC GCFCO	NBS* GSRMA GSMFC UF			5 5 2 2	2 4 1 1					5 10 5 5	2 4 2 15	Conducting this effort will be dependent on the outcome of 2.5.1
3	3.2	Develop an effective communication program or network to obtain and disseminate information on recovery actions and research results	continuing	4	ES*	GSMFC CES			5	5 2	5	5 2	5	5 2	5	5 2	Funding for producing and distributing quarterly newsletters

TABLE 3. (continued). IMPLEMENTATION SCHEDULE FOR GULF STURGEON RECOVERY ACTIONS

GULF STURGEON RECOVERY IMPLEMENTATION SCHEDULE

Priority	Task #	Task Description	Task Duration (Years)	Responsible Party: FWS Region	Responsible Party: FWS Program	Responsible Party: Other	FY 1 FWS	FY 1 Other	FY 2 FWS	FY 2 Other	FY 3 FWS	FY 3 Other	FY 4 FWS	FY 4 Other	FY 5 FWS	FY 5 Other	Comments
3	3.3	Develop a non-scientific constituency and public information program directed toward enhancing recovery actions	underway continuing	4	FF* ES* GCFCO CES	GSMFC* NMFS GSRMA			5 5 8	10 5	5 5 8	10 5	5 5 8	5	2 2 8	5	
3	1.5.2	Assess the potential to develop genetic markers to differentiate wild and hatchery-produced Gulf sturgeon	ongoing	4	FF* ES	NMFS UF			25 25	10 10	25 25	10 10					Funding this task dependent on task 1.4.3 decision
3	1.4.2	Identify physical, chemical and biological parameters necessary to maintain growth, health, and survival of fish reared under artificial conditions	underway continuing	4	WNFH WSRFC*	NBS UF LDWF ADNCR	5 5	10 5 3 3	5 20	10 5 3 3	10 20	10 8 5 5	10 20	10 8 5 5	10 20	10 10 5 5	Continuation of this effort dependent on the outcome of 2.6.1.
3	1.4.3	ID and test non-genetic internal and external markers or techniques to differentiate wild and hatchery-produced Gulf sturgeon	2	4	FF FRO-PC*	NBS CCC GSRMA			25 5	5 2 4	25 5	5 2 4					Funding this task dependent on task 1.4.3 decision
3	4.4	Develop and implement a program to monitor levels and habitat conditions of known populations in the management units as well as newly discovered, introduced, or expanding populations	continuing	4	ES* FRO-PC	NBS CCC GSRMA	1 5	5 5 20	5 5	5 5 20	1 5	5 5 20	5 5	5 5 20	1 5	5 5 20	
3	5.1	Assess overall success of the recovery program and recommend action	continuing	4	ES*		2		2		2		2		2		

APPENDIX A

FISHERY MANAGEMENT JURISDICTIONS, LAWS AND POLICIES AFFECTING THE GULF STURGEON

APPENDIX A

FISHERY MANAGEMENT JURISDICTIONS, LAWS AND POLICIES AFFECTING THE STOCKS:

Gulf sturgeon may utilize both fresh water and marine habitats at different times of the year. Excursions into the territorial waters (Exclusive Economic Zone) of the United States may occur. This factor in its biology, together with its range, subject the subspecies to the regulatory jurisdictions of the federal government as well as the States of Alabama, Louisiana, Mississippi and Florida. Numerous state and federal legislative and regulatory actions may affect the stocks. The following is a partial list of some of the more important agencies and regulations that affect the Gulf sturgeon and its habitat. State agencies should be consulted for specific and current state laws and regulations.

Federal Management Institutions. Although some recreational and subsistence harvests of Gulf sturgeon have occurred at times, the primary fishery for the sturgeon has been commercial. Because Gulf sturgeon fisheries have occurred primarily in state waters, federal agencies historically have not directly managed the stocks; though, the federal government has maintained commercial fishery landing records on the subspecies for about the past 100 years. Nonetheless, a variety of federal agencies, through their administration of laws, regulations and policies, may influence Gulf sturgeon stocks.

Regional Fishery Management Councils. With the passage of the Magnuson Fishery Conservation and Management Act (MFCMA), the federal government assumed responsibility for fishery management within the Exclusive Economic Zone (EEZ). The EEZ is contiguous to the territorial sea, with an inner boundary at the outer boundary of each coastal state. The outer boundary continues out 200 miles. Management of the EEZ is to be based on fishery management plans developed by regional fishery management councils. Each council prepares plans, with respect to each fishery requiring management, within its geographical area of authority and amends such plans as necessary. Plans are implemented as federal regulation through the Department of Commerce (DOC).

Among the guidelines, under which the councils must operate, are standards which state that, to the extent practicable, an individual stock of fish shall be managed as a unit throughout its range and that management shall, where practicable, promote efficiency, minimize costs and avoid unnecessary duplication (MFCMA Section 301a).

The Gulf of Mexico Fishery Management Council has not developed, nor is it considering, a management plan for the Gulf sturgeon. Furthermore, no significant fishery for the subspecies exists in the EEZ of the U.S. Gulf of Mexico.

Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).

National Marine Fisheries Service. The Secretary of Commerce, acting through the NMFS, has the ultimate authority to approve or disapprove all fishery management plans prepared by regional fishery management councils. Where a council fails to develop a plan, or to correct an unacceptable plan, the Secretary may do so. The NMFS also collects data and statistics on fisheries and fishermen, performs research, and conducts management authorized by international treaties. The NMFS has the authority to enforce the Magnuson Act and the Lacey Act and is the federal trustee for living and nonliving natural resources in coastal and marine areas under United States jurisdiction pursuant to the Endangered Species Act, Section 107(f) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund"), Section 311(f)(5) of the Clean Water Act (CWA), Executive Order 12580 of January 23, 1987, and Subpart G of the National Oil and Hazardous Substances Pollution Contingency Plan.

The NMFS exercises no management jurisdiction of the Gulf sturgeon, other than permitting scientific or incidental take under the Endangered Species Act and enforcement. The NMFS conducts some research and data collection programs and comments on all projects that affect marine fishery habitat under the Fish and Wildlife Coordination Act and Section 10 of the Rivers and Harbors Act.

The NMFS has entered into a Cooperative Agrrement with the Department of the Army to Restore and Create Fish Habitat. Under this agreement, the NMFS and the COE coordinate efforts to identify federal projects that could be modified to enhance fish habitat.

Office of Ocean and Coastal Resource Management (OCRM). The OCRM asserts its authority through the National Marine Sanctuaries Program pursuant to Title III of the Marine Protection, Research, and Sanctuaries Act (MPRSA). The OCRM Estuarine Sanctuary Program has designated Looe Key in Monroe County, Rookery Bay in Collier County, the Apalachicola River and Bay in Franklin County, Florida, and Weeks Bay in Baldwin County, Alabama, as estuarine sanctuaries.

The OCRM may influence fishery management for Gulf sturgeon indirectly through administration of the Coastal Zone Management Program and by setting standards and approving funding for state coastal zone management programs. Some states in the Gulf utilize a portion of these monies in their habitat protection and enhancement programs including reef maintenance and enhancement.

Department of the Interior (DOI).

National Park Service (NPS). The NPS under the DOI may regulate fishing activities within national park boundaries. Such regulations may affect Gulf sturgeon within specific parks. The NPS has authority to protect fishes and fish habitat primarily through the establishment of coastal and nearshore national parks and national monuments. Everglades National Park in Florida and the Mississippi District of Gulf Islands National Seashore are two examples of national park areas where Gulf sturgeon may occur.

U.S. Fish and Wildlife Service. The authority of the FWS to affect the management of the Gulf sturgeon is based primarily on the Endangered Species Act and the Fish and Wildlife Coordination Act. The FWS is the lead agency in developing the recovery plan for the subspecies under the Endangered Species Act. Under the Fish and Wildlife Coordination Act, the FWS, in conjunction with the NMFS, reviews and comments on proposals to alter habitat. Dam construction, drainage projects, channel alteration, wetlands filling and marine construction are projects that can potentially affect the Gulf sturgeon. Further, the FWS may seek mitigation of fishery resource impairment due to federal water-related development. The FWS has the responsibility to focus efforts on nationally significant fishery resources. The FWS also facilitates restoration by rebuilding certain major, economically valuable, anadromous, endangered, threatened, and interjurisdictional (managed by two or more states) fishery resources to full, self-sustainable productivity. Because the Gulf sturgeon is a threatened and an anadromous species, the FWS has conducted studies on various aspects of the subspecies' biology.

Gulf sturgeon occur in the aquatic portions (riverine, estuarine, marine) of national wildlife refuges (NWR) such as Pine Island NWR, Island Bay NWR, Passage Key NWR, Pinellas NWR, Chassahowitzka NWR,Cedar Keys NWR, Lower Suwannee NWR, St. Marks NWR, St. Vincent NWR, Florida, Bon Secour NWR, Alabama, Bogue Chitto NWR, Louisiana and Mississippi, and Delta NWR, Breton Island NWR, Bayou Sauvage NWR, Lacassine NWR, Louisiana. Fish and wildlife populations and their harvest within refuges are usually managed by the respective state which the refuge is located. Special use permits are required for commercial fishing on national wildlife refuges.

National Biological Service. The National Biological Service (NBS) is the Department of Interior's newest bureau. The NBS was created November 11, 1993, by consolidating the biological research, inventory, monitoring, and information transfer programs of seven Interior bureaus: FWS, NPS, MMS, USGS, Bureau of Land Management, Bureau of Reclaimation, and Office of Surface Mining. The Southeastern Biological Service Center (Center), Gainesville, Florida, of NBS was formerly a research center for FWS. The Center has conducted research on Gulf sturgeon since 1987 and will continue work in this area as requested by FWS and other agencies.

Environmental Protection Agency. The EPA, through its administration of the Clean Water Act, National Pollutant Discharge Elimination System (NPDES), may provide protection to Gulf sturgeon habitat. Applications for permits to discharge pollutants may be disapproved or conditioned to protect fresh and estuarine aquatic resources.

U.S. Department of the Army, Corps of Engineers. Gulf sturgeon habitat may be influenced by the COE's regulatory responsibilities pursuant to the Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Under these laws, the COE may authorize proposals to dredge, fill and construct in navigable waters (Section 10) or to discharge dredged or fill material into wetland areas and waters of the United States (Section 404). Such proposals could affect Gulf sturgeon habitat. The COE is also responsible for planning, construction and maintenance of dams, navigation channels and other projects that may affect Gulf sturgeon habitat.

Treaties and Other International Agreements. There are no treaties or other international agreements that affect the Gulf sturgeon. No foreign fishing applications for Gulf sturgeon harvest have been submitted to the United States government.

Federal Laws, Regulations and Policies. The following Federal laws, regulations and policies may directly and indirectly influence the habitat, populations and ultimately the management of the Gulf sturgeon.

Anadromous Fish Conservation Act (AFCA). The AFCA authorizes the Secretary of the Interior to initiate cooperative programs with the states to conserve, develop and enhance the nation's anadromous fisheries. The Act authorizes construction, installation, maintenance and operation of structures to improve or facilitate feeding, spawning and free migration of anadromous fish.

Coastal Zone Management Act and Estuarine Areas Act. Congress passed policy on values of estuaries and coastal areas through these Acts. Comprehensive planning programs to be carried out at the state level, were established to enhance, protect, and utilize coastal resources. Federal activities must comply with the individual state programs. Habitat may be protected by planning and regulating development damage to sensitive coastal habitats.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). This act is also referred to as the "Superfund". It can provide funding for "clean-up" of important habitat areas affected by oil spills or other distinct pollution discharge events.

Endangered Species Act (ESA). The ESA provides for the protection of habitat necessary for the continued existence of species listed as threatened or endangered. Section 7 of the ESA requires consultation with the FWS or NMFS by a federal agency if an action authorized, funded or carried out by such agency may affect a listed species or its critical habitat (a legal, area-specific designation). Section 7 also prohibits any federal action that would jeopardize the continued existence of a listed species or its critical habitat. Section 9 of the ESA prohibits any person or entity from "taking" a listed species without a proper permit from the FWS or NMFS. Under the ESA, taking may include harassment or habitat degradation if such would interfere with feeding, reproduction or other essential life functions. The ESA also requires preparation of a recovery plan for each listed species outlining actions needed to allow the particular species to reach a population level at which it may be delisted.

Federal Power Act (FPA). The FPA regulates the construction and operation of hydroelectric power plants through a system of licenses and permits issued by the federal Energy Regulatory Commission (FERC) (formerly Federal Power Commission). The FWS, NMFS, state agencies and others may review proposed licenses and make recommendations with respect to the needs of instream flow for fish and wildlife downstream of dams as well as the impacts that reservoir establishment may have on fish and wildlife upstream of the dams. The Act also provides for construction of fish passage facilities during dam or diversion construction. Dams are likely major factors affecting anadromous fish populations in some Gulf streams.

Federal Water Pollution Control Act (FWPCA). Also called the "Clean Water Act", the FWPCA provides for the protection of water quality at the federal level. The law also provides for assessment of injury, destruction, or loss of natural resources caused by discharge of pollutants.

Of major significance is Section 404 of the Clean Water Act (CWA), which prohibits the discharge of dredged or fill material into navigable waters without a permit. Navigable waters are defined under the CWA to include all waters of the United States, including the territorial seas and wetlands adjacent to such waters. The permit program is administered by the COE. The Environmental Protection Agency (EPA) may approve delegation of Section 404 permit authority for certain waters (not including traditional navigable waters) to a state agency; however, it retains the authority to prohibit or deny a proposed discharge under Section 404(c) of the CWA. Recent attempts to revise Section 404 or change the legal definition of wetlands may affect the utility of the CWA in wetlands protection. Although of limited applicability to anadromous fish restoration, Section 404 may be important in protecting certain types of coastal habitats or in protecting water quality in certain streams. It may also be a consideration in approval of certain types of restoration projects.

The FWPCA also authorized programs to remove or limit the entry of various types of pollutants into the nation's waters. A point source permit system was established by the EPA and is now being administered at the state level in most states. This system, referred to as the National Pollutant Discharge Elimination System (NPDES), sets specific limits on discharge of various types of pollutants from point source outfalls. A non-point source control program focuses primarily on the reduction of agricultural siltation and chemical pollution resulting from rain runoff into the nation's streams. This control effort currently relies on the use of land management practices to reduce surface runoff through programs administered primarily by the Department of Agriculture.

Both chemical contamination and siltation may be major factors limiting populations of anadromous Gulf fish species. Efforts to achieve anadromous fish restoration in key river drainages should be aimed at assuring compliance with established point and non-point source reduction programs in these basins.

Federal Water Project Recreation Act. This Act requires that consideration be given to fish and wildlife enhancement in federal water projects.

Fish and Wildlife Act of 1956. This act provides assistance to states in the form of law enforcement training and cooperative law enforcement agreements. It also allows for disposal of property abandoned or forfeited in conjunction with convictions. Some equipment may be transferred to states. The act prohibits airborne hunting and fishing activities.

Fish and Wildlife Coordination Act (FWCA). The Fish and Wildlife Coordination Act (FWCA) is the primary law providing for consideration of fish and wildlife habitat values in conjunction with federal water development activities. Under this law the Secretaries of Interior and Commerce may investigate, report and advise on the effects federal water development projects may have on fish and wildlife habitat. Such reports and recommendations, which require concurrence of the state(s) involved, must accompany the construction agency's request for congressional authorization, although, the construction agency is not bound by the recommendations. Construction agencies may transfer funds to the FWS or NMFS to investigate and report on specific projects.

The FWCA also applies to water-related activities proposed by other organizations or individuals if those activities require a federal permit or license. The FWS and NMFS may review the proposed permit action and recommend to the permitting agencies to avoid or mitigate any potential adverse effects on fish and wildlife habitat.

Fish Restoration and Management Projects Act of 1950. Under this act, the DOI is authorized to provide funds to state fish and game agencies for fish restoration and management projects. Funds for protection of threatened fish communities that are located within state waters could be made available under the act.

Food and Agriculture Act of 1962. This Act established a Resource Conservation and Development Program for regionally-sponsored flood control and drainage projects that receive financial and technical assistance from the Soil Conservation Service. Though not as active a program as it once was, activities under this program may have relevance, both positive and negative, to anadromous fish habitat protection, restoration or enhancement.

Lacey Act of 1981, as amended. The Lacey Act prohibits import, export and interstate transport of illegally-taken fish and wildlife. As such, the Act provides for federal prosecution for violations of state fish and wildlife laws. The potential for federal convictions under this Act, with its more stringent penalties, has probably reduced interstate transport of illegally-possessed Gulf sturgeon.

Magnuson Fishery Conservation and Management Act. This Act provides for the conservation of habitats throughout the ranges of anadromous species within the Exclusive Economic Zone (EEZ). It mandates the preparation of fishery management plans for important fishery resources and sets national standards to be met by such plans. Each plan attempts to define, establish and maintain the optimum yield for a given fishery.

Marine Plastic Research and Control Act of 1987 and MARPOL Annex V. MARPOL Annex V is a product of the International Convention for the Prevention of Pollution from Ships, 1973/78. Regulations under this Act prohibit ocean discharge of plastics from ships; restrict discharge of other types of floating ship's garbage (packaging and dunnage) for up to 25 nautical miles from any land; restrict discharge of victual and other recomposable waste up to 12 nautical miles from land; and require ports and terminals to provide garbage reception facilities. The MPRCA of 1987 and 33 CFR, Part 151, Subpart A, implement MARPOL V in the United States.

Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA), Titles I and III and the Shore Protection Act of 1988 (SPA). The MPRSA protects fish habitat through establishment and maintenance of marine sanctuaries. This Act and the SPA regulate ocean transportation and dumping of dredged materials, sewage sludge and other materials. Criteria for issuing permits include considering the effects dumping has on the marine environment, ecological systems and fisheries resources. Permits are issued by the Corps of Engineers.

National Environmental Policy Act (NEPA). The NEPA requires an environmental review process of all federal actions. This includes preparation of an environmental impact statement for major federal actions that may affect the quality of the human environment. Less rigorous environmental assessments are reviewed for most other actions while some actions are categorically excluded from formal review. These reviews provide an opportunity for the agency and the public to comment, on projects that may impact fish and wildlife habitat.

Oil Pollution Act. This Act provides a degree of protection to coastal fisheries habitat by regulating discharge of oil from United States registry ships. Under the Act, tankers cannot discharge oil within 50 nautical miles of land, and other ships must discharge as far as practicable from land.

Outer Continental Shelf (OCS) Lands Act Amendments of 1979. These Amendments provide for assessments of the effects oil and gas exploration, development and production have on biological resources. The law also provides a channel for comments on federal approval of leasing OCS areas for exploration and development. Oil and gas leasing activities could be of concern for coastal anadromous fish habitat and offshore winter habitat of the Gulf sturgeon.

River and Harbor Act of 1899. Section 10 of the River and Harbor Act requires a permit from the U.S. Army Corps of Engineers (COE) to place structures in navigable waters of the United States or modify a navigable stream by excavation or filling activities.

Water Resources Development Acts (WRDA). These legislative actions authorize the COE to study and/or construct individual water resource projects. Prior to 1974 such acts were known as the "Flood Control Act of (year)", the "River and Harbor Act of (year)" or commonly called the "Omnibus Bill." Beginning in 1974 these laws have been referred to as the "WRDA of (year)". Numerous projects may be authorized under these Acts in any given year. Under the FWCA, "Wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs . . ." and the FWS, NMFS and state fish and wildlife agencies may review, comment and make recommendations to the COE regarding these projects' impacts on fish and wildlife resources. These comments may address the avoidance, mitigation or compensation for habitat damages.

Of particular relevance to anadromous fish habitat restoration or enhancement is the WRDA of 1986. This Act authorized the COE to study and construct environmental enhancement projects in conjunction with existing federal water projects.

STATE MANAGEMENT INSTITUTIONS, LAWS, REGULATIONS AND POLICIES.

State management institutions, laws and regulations for the Gulf sturgeon are relatively consistent among the four Gulf States within the species' range. Each state delegates substantial authority to its administrative agencies for establishing management regulations. Brief narrative descriptions are presented below for each state institution. Important state laws, regulations and policies are also summarized. **To the greatest extent possible, these requirements are current to the date of publication.**

FLORIDA

Administrative Organization.

Florida Marine Fisheries Commission
2540 Executive Center Circle West, Suite 106
Tallahassee, FL 32301
Telephone: (904) 487-0554

The Florida Marine Fisheries Commission, a seven-member board appointed by the governor and confirmed by the senate, was created by the Florida legislature in 1983. This commission was delegated rule-making authority over marine life in the following areas of concern: gear specification; prohibited gear; bag limits; size limits; species that may not be sold; protected species; closed areas; seasons; quality control codes with the exception of specific exemptions for shellfish; and special considerations relating to oyster and clam relaying. All rules passed by the commission require approval by the governor and cabinet. The commission does not have authority over endangered species, license fees, penalty provisions or over regulation of fishing gear in residential saltwater canals.

Florida Department of Environmental Protection (FDEP)
Division of Marine Resources
3900 Commonwealth Boulevard
Tallahassee, Florida 32303
Telephone: (904) 488-6058

This agency is charged with the administration, supervision, development and conservation of marine natural resources in Florida. The Florida Department of Natural Resources was the predecessor marine resources agency until its merger with the Florida Department of Environmental Regulation July 1, 1993. The agency is headed by the Governor and Cabinet. The governor and cabinet serve as the seven-member board that approves or disapproves all rules and regulations promulgated by the FDEP. The administrative head of the FDEP is the Department Secretary. Within the FDEP the Division of Marine Resources, through Section 370.02(2), Florida Statutes, is empowered to conduct research directed toward management of marine and anadromous fisheries in the interest of all people of Florida. The Division of Law Enforcement is responsible for enforcement of all marine resource related laws and all rules and regulations of the department. The Division of Marine Resources has the responsibility of overseeing the management and research efforts on the Gulf sturgeon including issuance of collecting permits for the subspecies.

Florida Game and Fresh Water Fish Commission.
Division of Wildlife
620 South Merdian Street
Tallahassee, Florida 32399
Contact: Mr. Don A. Wood, Endangered Species Coordinator
Telephone: (904) 488-3831

This agency is charged with the administration, supervision, development and conservation of wildlife and fresh water aquatic life in Florida. The FGFC is a constitutionally autonomous agency and is overseen by a governor appointed five-member board. The administrative head of the FGFC is the executive director. Within the FGFC the Division of Wildlife Resources, in accordance with the Florida Endangered and Threatened Species Act of 1977, Section 372.072, Florida Statutes, and the Wildlife Code of the State of Florida, Title 39, Florida Administrative Code, Article IV, Sec. 9, Florida Constitution, is responsible for research and management of listed fresh water and upland species. These efforts include the administrative designation of all wildlife species (including marine and estuarine species), issuance of collection permits, and various types of research of listed upland and fresh water aquatic wildlife species. The Gulf sturgeon was listed as a species of special concern by the FGFC in 1987.

Florida has habitat protection and permitting programs and a federally-approved Coastal Zone Management (CZM) program.

Legislative Authorization. Chapter 370 of the Florida Statutes Annotated contains law regulating coastal fisheries. The legislature passes statutes for the management of fisheries resources as well as specific laws which are applicable within individual counties.

Reciprocal Agreement and Limited Entry Provisions. Not applicable, since any take of Gulf sturgeon is illegal in Florida.

Commercial Landings Data Reporting Requirements. Not applicable since all take of Gulf sturgeon is illegal in Florida.

Penalties for Violations. Penalties for violations of Florida statutes and regulations are prescribed in Section 370.021, Florida Statutes. Upon the arrest and conviction for violation of any of the regulations or laws, the license holder shall show just cause why his saltwater license should not be suspended or revoked.

Annual License Fees. Not applicable, since all take of Gulf sturgeon is illegal in Florida.

Laws and Regulations. It is illegal to take *Acipenser oxyrinchus* by any means statewide according to Rule No. 46-15.01 (1984) of the Florida Marine Fisheries Commission. (Most federal and state agencies have used the specific name *A. oxyrinchus* instead of the subspecific name *A. o. desotoi*.

ALABAMA

Administrative Organization.

Alabama Department of Conservation and Natural Resources (ADCNR)
Alabama Marine Resources Division (AMRD)
P.O. Box 189
Dauphin Island, Alabama 36528
Telephone: (205) 861-2882

Management authority of fishery resources in Alabama is held by the Commissioner of the Department of Conservation and Natural Resources. The Commissioner may promulgate rules or regulations designed for the protection, propagation and conservation of all seafood. He may prescribe the manner of taking, times when fishing may occur and designate areas where fish may or may not be caught; however, all regulations are to be directed toward the best interest of the seafood industry.[5]

Most regulations are promulgated through the Administrative Procedures Act approved by the Alabama Legislature in 1983; however, bag limits and seasons are not subject to this Act. The Administrative Procedures Act outlines a series of events that must precede the enactment of any regulations other than those of an emergency nature. Among this series of events are (a) the advertisement of the intent of the regulation, (b) a public hearing for the regulation, (c) a 35-day waiting period following the pubic hearing to address comments from the hearing and (d) a final review of the regulation by a joint house and senate review committee.

Alabama also has the Alabama Conservation Advisory Board (ACAB) that is endowed with the responsibility to provide advice on policies of the ADCNR. The board consists of the governor, the ADCNR commissioner and ten board members.

The AMRD has responsibility for enforcing state laws and regulations, for conducting marine biological research and for serving as the administrative arm of the commissioner with respect to marine resources. The division recommends regulations to the commissioner.

Alabama has a habitat protection and permitting program and a federally approved CZM program.

Legislative Authorization. Chapters 2 and 12 of Title 9, Code of Alabama, contain statutes that concern marine fisheries.

Reciprocal Agreement and Limited Entry Provisions. Not applicable since all take of Gulf sturgeon is illegal in Alabama.

Commercial Landings Data Reporting Requirements. Not applicable since all take of Gulf sturgeon is illegal in Alabama.

Penalties for Violations. Take of Gulf sturgeon is illegal in Alabama, any take is considered a Class C misdemeanor and punishable by fines up to $500.00 and three months in jail.

Annual License Fees. Not applicable since all take of Gulf sturgeon is illegal in Alabama.

Laws and Regulations. It is currently illegal to take Gulf sturgeon in freshwater or coastal waters in Alabama. Alabama has no official State list of threatened and endangered species. *Acipenser oxyrinchus* is considered a threatened species by the Symposium on Endangered and Threatened Plants and Animals of Alabama (Boshung 1976).

MISSISSIPPI

Administrative Organization.

Mississippi Department of Wildlife, Fisheries and Parks (MDWFP)
Bureau of Marine Resources (BMR)
2620 Beach Boulevard
Biloxi, Mississippi 39531
Telephone: (601) 385-5860

The MDWFP administers coastal fisheries and habitat protection programs through the BMR. Authority to promulgate regulations and policies is vested in the Mississippi Commission on Wildlife, Fisheries and Parks, the controlling body of the MDWFP. The commission consists of five members appointed by the governor. The commission has full power to "manage, control, supervise and direct any matters pertaining to all saltwater aquatic life not otherwise delegated to another agency" (Mississippi Code Annotated 49-15-11).

Mississippi has a habitat protection and permitting program and a federally approved CZM program.

Legislative Authority. Chapter 49-15 of the Mississippi Code of 1972 (Annotated) contains provisions for the management of marine fisheries resources.

Reciprocal Agreement and Limited Entry Provisions. Not applicable since it is illegal to take Gulf sturgeon anywhere in the State of Mississippi.

Commercial Landings Data Reporting Requirements. Not applicable since it is illegal to take Gulf sturgeon anywhere in the State of Mississippi.

Penalties for Violations. Any person, firm or corporation violating any of the provisions of Chapter 49-15 or any ordinance duly adopted by the commission, unless otherwise specifically provided for herein, shall, on conviction, be fined not less than $100, nor more than $500, for the first offense, unless the first offense is committed during a closed season, in which case the fine shall be not less than $500, nor more than $1,000; and not less than $500, nor more than $1,000, for the second offense when such offense is committed within a period of 3 years from the first offense; and not less than $2,000 nor more than $4,000, or imprisonment in the county jail for a period not exceeding 30 days for any third or subsequent offense when such offense is committed within a period of 3 years from the first offense and also upon conviction of such third or subsequent offense, it shall be the duty of the court to revoke the license of the convicted party and of the boat or vessel used in such offense, and no further license shall be issued to such person or for said boat to engage in catching or taking of any seafoods from the waters of the State of Mississippi for a period of 1 year following such conviction. Further, upon conviction of such third or subsequent offense committed within a period of 3 years from the first offense, it shall also be the duty of the court to order the forfeiture of any equipment or nets used in such offense. Provided, however, that equipment as used in this section shall not mean boats or vessels. Any person convicted and sentenced under this section shall not be considered for suspension or other reduction of sentence. Except as provided under subsection 5 of Section 49-15-45, any fines collected under this section shall be paid to the Mississippi Commission on Wildlife, Fisheries and Parks to be paid into the Seafood Fund.

Annual License Fees. Not applicable since it is illegal to take Gulf sturgeon anywhere in the State of Mississippi.

Laws and Regulations. *Acipenser oxyrinchus* was listed as an endangered species by the Mississippi Game and Fish Commission and the Rare and Endangered Species Committee (1975) and is protected by law. The subspecies is also listed as endangered by the Mississippi Natural Heritage Program, 1977, and as a Special Animal Species by the Mississippi Parks Commission, Bureau of Outdoor Recreation, Jackson, MS.

LOUISIANA

Administrative Organization.

Louisiana Department of Wildlife and Fisheries (LDWF)
P.O. Box 98000
Baton Rouge, Louisiana 70898
Telephone: (504) 765-3617

The LDWF is one of 21 major administrative units of the Louisiana government. A seven-member board, the Louisiana Wildlife and Fisheries Commission (LWFC) is appointed by the Governor. Six of the members serve overlapping terms of six years, and one serves a term concurrent with the Governor. The commission is a policy-making and budgetary-control board with no administrative functions. The legislature has sole authority to establish management programs and policies; however, the legislature has delegated certain authority and responsibility to the LDWF. The Secretary of the LDWF is the executive head and chief administrative officer of the department and is responsible for the administration, control and operation of the functions, programs and affairs of the department. The secretary is appointed by the Governor with consent of the Senate.

Within the administrative system, an Assistant Secretary is in charge of the Office of Fisheries. In this office a Marine Fisheries Division and an Inland Fisheries Division may have management jurisdiction over the Gulf sturgeon. The Enforcement Division, in the Office of the Secretary, is responsible for enforcing all fishery statutes and regulations.

The LDWF's Natural Heritage Program is responsible for administering the laws, rules, and regulations regarding threatened and endangered species (R.S. 56:1830). In addition, under a full authorities Section 6 agreement with the FWS, the take of threatened and endangered species may be authorized by permits issued by the Department.

Louisiana has habitat protection and permitting programs and a federally approved CZM program.

Legislative Authorization. Title 56 Louisiana Revised Statutes contains rules and regulations that govern marine fisheries in the state.

Reciprocal Agreement and Limited Entry Provisions. Not applicable, since take of Gulf sturgeon is illegal in Louisiana.

Commercial Landings Data Reporting Requirements. Not applicable, since take of Gulf sturgeon is illegal in Louisiana.

Penalties for Violations. The fine for each illegally caught fish is $2,500.00

Annual License Fees. Not applicable, since take of Gulf sturgeon is illegal in Louisiana.

Laws and Regulations. Louisiana law currently prohibits take of all sturgeon anywhere in the state. The Louisiana Division of Natural Heritage is responsible for listing of endangered and threatened species.

U.S. Fish & Wildlife Service

Revised RECOVERY PLAN

for the

Pallid Sturgeon (*Scaphirhynchus albus*)

Original Plan Approved: November 1993

Prepared by:
Pallid Sturgeon Recovery Coordinator
U.S. Fish and Wildlife Service
Montana Fish and Wildlife Conservation Office
Billings, Montana

For

Mountain-Prairie Region
U.S. Fish and Wildlife Service
Denver, CO

January 2014

U.S. Fish & Wildlife Service

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Mountain-Prairie Region
U.S. Fish and Wildlife Service
Denver, CO

Approved: ______________________________
Deputy Regional Director, Region 6, U.S. Fish and Wildlife Service

Date: 1.29.14

DISCLAIMER

Suggested literature citation:

U.S. Fish and Wildlife Service. 2014. Revised Recovery Plan for the Pallid Sturgeon (*Scaphirhynchus albus*). U.S. Fish and Wildlife Service, Denver, Colorado. 115 pp.

Recovery plans can be downloaded from: http://ecos.fws.gov/tess_public/SpeciesRecovery.do

ACKNOWLEDGMENTS

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* Pallid Sturgeon Recovery Team member when document revision was first initiated, however individual no longer serves on the Recovery Team.

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The Upper Basin Pallid Sturgeon Workgroup

The Middle Basin Pallid Sturgeon Workgroup

The Lower Basin Pallid Sturgeon Workgroup

U.S. Army Corps of Engineers

EXECUTIVE SUMMARY

CURRENT SPECIES STATUS: The Pallid Sturgeon was listed as endangered under the Endangered Species Act on September 6, 1990 (55 FR 36641-36647). Since listing, the status of the species has improved and is currently stable. New information related to habitat extent and condition, abundance, and potential recruitment in the Mississippi and Atchafalaya rivers has improved our understanding of the species in these areas. While the numbers of wild Pallid Sturgeon collected in the Missouri, Mississippi and Atchafalaya rivers are higher than initially documented when listed and evidence for limited recruitment exists for the lower Missouri and Mississippi rivers, the population has not been fully quantified. This increase in observations is the result of increased monitoring efforts, improvements in sampling techniques, and greater emphasis on research in the impounded portion of the range. Despite increased efforts, data regarding recruitment, mortality, habitat use, and abundance remain limited. Population estimates for wild Pallid Sturgeon within some inter-reservoir reaches of the Missouri River indicate the extant wild populations are declining or extirpated. To prevent further extirpation, a conservation propagation program has been established. The Pallid Sturgeon Conservation Augmentation Program (PSCAP) appears to be successful in maintaining the species' presence within the Missouri River basin. However, if supplementation efforts were to cease, the species would once again face local extirpation within several reaches.

HABITAT REQUIREMENTS AND LIMITING FACTORS: The Pallid Sturgeon is native to the Missouri and Mississippi rivers and adapted to the pre-development habitat conditions that historically existed in these rivers. These conditions generally can be described as large, free-flowing, warm-water, and turbid rivers with a diverse assemblage of dynamic physical habitats. Limiting factors include: 1) activities which affect in-river connectivity and the natural form, function, and hydrologic processes of rivers; 2) illegal harvest; 3) impaired water quality and quantity; 4) entrainment; and 5) life history attributes of the species (i.e., delayed sexual maturity, females not spawning every year, and larval drift requirements). The degree to which these factors affect the species varies among river reaches.

RECOVERY STRATEGY: The primary strategy for recovery of Pallid Sturgeon is to: 1) conserve the range of genetic and morphological diversity of the species across its historical range; 2) fully quantify population demographics and status within each management unit; 3) improve population size and viability within each management unit; 4) reduce threats having the greatest impact on the species within each management unit; and, 5) use artificial propagation to prevent local extirpation within management units where recruitment failure is occurring.

Achieving our recovery strategy will require: 1) increased knowledge of the status of Pallid Sturgeon throughout its range; 2) better understanding of Pallid Sturgeon life history, ecology, mortality, and habitat requirements; 3) improve assessments of all potential threats affecting the species; and 4) application of information gained through research and monitoring to effectively implement management actions where recovery can be achieved (see Recovery Outline/Narrative).

RECOVERY GOAL: The ultimate goal is species recovery and delisting. The intermediate goal is downlisting the species from endangered to threatened.

RECOVERY OBJECTIVES: The recovery objectives include the implementation of effective management actions that will reduce or alleviate the impacts from threats to the species within each management unit and across the species' range. Recovery actions to address threats within management units should be informed by adequate knowledge of pallid sturgeon abundance, population structure, life history, ecology, mortality, and habitat requirements specific to those units.

RECOVERY CRITERIA: Pallid Sturgeon will be considered for reclassification from endangered to threatened when the listing/recovery factor criteria (p. 54) are sufficiently addressed such that a self-sustaining genetically diverse population is realized and maintained within each management unit for 2 generations (20-30 years). Delisting will be considered when the listing/recovery factor criteria are sufficiently addressed and adequate protective and conservation measures are established to provide reasonable assurance of long-term persistence of the species within each management unit in the absence of the Endangered Species Act's protections.

In this context, a self-sustaining population is described as a naturally spawning population that results in sufficient recruitment of Pallid Sturgeon into the adult population at levels necessary to maintain a genetically diverse wild adult population in the absence of artificial population augmentation (see *Criteria for Reclassification to Threatened Status* p. 54). Additionally, in this context a genetically diverse population is defined as one in which the effective population size (N_e) is sufficient to maintain adaptive genetic variability into the foreseeable future. These criteria should be achieved and adequately demonstrated within each management unit prior to consideration for reclassification. Because the nature of threats to the species and impediments to recovery vary among management units, it is likely that individual units may achieve population sustainability criteria earlier than others. As populations recover and the inter-relationships of populations on the landscape are better known, the data will be reviewed to determine whether the designation of distinct population segments (DPSs) is warranted.

ACTIONS NEEDED (see *Recovery Outline/Narrative* pp. 58-74):

1. Conserve and restore Pallid Sturgeon individuals, populations, and habitats.
2. Conduct research necessary to promote survival and recovery of Pallid Sturgeon.
3. Obtain information on population genetics, status, and trends.
4. Maintain the Pallid Sturgeon Conservation Augmentation Program where deemed necessary.
5. Coordinate and implement conservation and recovery of Pallid Sturgeon.
6. Post downlisting or delisting planning.

ESTIMATED COST OF RECOVERY TASK IMPLEMENTATION (not adjusted for inflation): The estimated cost to implement this recovery plan and achieve species recovery is $239,170,000.

Of this amount, the estimated costs for downlisting from endangered to threatened is $221,820,000 and post reclassification costs are estimated to be $17,350,000. More detailed descriptions of the recovery tasks can be found in the *Recovery Outline/Narrative* (pp. 58-74) and a prioritized list of recovery tasks can be found in the *Implementation Schedule* (pp. 75-78).

DATE OF RECOVERY: The estimated earliest date for status reclassification from endangered to threatened is 2030 and from threatened to recovered is 2047 provided recovery tasks are implemented and recovery criteria are met. These estimates may change as new data become available.

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FIGURES

Abbreviated units used in this plan

cfs	cubic feet per second
ft	foot (feet)
ft/s	foot (feet) per second
km	kilometer(s)
m	meter(s)
m/s	meter(s) per second
mg/l	milligram(s) per liter
mi	mile(s)
NTU	nephelometric turbidity units
Rkm	River kilometer(s)
Rmi	River mile(s)

Acronyms used in this plan

CLMU:	Central Lowlands Management Unit
CPMU:	Coastal Plain Management Unit
DPS:	Distinct Population Segments
GPMU:	Great Plains Management Unit
IHMU:	Interior Highlands Management Unit
PCB:	Polychlorinated Biphenyls
PSCAP:	Pallid Sturgeon Conservation Augmentation Program
RSD:	Relative Stock Density
USFWS:	U.S. Fish and Wildlife Service

Part I: Background

History

Pallid Sturgeon (*Scaphirhynchus albus*), as well as other sturgeon species, are often referred to as "living dinosaurs". This moniker results from existence of fossilized sturgeon believed to be precursors to, or possibly common ancestors of, contemporary *Scaphirhynchus* species that coexisted with dinosaurs during the Cretaceous period of the Mesozoic era. Evidence for this coexistence is based on North American fossil sturgeon specimens (*Priscosturion longipinnis* and *Protoscaphirhynchus squamosus*) which date up to 78 million years before present (Grande and Hilton 2006; Hilton and Grande 2006; Grande and Hilton 2009). Today, eight species and one subspecies of sturgeon belonging to the family Acipenseridae inhabit North America; specifically these are:

- Pallid Sturgeon (*Scaphirhynchus albus*) – *E*;
- Shovelnose Sturgeon (*Scaphirhynchus platorynchus*) – *T-SOA*;
- Alabama Sturgeon (*Scaphirhynchus suttkusi*) – *E*;
- White Sturgeon (*Acipenser transmontanus*) – *E*;
- Green Sturgeon (*Acipenser medirostris*) – *T*;
- Lake Sturgeon (*Acipenser fulvescens*);
- Shortnose Sturgeon (*Acipenser brevirostrum*) – *E*;
- Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*); *– E (4 DPS) and T (1 DPS)*
- Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) – *T*;

Seven of these species are on the Federal list of endangered and threatened wildlife and plants, of which two species are listed as threatened (*T*), four are listed as endangered (*E*), one has DPSs that are either listed as threatened or endangered, and one is treated as threatened due to its similarity of appearance (T-SOA) to the listed Pallid Sturgeon (detail provided under Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes). While the Lake Sturgeon is not federally listed, it has declined throughout its native range and receives special protections in most states and provinces where it occurs.

The Pallid Sturgeon was listed as endangered on September 6, 1990 (55 FR 36641-36647).

Species Description and Taxonomy

The Pallid Sturgeon was first recognized as a species different from Shovelnose Sturgeon by S. A. Forbes and R. E. Richardson in 1905 based on a study of nine specimens collected from the Mississippi River near Grafton, Illinois (Forbes and Richardson 1905). They named this new species *Parascaphirhynchus albus*. Later reclassification assigned it to the genus *Scaphirhynchus* where it has remained (Bailey and Cross 1954; Campton et al. 2000).

General Description

Pallid Sturgeon have a flattened shovel-shaped snout; a long, slender, and completely armored caudal peduncle (the tapered portion of the body which terminates at the tail); and lack a spiracle (small openings found on each side of the head) (Forbes and Richardson 1905). As with other sturgeon, the mouth is toothless, protrusible (capable of being extended and withdrawn from its natural position), and ventrally positioned under the head. The skeletal structure is primarily composed of cartilage rather than bone.

Pallid Sturgeon are similar in appearance to the more common Shovelnose Sturgeon. Both species inhabit overlapping portions of the Missouri and Mississippi river basins. In their original description, Forbes and Richardson (1905) noted that Pallid Sturgeon differed from Shovelnose Sturgeon in size, color, head length, eye size, mouth width, barbel length ratios, ossification, gill raker morphology, number of ribs, and size of the air bladder. Bailey and Cross (1954) identified several additional differences between the two species, including barbel arrangement and position, barbel structure (i.e., diameter and papillae), and both dorsal and anal fin ray counts. They also developed a suite of diagnostic measurement ratios intended to eliminate the effects of size, age, and possibly geographic variation. In general, mature Pallid Sturgeon attain larger sizes than mature Shovelnose Sturgeon and they have longer outer barbels and shorter inner barbels with inner barbels originating anterior to outer barbels. Additionally, Pallid Sturgeon have wider mouths and naked bellies generally lack the mosaic of embedded scutes that armor the ventral surface of the Shovelnose Sturgeon.

Several of these diagnostic characters and ratios change with age of the fish (allometric growth), making identification of juvenile and subadult fish difficult. Fishery biologists have found that in most cases the seven morphometric ratios described in Bailey and Cross (1954) as well as subsequent indices developed by Wills et al. (2002) were not mutually exclusive when used to compare Pallid to Shovelnose sturgeon in the middle Mississippi River (Bettoli et al. 2009) or when used to compare both species from different geographic reaches (Murphy et al. 2007a). Also, these indices do not work well on smaller-sized specimens (Kuhajda et al. 2007). This lack of uniform applicability of morphometric indices may be attributable to greater morphological differences documented between upper Missouri River Pallid Sturgeon and Pallid Sturgeon samples in the middle and lower Mississippi and Atchafalaya rivers (Murphy et al. 2007a). Additionally, Pallid Sturgeon from the upper Missouri River live longer and grow larger than those found in the lower Missouri and Mississippi rivers (Figure 1).

Figure 1 Preserved adult Pallid Sturgeon: the larger specimen (background) is from the upper Missouri River and the smaller specimen (foreground) is from the lower Mississippi/Atchafalaya Rivers. Both specimens are among the larger specimens recorded from each region. (Photo courtesy Dr. Bernard Kuhajda, Tennessee Aquarium Conservation Institute).

Historical Distribution and Abundance

The historical distribution of the Pallid Sturgeon (Figure 2) includes the Missouri and Yellowstone rivers in Montana downstream to the Missouri-Mississippi confluence and the Mississippi River possibly from near Keokuk, Iowa[1] downstream to New Orleans, Louisiana (Coker 1929; Bailey and Cross 1954; Brown 1955; Carlson and Pflieger 1981; Kallemeyn 1983; Keenlyne 1989 and 1995).

Pallid Sturgeon also were documented in the lower reaches of some of the larger tributaries to the Missouri, Mississippi, and Yellowstone rivers including the Tongue, Milk, Niobrara, Platte, Kansas, Big Sioux, St. Francis, Grand, and Big Sunflower rivers (Bailey and Cross 1954; Brown 1955; Keenlyne 1989; Ross 2001; Snook et al. 2002; Braaten and Fuller 2005; Peters and Parham 2008). The total length of the Pallid Sturgeon's range historically was about 5,656 River kilometers (Rkm) (3,515 River miles (Rmi)).

Because the Pallid Sturgeon was not recognized as a species until 1905, little detailed information is available concerning early abundance. Forbes and Richardson (1905) suggested that the lack of prior recognition of the species might have been attributable to scarcity, noting that Pallid Sturgeon accounted for about one in five hundred individuals of the *Scaphirhynchus* sturgeon collected from the central Mississippi River. The species was reported to be more abundant in the turbid lower Missouri River where some fishermen reported one in five sturgeon as Pallid Sturgeon (Forbes and Richardson 1905). However, it is probable that commercial fishermen failed to accurately distinguish the species in their sturgeon catches. As late as the mid-1900s, it was common for Pallid Sturgeon to be included in commercial catch records as either Shovelnose or Lake sturgeon (Keenlyne 1995). Although considered to be nowhere common, Bailey and Cross (1954) indicated that Pallid Sturgeon were considerably more abundant in larger turbid rivers than in clear or moderately turbid waters.

Correspondence and notes of researchers suggest that Pallid Sturgeon were often encountered in portions of the Missouri River as late as the 1960s (Keenlyne 1989). While there are fewer than 40 historical (pre-listing) records of Pallid Sturgeon from the Mississippi River (Kallemeyn 1983, Keenlyne 1989), this may be attributed to a lack of historical systematic fish collections from that portion of the range.

Present Distribution and Abundance

Since listing in 1990, wild Pallid Sturgeon have been documented in the Missouri River between Fort Benton and the headwaters of Fort Peck Reservoir, Montana; downstream from Fort Peck Dam, Montana to the headwaters of Lake Sakakawea, North Dakota; downstream from Garrison Dam, North Dakota to the headwaters of Lake Oahe, South Dakota; from Oahe Dam downstream to within Lake Sharpe, South Dakota; between Fort Randall and Gavins Point Dams, South Dakota and Nebraska; downstream from Gavins Point Dam to St. Louis, Missouri; in the lower Milk and Yellowstone rivers, Montana and North Dakota; the lower Big Sioux River, South Dakota; the lower Platte River, Nebraska; the lower Niobrara River, Nebraska; and the lower Kansas River, Kansas (Figure 3). Pallid Sturgeon observations and records have increased with

[1] Bailey and Cross (1954) considered the observation near Keokuk, Iowa as "dubious" and remark the species is likely represented by "stragglers from down river."

sampling effort in the Mississippi River basin. In 1991, the species was identified in the Atchafalaya River, Louisiana (Reed and Ewing 1993) (Figure 3).

The contemporary downstream extent of Pallid Sturgeon ends near New Orleans, Louisiana (Killgore in litt., 2008). Additionally, the species has been documented in the lower Arkansas River (Kuntz in litt., 2012), the lower Obion River, Tennessee (Killgore et al. 2007b), as well as navigation pools 1 and 2, i.e., downstream from Lock and Dam 3, in the Red River, Louisiana (Slack et al. 2012) (Figure 3).

In 1995, a preliminary estimate found about 45 wild Pallid Sturgeon existed in the Missouri River upstream of Fort Peck Reservoir (Gardner 1996). More recent data suggest that substantially fewer wild fish remain today. For example only three wild Pallid Sturgeon were collected during 2007 – 2013, indicating wild Pallid Sturgeon numbers in the Missouri River upstream of Fort Peck Reservoir are too low for a reliable population estimate (Tews in litt., 2013). An estimated 125 wild Pallid Sturgeon remain in the Missouri River downstream of Fort Peck Dam to the headwaters of Lake Sakakawea including the lower Yellowstone River (Jaeger et al. 2009). While current abundance estimates are lacking for the entire Missouri River downstream of Gavins Point Dam, Steffensen et al. (2012) generated annual population estimates for both wild and hatchery-reared Pallid Sturgeon for the reach of the Missouri River extending from the Platte River confluence downstream 80.5 Rkm (50 Rmi). Their results estimated wild Pallid Sturgeon at 5.4 to 8.9 fish/Rkm (8.7 to 14.3fish/Rmi) and hatchery produced Pallid Sturgeon at 28.6 to 32.3 fish/Rkm (46.1 to 52.0 fish/Rmi). Extrapolating these estimates to the entire lower Missouri River suggests that the wild population may consist of as many as 5,991 mature individuals (Steffensen et al. 2013). This population may be stabilizing as a result of the Pallid Sturgeon Conservation Augmentation Program (PSCAP), but remains neither self-sustaining nor viable (Steffensen 2012; Steffensen et al. 2013). Garvey et al. (2009) generated an estimate of 1,600 (5 fish/Rkm, 0.8 fish/Rmi) to 4,900 (15.2 fish/Rkm, 24.5 fish/Rmi) Pallid Sturgeon for the middle Mississippi River (i.e., mouth of the Missouri River Downstream to the Ohio River confluence). In 2009, a sturgeon survey in the Upper Mississippi River captured a single Pallid Sturgeon below lock and dam 25 near Winfield, Missouri (Herzog in litt., 2009). No estimates are available for the remainder of the Mississippi River. Since 1994, the PSCAP has released hatchery-reared Pallid Sturgeon within the Missouri River, portions of the Yellowstone River, and sporadically in the Mississippi River. Supplementation data are summarized within the stocking plan (USFWS 2008).

Habitat Preferences

Pallid Sturgeon are a bottom-oriented, large river obligate fish inhabiting the Missouri and Mississippi rivers and some tributaries from Montana to Louisiana (Kallemeyn 1983). Pallid Sturgeon evolved in the diverse environments of the Missouri and Mississippi river systems. Floodplains, backwaters, chutes, sloughs, islands, sandbars, and a dynamic main channel formed the large-river ecosystem that met the habitat and life history requirements of Pallid Sturgeon and other native large-river fishes.

Figure 2 Map of prominent rivers in the Mississippi River Basin. Bold line approximates historical range of Pallid Sturgeon (Coker 1929; Bailey and Cross 1954; Brown 1955; Carlson and Pflieger 1981; Kallemeyn 1983; Keenlyne 1995).

Figure 3 Post-development map of prominent rivers in the Mississippi River Basin. Bold line approximates current range of Pallid Sturgeon and includes both wild and hatchery-reared fish. (Data: National Pallid Sturgeon Database, U.S. Fish and Wildlife Service, Bismarck, North Dakota).

Habitat Use

Research into habitat usage has produced some useful insights in many portions of the Pallid Sturgeon's range. However, it should be cautioned that much of these data are based on habitat characterizations in altered environments, in some cases substantially altered environments, including an altered hydrograph and temperatures, suppression of fluvial processes, stabilized river banks, loss of natural meanders and side channels, fragmented habitats, and increased water velocities. Thus, the following information and current understanding of habitat use may not necessarily reflect preferred habitats for the species, but rather define suitable habitats within an altered ecosystem.

Pallid Sturgeon primarily utilize main channel, secondary channel, and channel border habitats throughout their range. Juvenile and adult Pallid Sturgeon are rarely observed in habitats lacking flowing water which are removed from the main channel (i.e., backwaters and sloughs). Specific patterns of habitat use and the range of habitat parameters used may vary with availability and by life stage, size, age, and geographic location. In the upper portions of the species' range, juvenile hatchery-reared Pallid Sturgeon select main-channel habitats (Gerrity 2005). In the Yellowstone and Platte rivers, adult Pallid Sturgeon select areas with frequent islands and sinuous channels while rarely occupying areas without islands or with straight channels (Bramblett and White 2001; Snook et al. 2002; Peters and Parham 2008). While adult Pallid Sturgeon in the channelized lower Missouri River primarily use channel border habitats associated with engineered structures, they have been documented utilizing side channels, as well as newly inundated floodplain habitats with flowing water associated with historic discharges from Gavins Point Dam (Justin Haas in litt., 2013). In the middle Mississippi River, Pallid Sturgeon select for areas downstream from islands that are often associated with channel border habitats and select against main-channel habitats (Hurley et al. 2004). Other Mississippi River capture locations tend to be near the tips of wing-dikes (an engineered channel training structure), steep sloping banks, and channel border areas (Killgore et al. 2007b; Schramm and Mirick 2009).

Habitat requirements of larval and young-of-year Pallid Sturgeon remain largely undescribed across the species' range, primarily as a result of low populations of spawning adults and poor recruitment. However, some authors have postulated that early life-stage habitats in channelized river reaches may be similar among *Scaphirhynchus* species (Phelps et al. 2010; Ridenour et al. 2011). Young of year *Scaphirhynchus* in the lower Missouri River were found in habitats associated with the main channel border and moderate velocities (0.5-0.7 meters per second (m/s), 1.6-2.3 feet per second (ft/s)) (Ridenour et al. 2011). Age- 0 *Scaphirhynchus* sturgeon in the Middle Mississippi River were more often found in channel border and island-side channel habitats and positively associated with low velocities (~0.1 m/s, 0.33 ft/s), moderate depths (2-5 m, 6.6-16.4 ft), and sand substrate (Phelps et al. 2010). No Pallid Sturgeon were positively identified among the specimens collected in either study, thus, while these data offer useful insights, empirically derived larvae and young-of-year Pallid Sturgeon data are lacking.

Substrate

Pallid Sturgeon have been documented over a variety of available substrates, but are often associated with sandy and fine bottom materials (Bramblett and White 2001; Gerrity 2005; Snook et al. 2002; Swigle 2003; Peters and Parham 2008; Spindler 2008) and exhibit a selection for sand over mud, silt, or vegetation (Elliott et al. 2004). Substrate association appears to be seasonal (Koch et al. 2006a; Koch et al. 2012). During winter and spring, sand, sand and gravel, and rock substrates are used and during the summer and fall sand substrate is most often used (Koch et al. 2006a). In the middle Mississippi River, Pallid Sturgeon transition from predominantly sandy substrates to gravel during May which may be associated with spawning (Koch et al. 2012). In these river systems and others, Pallid Sturgeon appear to use underwater sand dunes (Bramblett 1996; Constant et al. 1997; Snook et al. 2002; Elliott et al. 2004; Jordan et al. 2006) which may serve as some form of holding, resting, or feeding area.

Depths and Velocity

Pallid Sturgeon are primarily benthic fishes, that is they spend the majority of their time at or near the river bottom. Across their range, Pallid Sturgeon have been documented in waters of varying depths and velocities. Depths at collection sites range from 0.58 m to > 20 m (1.9 to > 65 ft), though there may be selection for areas >0.8 m (2.6 ft) deep (Bramblett and White 2001; Carlson and Pflieger 1981; Constant et al. 1997; Erickson 1992; Gerrity 2005; Jordan et al. 2006; Peters and Parham 2008; Wanner et al. 2007). Despite the wide range of depths associated with capture locations, one commonality is apparent: this species is typically found in areas where relative depths (the depth at the fish location divided by the maximum channel cross section depth expressed as a percent) exceed 75% (Constant et al. 1997; Gerrity 2005; Jordan et al. 2006; Wanner et al. 2007).

Bottom water velocities associated with collection locations are generally < 1.5 m/s (4.9 ft/s) with reported averages ranging from 0.58 m/s to 0.88 m/s (1.9 ft/s to 2.9 ft/s) (Carlson and Pflieger 1981; Elliott et al. 2004; Erickson 1992; Jordan et al. 2006; Swigle 2003; Snook et al. 2002).

Turbidity

Pallid Sturgeon have been collected from a variety of turbidity conditions, including highly altered areas with consistently low turbidities (i.e., 5-100 nephelometric turbidity units (NTU)) to comparatively natural systems like the Yellowstone River with seasonally high turbidity levels (> 1,000 NTU) (Braaten and Fuller 2002, 2003; Erickson 1992; Jordan et al. 2006; Peters and Parham 2008). Currently, the effects from altered turbidity levels are poorly understood. Given their small eye structure, four barbels with taste buds, taste buds on lips, and ampullary electroreceptors on the underside of the snout, the species appears to be highly adapted to low-visibility environments. It is reasonable to infer that the historically high turbidity levels in the Missouri and Mississippi rivers was a component of the natural ecological processes under which the species evolved. Thus, rivers defined by high turbidity levels that fluctuate seasonally and annually are considered important because the species' life history traits (i.e., predator avoidance or feeding mechanisms) evolved in low visibility environments.

Life History

Pallid Sturgeon can be long-lived, with females reaching sexual maturity later than males (Keenlyne and Jenkins 1993). Based on wild fish, estimated age at first reproduction was 15 to 20 years for females and approximately 5 years for males (Keenlyne and Jenkins 1993). Like most fish species, water temperatures influence growth and maturity. Female hatchery-reared Pallid Sturgeon maintained in an artificially controlled hatchery environment (i.e., near constant

16 to 20^{o} C, 61 to 68 ^{o} F temperatures) can attain sexual maturity at age 6, whereas female Pallid Sturgeon subject to colder winter water temperatures reached maturity around age 9 (Webb in litt., 2011). Hatchery-reared Pallid Sturgeon in the lower Missouri River reached sexual material at ages 9 and 7 for males and females, respectively (Steffensen 2012). However, as of 2012, no 1997 year-class hatchery-reared Pallid Sturgeon, released in the upper Missouri River between Fort Peck Dam and Lake Sakakawea, have been found to be sexually mature. Thus, age at first reproduction can vary between hatchery-reared and wild fish and is dependent on local conditions.

Females do not spawn each year (Kallemeyn 1983). Observations of wild Pallid Sturgeon collected as part of the Pallid Sturgeon Conservation Augmentation Program (PSCAP) in the northern part of the range indicates that female spawning periodicity is 2-3 years (Rob Holm, USFWS Garrison Dam Hatchery, unpublished data).

Fecundity is related to body size. The largest upper Missouri River fish can produce as many as 150,000-170,000 eggs (Keenlyne et al. 1992; Rob Holm, USFWS Garrison Dam Hatchery, unpublished data), whereas smaller bodied females in the southern extent of the range may only produce 43,000-58,000 eggs (George et al. 2012). Spawning appears to occur between March and July, with lower latitude fish spawning earlier than those in the northern portion of the range. Adult Pallid Sturgeon can move long distances upstream prior to spawning; a behavior that can be associated with spawning migrations (U.S. Geological Survey 2007; DeLonay et al. 2009). Females likely spawn at or near the apex of these movements (Bramblett and White 2001; DeLonay et al. 2009). Spawning appears to occur adjacent to or over coarse substrate (boulder, cobble, gravel) or bedrock, in deeper water, with relatively fast, converging flows, and is driven by several environmental stimuli including day length, water temperature, and flow (U.S. Geological Survey 2007; DeLonay et al. 2009).

Incubation rates are governed by and dependant upon water temperature. In a hatchery environment, fertilized eggs hatch in approximately 5-7 days (Keenlyne 1995). Incubation rates may deviate slightly from this in the wild. Newly hatched larvae are predominantly pelagic, drifting in the currents for 11 to 13 days and likely dispersing several hundred km downstream from spawn and hatch locations (Kynard et al. 2002, 2007; Braaten et al. 2008, 2010, 2012a; Phelps et al. 2012).

Diets

Data on food habits of age-0 Pallid Sturgeon are limited. In a hatchery environment, exogenously feeding fry (fry that have absorbed their yolk and are actively feeding) will readily consume brine shrimp, suggesting zooplankton and/or small invertebrates are likely the food base for this age group. Data available for wild age-0 *Scaphirhynchus* indicate mayflies (Ephemeroptera) and midge (Chironomidae) larvae are important (Sechler et al. 2012).

Juvenile and adult Pallid Sturgeon diets are generally composed of fish and aquatic insect larvae with a trend toward piscivory as they increase in size (Carlson and Pflieger 1981; Hoover et al. 2007; Gerrity et al. 2006; Grohs et al. 2009; Wanner 2006; French 2013).

Based on the above diet data and habitat utilization by prey items, it appears that Pallid Sturgeon will feed over a variety of substrates (Hoover et al. 2007; Keevin et al. 2007). However, the abundance of Trichoptera in the diet of fish studied in some reaches suggests that harder substrates like gravel and rock material may have become important feeding areas (Hoover et al. 2007), though it remains unknown if this was historically the case or a contemporary response to stabilization and channel maintenance activities increasing the abundance of localized rock material.

Population Genetic Structure

Genetic information suggests evolutionary differences across the range. Campton et al. (2000) used approximately 500 base pairs of the mitochondrial DNA control region to examine genetic variation within and among three Pallid Sturgeon groups; two from the upper Missouri River and one from the Atchafalaya River. The Pallid Sturgeon from the upper Missouri River and Atchafalaya Rivers did not share any haplotypes ($P < 0.001$), and the genetic distance between these two groups (0.14%) was nearly as great as the genetic distance between Pallid and Shovelnose sturgeon in the upper Missouri River (0.15%). The authors note that this may represent reproductive isolation and genetic divergence between these two populations of Pallid Sturgeon that is nearly as old as the isolation between Pallid and Shovelnose sturgeon.

Tranah et al. (2001) examined genetic variation within and among the same three Pallid Sturgeon groups as Campton (2000) using five microsatellite loci. The two upper Missouri River groups, separated by Ft. Peck Dam, did not differ significantly from each other. However, Pallid Sturgeon genetic samples from the upper Missouri River population did differ from samples collected from the Atchafalaya River ($F_{st} = 0.13$ and 0.25; both $P < 0.01$). Thus, Pallid Sturgeon collected from the Missouri River in Montana (the northern fringe of their range) are reproductively isolated from those sampled from the southern extreme of their range and likely represent genetically distinct populations (Tranah et al. 2001).

Subsequent work on allele frequencies at 16 microsatellite loci identified significant differences between upper Missouri River Pallid Sturgeon samples when compared with samples from the lower Missouri, Mississippi, and Atchafalaya rivers (Schrey 2007). While samples from the middle Missouri River (i.e., collected between Gavins Point Dam, South Dakota, downstream to Kansas City, Missouri) appeared to be genetically intermediate between the northern and southern samples (Schrey 2007).

These data indicate that genetic structuring exists within the Pallid Sturgeon's range consisting of two distinct groups at the extremes of the species' range with an intermediate group in the middle Missouri River (Campton et al. 2000; Tranah et al. 2001; Schrey 2007). These data suggest a pattern of isolation by distance, with gene flow more likely to occur between adjacent groups than among geographically distant groups, and thus, genetic differences increase with geographical distance. Additionally, data indicate that these genetic differences translate into biological differences (i.e., differences in growth rates, metabolic rates, and consumption rates) indicative of local adaptations (Meyer 2011). However, Pallid Sturgeon from the upper Missouri River are the most distinct from the other groups sampled (Schrey and Heist 2007). Anthropogenic changes to the upper Missouri River have affected migratory opportunities and, thus, gene flow; main-stem dams have reduced, altered, or eliminated both emigration and immigration. The genetic structuring detected within the range likely predates these anthropogenic features (Schrey and Heist 2007) suggesting that before the dams, historical reproductive isolating mechanisms were present within the range or at least portions of the range.

Reasons for listing/current threats

Section 4(a)(1) of the Endangered Species Act requires that reclassification decisions be based on the five factors outlined below. These threats are explained here to provide a context for actions necessary to restore the species to healthy population levels no longer meeting the definition of endangered, and ultimately, no longer meeting the definition of threatened. Section 3 of the Endangered Species Act defines a species as "endangered" if it is in danger of extinction throughout all or a significant portion of its range and as "threatened" if it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Factor A: Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range

The following known and potential threats that affect the habitat or range of Pallid Sturgeon are discussed in this section, and include: 1) large river habitat alterations, including river channelization, impoundment, and altered flow regimes; 2) water quality; 3) entrainment; and 4) climate change.

RIVER CHANNELIZATION, BANK STABILIZATION, IMPOUNDMENT, AND ALTERED FLOW REGIMES

Modification and curtailment of Pallid Sturgeon habitat and range are attributed to large river habitat alterations, including river channelization, bank stabilization, impoundment, and altered flow regimes. Following is a brief summary of these activities by river system.

MISSOURI RIVER

Historically, the Missouri River was dynamic, ever-changing, and composed of multiple channels, chutes, sloughs, backwater areas, side channels, and migrating islands and sandbars. As early as 1832, Congress endorsed an act approving the removal of snags from the river (Funk and Robinson 1974). In 1884, the Missouri River Commission was formed to improve navigation on the river (Funk and Robinson 1974). Revetments of woven willow and rock were used to stabilize banks, and dikes were built to narrow the channel and close off chutes. However, commercial navigation declined with the expansion of railroad networks. In 1902 the Missouri River Commission was dissolved and responsibility for the Missouri River was given directly to the U.S. Army Corps of Engineers (Funk and Robinson 1974). In 1912, Congress approved a navigation channel 1.8 m (6 ft) in depth from Kansas City, Missouri downstream to the confluence with the Mississippi River near St. Louis, Missouri. Subsequently, the Rivers and Harbors Act of 1945 authorized an increase in channel depth to 2.7 m (9 ft) and width to 91.4 m (300 ft) from Sioux City, Iowa downstream to the confluence. A self-scouring channel was largely completed by 1967 (Funk and Robinson 1974).

During the last century, the Missouri River was altered as a result of the Flood Control Act of 1944 to address societal needs. The most obvious habitat changes were the installation of dams in the upper Missouri River and some tributaries (Figure 4) as well as channelization and stabilization of the lower Missouri River for navigation. These anthropogenic modifications greatly reduced the river's ability to satisfy the life history requirements of Pallid Sturgeon by: 1) blocking movements to spawning and feeding areas; 2) affecting historical genetic exchange among reaches, (i.e., reducing or eliminating emigration and immigration); 3) decreasing turbidity levels by trapping sediment in reservoirs; 4) reducing distances available for larvae to drift; 5) altering water temperatures; 6) altering conditions and flows in spawning areas; 7) altering flows and temperatures associated with spawning movements; and 8) possibly reducing food sources by lowering productivity (Hesse et al. 1989; Keenlyne 1989; USFWS 2000a; Bowen et al. 2003).

Flows in the Missouri and Yellowstone rivers between Fort Peck Dam and Lake Sakakawea influence Pallid Sturgeon spawning movements and migrations within this reach. In general, Pallid Sturgeon reside in the Missouri River downstream from the confluence of the Missouri and Yellowstone rivers during fall and winter months (Fuller and Braaten 2012). As discharge increases in the spring, adult Pallid Sturgeon respond by migrating upstream. Typically, radio-tagged adult Pallid Sturgeon migrate into the unregulated Yellowstone River (Fuller and Braaten 2012) to spawn. Spawning adults are believed to avoid the colder, less turbid flows in the Missouri River above the Yellowstone confluence. However, during the spring of 2011, a disproportionate number of adult Pallid Sturgeon migrated up the Missouri River and remained upstream of Wolf Point, Montana (Figure 4) during the spawning period (Fuller and Haddix 2012). This change in migration behavior coincided with exceptionally higher than normal releases at Fort Peck Dam, as well historically high discharge from the Milk River. Following this spawning migration, a genetically confirmed wild Pallid Sturgeon larva was collected (Fuller and Haddix 2012). This is the first documented confirmation of spawning success in the Missouri River downstream from Fort Peck Dam; confirming that suitable spawning areas exist in this reach of the Missouri River and that Pallid Sturgeon can and will utilize this reach for spawning if conditions are suitable.

Water levels in the reservoirs impounded by Fort Peck Dam (Fort Peck Reservoir) and Garrison Dam (Lake Sakakawea) (Figure 4) may be impediments to larval Pallid Sturgeon survival by limiting the amount of riverine habitat available for Pallid Sturgeon to complete the transition from free embryos to exogenously feeding larvae. Pallid Sturgeon free embryos and larvae can passively drift as much as 245 to 530 km (152 to 329 mi) depending on water column velocity and temperature (Kynard et al. 2002; Braaten et al. 2008). Studies to assess larval Pallid Sturgeon drift dynamics (Braaten et al. 2008, 2010) released hatchery-reared Pallid Sturgeon free embryos and larvae in 2004 and 2007. Subsequent sampling has collected juvenile Pallid Sturgeon derived from these releases (Braaten et al. 2012b). Survivorship of released embryos and larvae to age-1 is related to age at release (days post-hatch) and correlated with release location; survivorship of the younger free embryos (i.e., 5 days post hatch) to age-1 was only observed from the most upstream release site (Braaten et al. 2012b). These data indicate that free embryos, as young as five days post-hatch, are able to survive to age-1 in the Missouri River between Fort Peck Dam and Lake Sakakawea, provided they have adequate dispersal distance to complete the developmental transition to feeding larvae. These observations support the hypothesis by Kynard et al. (2007) which implicates total drift distance as a limitation on natural recruitment in this reach of the Missouri River. Thus, within a given reach of river the distance required to complete the early life history requirements is dependent on reach length, river discharge, velocity, habitat complexity, and temperature.

In addition to limiting drift distance and duration, affecting spawning cues for adults, and inundating habitats, an altered hydrograph also affects downstream temperature profiles and reduces sediment transport. Cold water releases from dams have been attributed to spawning delays in several native riverine fishes and changing fish community composition downstream (Wolf 1995; Jordan 2000). Canyon Ferry, Hauser, and Holter dams are upstream of Great Falls, Montana. Though they do not impose any migratory barriers for Pallid Sturgeon, these structures, like other main-stem Missouri River dams, can affect sediment and nutrient transport and maintain an artificial hydrograph. Thus, the main-stem and tributary dams upstream of Fort Peck Dam (Figure 4) affect downstream reaches by reducing both sediment input and transport. The results are a reduction of naturally occurring habitat features like sandbars. Discharge and sediment load, together with physiographic setting, are primary factors controlling the morphology of large alluvial rivers (Kellerhals and Church 1989). Seasonally high turbidity levels are a natural component of pre-impoundment ecological processes. Reduced sediment transport and the associated decrease in turbidity could affect Pallid Sturgeon recruitment and feeding efficiency.

The relationship between high turbidity levels and larval Pallid Sturgeon survival is unclear. In laboratory studies, increased predation on White Sturgeon yolk-sac larvae was observed at low turbidity levels, suggesting that high turbidity levels associated with a natural hydrograph and natural sediment transport regimes may offer concealment for free-drifting sturgeon embryos and larvae (Gadomski and Parsley 2005). Given that the diet of Pallid Sturgeon is generally composed of fish and aquatic insect larvae with some preference for piscivory as they mature (see *Life History* section, above), higher pre-impoundment turbidity levels may have afforded improved foraging effectiveness by providing older juveniles and adults some level of concealment. From the headwaters of Lake Sakakawea above Garrison Dam, North Dakota to Gavins Point Dam, South Dakota (Figure 4), the Missouri River retains little of its historical riverine habitat; most of this reach is impounded in reservoirs. However, some Pallid Sturgeon persist in the more riverine reaches within a few of these reservoirs, though successful spawning and recruitment is unlikely. Because of the presence of Pallid Sturgeon in some inter-reservoir reaches, those occupied reaches have been included in recovery efforts (Erickson 1992; Jordan et al. 2006; Wanner et al. 2007). Despite these data, most of these inter-reservoir reaches are poorly understood and further research is needed to evaluate and define their significance to species' recovery.

The Missouri River downstream of Gavins Point Dam is over 1,296 Rkm (800 Rmi) in length, is unimpeded by dams, and is biologically and hydrologically connected with the Mississippi River. However, this reach is highly impacted be past and present anthropogenic modifications. For example, in the unchannelized reach extending from Gavins Point Dam downstream for approximately 95 Rkm (59 Rmi) side channel and backwater habitats have changed (Yager et al. 2011). Changes include 77% and 37% reductions, respectively, in total and mean area of side channels, as well as decreases of 79% and 42%, respectively, in total and mean length of side channels (Yager et al. 2011). Channelization of the Missouri River downstream from this reach has reduced water surface area by half, doubled current velocity, decreased habitat diversity, and decreased sediment transport (Funk and Robinson 1974; USFWS 2000a).

Although the Missouri River downstream of Gavins Point Dam is not impounded, it is influenced by the operation of upstream dams. Additionally, nearly all major tributaries to this reach have one or more dams which cumulatively affect flows and sediment transport. Damming and channelizing the Missouri River and tributaries adversely affects Pallid Sturgeon (USFWS 2000a, 2003).

MISSOURI RIVER TRIBUTARIES

At the time of listing, few observations of Pallid Sturgeon occurred in waters outside of the main-stem Mississippi, Missouri, and Yellowstone rivers; tributary observations were attributed to special circumstances associated with high-flow conditions (55 FR 36641-36647). While historical captures of Pallid Sturgeon occurred near the mouths of tributaries or within close proximity to tributary confluences with the Missouri River, more recent observations indicate that Missouri River tributaries may be more important than originally recognized when the species was listed. These habitats appear to be important to the Pallid Sturgeon during certain times of the year or perhaps during certain life stages. Tributaries identified below are based on documented observations of Pallid Sturgeon and should not be considered a definitive list. This list may be revised if new data become available.

Marias River

Historically, the Marias River (Figure 4) influenced the Missouri River downstream from their merger. The influence of the Marias River on the Missouri River is not only limited to physical features but also affects the fish communities. Several large migratory species such as Paddlefish (*Polyodon spathula*), Blue Sucker (*Cycleptus elongatus*), and Shovelnose Sturgeon presently or historically were known to migrate up the Marias River, presumably to spawn (Gardner and Jensen 2007). It is possible that Pallid Sturgeon also may have historically migrated up the Marias River to spawn. Operations of Tiber Dam (Figure 4) on the Marias River at Rkm 132 (Rmi 82) have now altered the natural flow and sediment regime of the Marias River and may have affected its use by fish species including Pallid Sturgeon (Gardner and Jensen 2007). While historical data documenting occupation by wild Pallid Sturgeon are absent, hatchery-reared Pallid Sturgeon recently have been captured in the lower 1 Rkm (0.6 Rmi) (Gardner 2010).

Milk River

The Milk River (Figure 4) is ecologically important to the Missouri River downstream of Fort Peck Dam as it contributes flows, sediment, and warmer water temperatures. The Milk River is subject to irrigation diversions that can substantially alter the hydrograph in this system. Correspondingly, several barriers effectively block migrations within this system. The lowermost is Vandalia Diversion Dam (Figure 4) located near Rkm 188 (Rmi 117). In 2004, a radio-tagged wild adult Pallid Sturgeon was documented in the Milk River approximately 4 Rkm (2.5 Rmi) above the confluence with the Missouri River (Braaten and Fuller 2005; Fuller in litt., 2011). Additionally, a radio-tagged adult was reported entering the Milk River in 2010 (Fuller and Haddix 2012), and subsequently in 2011, 4 males and 1 female migrated into the Milk River;

the furthest upstream location was approximately 57.9 Rkm (36 Rmi) (Fuller in litt., 2011; Fuller and Haddix 2012)

Yellowstone River

The Yellowstone River is the largest tributary to the Missouri River (Figure 4). While often referred to as "the last undammed river," this descriptor is a misnomer. At about the same time that Forbes and Richardson (1905) were describing Pallid Sturgeon as a species, the first and lowermost of six low-head diversion dams was being constructed across the river. This structure, Intake Dam (Figure 4), was constructed by the Bureau of Reclamation approximately 115 Rkm (71 Rmi) from the confluence with the Missouri River and effectively limits upstream movements of Pallid Sturgeon (Bramblett and White 2001) and entrains fish from the river into the irrigation delivery canal (Jaeger et al. 2005).

Adult Pallid Sturgeon use the lower Yellowstone River seasonally, moving upstream from the Missouri River in early spring as water temperatures rise and discharge increases (Bramblett 1996; Fuller and Braaten 2012). Aggregations of adult Pallid Sturgeon in the lower Yellowstone River during late June through mid-July have been attributed to spawning activity (Bramblett 1996; Bramblett and White 2001; Fuller and Braaten 2012). Recent evidence confirms spawning occurs in the lower Yellowstone River. Fuller et al. (2008) documented a gravid female Pallid Sturgeon released her eggs where a large congregation of males were present. However, no Pallid Sturgeon larvae were documented in sampling efforts. Subsequently, in 2012, reproductive success was confirmed with the collection of a wild Pallid Sturgeon larvae (Braaten in litt., 2013). While it is suspected that spawning occurs in the lower Yellowstone River in most years (Fuller and Braaten 2012), recruitment remains undetected.

Upstream movements of both adult and juvenile Pallid Sturgeon are affected by Intake Dam. This barrier appears to be prohibiting adult fish from accessing upstream habitats which may be suitable for spawning (Bramblett and White 2001; Jaeger et al. 2005). However, to date, two hatchery-reared juvenile Pallid Sturgeon, released below Intake Dam, have been documented upstream of the dam (Backes in litt., 2013). While the specific mechanisms of migration over or around the dam are unknown, these collections suggest that Pallid Sturgeon may utilize habitats upstream of Intake Dam if they are accessible. Additionally, about half of juvenile hatchery-reared study fish released upstream of Intake Dam did not emigrate during the study period, suggesting that habitats upstream of Intake Dam may be capable of supporting Pallid Sturgeon (Jaeger et al. 2005). The prevailing hypothesis suggests that naturally-produced Pallid Sturgeon larvae in the lower Yellowstone River will drift into Lake Sakakawea as long as spawning occurs downstream of Intake Dam (Braaten et al. 2008). This information indicates that available drift distance for larvae is artificially truncated by Intake Dam on the upstream end and water levels in Lake Sakakawea at the downstream end. This lack of drift distance is an ongoing threat limiting recruitment in the upper Missouri River.

Pallid Sturgeon also have been entrained in the irrigation canal associated with Intake Dam (Jaeger et al. 2004). In 2012, a new irrigation water-control structure was completed that incorporates fish screens intended to eliminate entrainment losses. However, to date, upstream fish passage concerns at Intake Dam remain unresolved. Providing fish passage at Intake Dam can facilitate Pallid Sturgeon recovery by improving access to historically occupied habitats and providing the potential for increased larval drift distances.

Yellowtail Dam on the Bighorn River and Tongue River Dam on the Tongue River (Figure 4), both major tributaries to the Yellowstone River, have altered sediment transport and flows into the lower Yellowstone River. Other anthropogenic modifications on the Yellowstone River include bank stabilization projects to protect private property and transportation infrastructure, as well as municipal, industrial, and agricultural water withdrawal projects.

Niobrara River

Wild Pallid Sturgeon were documented in the lower Niobrara River (Figure 2) around the mid-1900s (Mestl in litt., 2011). Since that time, the lower reach of the Niobrara River has been affected by rapid aggradation due to the siltation at the head of Lewis and Clark Lake on the Missouri River. Approximately 2.2 to 2.8 m (7.5 to 9.5 ft) of aggradation, observed since the 1950s, has changed the lower Niobrara River from a "relatively deep, stable channel with large, bank-attached braid bars to a relatively shallow aggrading channel with braid bars" (Skelly et al. 2003). It is not known to what degree channel aggradation has affected habitats for Pallid Sturgeon.

Pallid Sturgeon habitat in the lower Niobrara River also may be affected by water withdrawals. The Nebraska Department of Natural Resources declared a portion of the lower Niobrara River as fully appropriated (Nebraska 2007), but the Nebraska Supreme Court reversed the fully appropriated designation in 2011 (Nebraska in litt., 2011). Although habitat suitability has changed substantially over the last five decades, the Niobrara River still retains braided channels with shifting sand bars representative of pre-channelization conditions of rivers throughout the Pallid Sturgeon's historical range (Peters and Parham 2008). Recently, three hatchery-reared Pallid Sturgeon originally released in the Missouri River were documented in the Niobrara River downstream of Spencer Dam (located at approximately Rkm 63 (Rmi 39) (Figure 3)); two were approximately 1.6-1.9 Rkm (1.0-1.2 Rmi) upstream of the confluence with the Missouri River while the other was approximately 9.6 Rkm (6 Rmi) upstream of the confluence (Wanner et al. 2010). Additional data are necessary to determine what role this tributary serves for the recovery of Pallid Sturgeon.

James River

The James River (Figure 4) is a north to south flowing prairie river that joins the Missouri River near Yankton, South Dakota. While historical data documenting occupation by Pallid Sturgeon are absent, a telemetry tagged adult pallid sturgeon moved 5.3 Rkm (3.3 Rmi) up the James River during its upstream spawning migration in 2011. It was subsequently recaptured downstream after spawning, though it is uncertain whether it spawned in the James River or in the Missouri River downstream of the confluence (DeLonay in litt., 2013). Additional data are necessary to determine what role this tributary serves for the recovery of Pallid Sturgeon.

Big Sioux River

The Big Sioux River (Figure 4) is a north to south flowing prairie river that originates in South Dakota and drains into the Missouri River downstream of Gavins Point Dam, the lowermost dam on the Missouri River. Historical observations of Pallid Sturgeon in this system are absent.

However, there is one contemporary report of an angler caught Pallid Sturgeon approximately 112 Rkm (70 Rmi) upstream of the confluence with the Missouri River (Stukel in litt., 2009) as well as documentation of one tagged Pallid Sturgeon that moved upstream 21.1 Rkm (13.1 Rmi) into this river from the Missouri River (DeLonay et al. 2009). Additional data are necessary to determine what role this tributary serves for the recovery of Pallid Sturgeon.

Platte River

The Platte River (Figure 4) is a Missouri River tributary downstream of Gavins Point Dam. With increased sampling efforts, a corresponding increase in the numbers of both hatchery-reared and presumed-wild Pallid Sturgeon have been observed in the lower Platte River (i.e., the Loup River Power Canal outlet near Columbus, Nebraska downstream to the confluence with the Missouri River) since the species was listed. Pallid Sturgeon have been well documented within the lower-most reaches of this river (i.e., up to the Elkhorn River confluence) (Snook et al. 2002; Swingle 2003; National Research Council 2005; Peters and Parham 2008). More recently there have been increased observations of Pallid Sturgeon upstream of the confluence of the Platte and Elkhorn rivers; effectively extending the contemporary range up to near Columbus, Nebraska (Hamel in litt, 2010; Hamel and Pegg 2013). Additionally, Pallid Sturgeon have been documented in the Platte River during the spring, summer and fall periods (Hamel in litt., 2009; Hamel and Pegg 2013). Finally, limited data indicate that the lower Platte River is likely used for spawning (Swigle 2003; Chojnacki in litt., 2012). These data indicate the lower Platte River provides suitable habitat, supports multiple life stages of the species, and should be viewed as important for species recovery.

Although not developed as a navigation corridor, the Platte River has been influenced by anthropogenic alterations that likely affect Pallid Sturgeon habitat. Water demands for industrial, municipal, and agricultural purposes led to construction of low-head diversion dams on the upper Platte River as well as large impoundments on the Platte River and its tributaries. Eschner et al. (1983) state that the Platte River and its tributaries "…have undergone major changes in hydrologic regime and morphology since 1860." These authors describe a process where islands eventually attached to the floodplain, became vegetated, and eventually fixed in place resulting in decreased channel widths. These authors attribute many of these changes in channel morphology to water development and diversions. Similarly, Rodekohr and Englebrecht (1988) noted the Platte River is more constricted than it was in 1949. Despite some of these changes, there appears to be sufficient beneficial qualities within the lower Platte River, such that Pallid Sturgeon occupy and utilize this reach (Swigle 2003; National Research Council 2005: Peters and Parham 2008; Hamel and Pegg 2013). However, the availability and quality of habitat within the lower Platte River can be affected by water withdrawal in conjunction with periods of drought (National Research Council 2005). Sampling within the Missouri River near the confluence of the Platte River also results in substantially more Pallid Sturgeon captures when compared against other Missouri River sampling sites downstream to the Kansas River confluence (Steffensen and Hamel 2007, 2008). This suggests that the Platte River not only provides suitable habitat, but it also provides some positive benefits to Pallid Sturgeon habitat in the Missouri River.

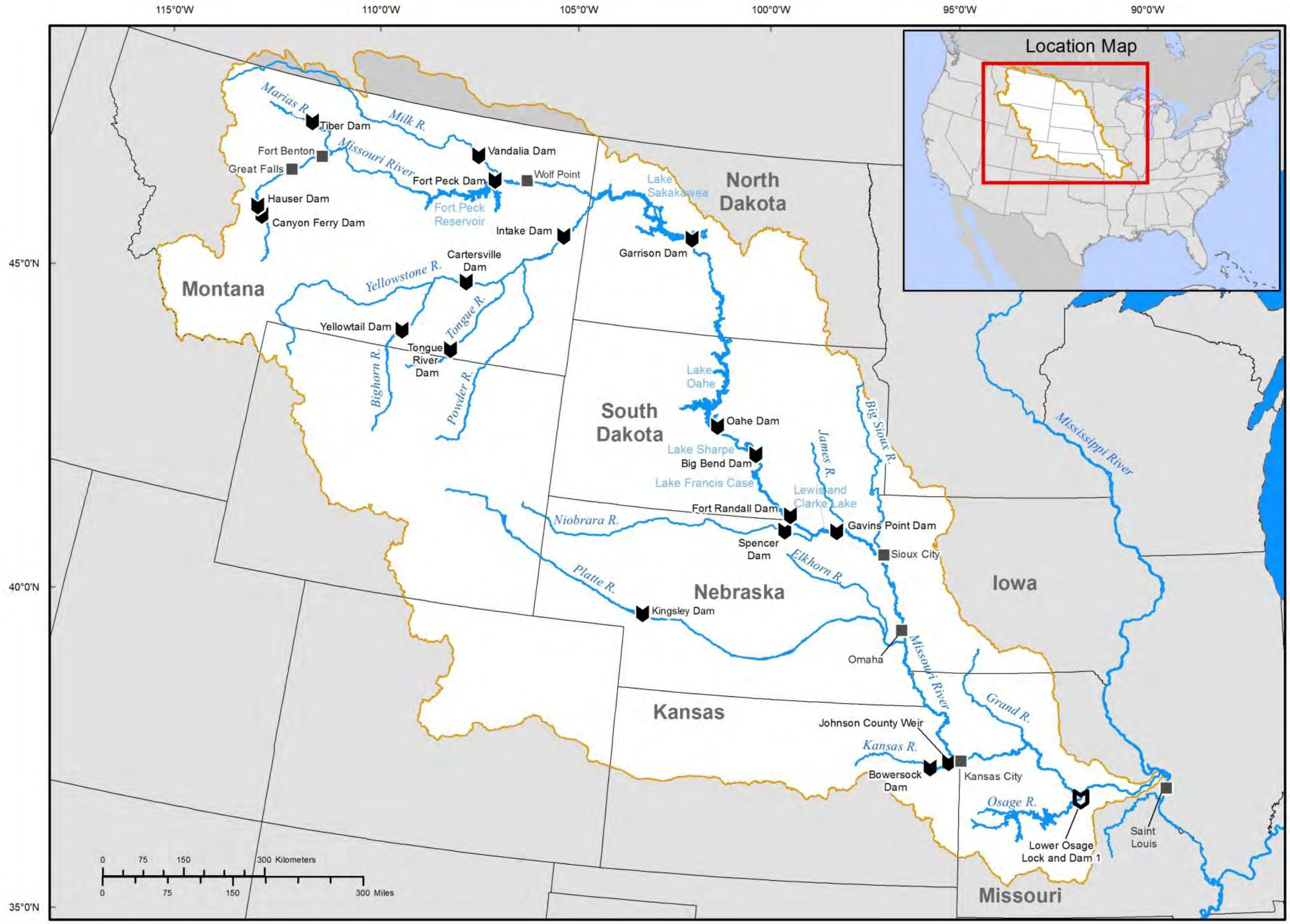

Figure 4 Map of prominent structures within the Missouri River Basin.

Elkhorn River
The Elkorn River is a north-west to south-east flowing tributary to the lower Platte River (Figure 4). When Pallid Sturgeon were listed, this river served merely as a reference point demarking its confluence with the Platte River as the upstream extent of Pallid Sturgeon in the Platte River. However, this river possesses many characteristics of streams currently used by Pallid Sturgeon and there are documented occurrences of Pallid Sturgeon in the Elkhorn River. Nebraska Game and Parks Commission records report angler catches of two Pallid Sturgeon; one each in 1999 and 2002 (National Research Council 2005). The 2002 record is reported to have occurred three miles upstream of Snyder, Nebraska, effectively extending the contemporary range of Pallid Sturgeon in this river (Figure 3). Additional data are necessary to determine what role this tributary serves for the recovery of Pallid Sturgeon.

Kansas River
The Kansas River (Figure 4) has anthropogenic alterations that likely affect some aspects of Pallid Sturgeon life history. Bowersock Dam (Rkm 82, Rmi 51) near Lawrence, Kansas was constructed in the 1870s (Figure 4). In 1952 six juvenile specimens (294-415 mm, 11.6-16.3 in) were collected below this dam during a period of record flooding (Bailey and Cross 1954). Because this barrier was installed prior to Pallid Sturgeon being identified as a species, there is little historical occupancy data for reaches upstream. The Johnson County Weir is another potential barrier to Pallid Sturgeon movement in the lower Kansas River (Rkm 23.7, Rmi 14.7). This structure was built in 1967 to maintain sufficient water delivery for municipal purposes. To date, 15 Pallid Sturgeon, most confirmed to be of hatchery origin (Niswonger, in litt., 2011), have been collected from the lower Kansas River. All known hatchery fish were originally stocked in the Missouri River.

Osage River
The Osage River is one of the larger Missouri River tributaries in Missouri (Figure 4). Pallid Sturgeon have been documented near the confluence of the Osage and Missouri rivers, including three hatchery-reared Pallid Sturgeon in the lower Osage River between Lock and Dam #1 (Rkm 19.4; Rmi 12.1) and the confluence with the Missouri River in 2010 (USFWS 2010, 2012).

Grand River
The Grand River (Figure 4) is a turbid tributary that was highly channelized during the same period that Pallid Sturgeon were likely declining. However, this system continues to support a predominantly native fish assemblage with species such as Lake Sturgeon occasionally being captured. While historical data documenting occupation by Pallid Sturgeon are absent, hatchery-reared Pallid Sturgeon have been captured in the lower 3 Rkm (1.8 Rmi) (Chillicothe News in litt., 2009; DeLonay et al. 2009).

MISSISSIPPI RIVER
The Mississippi River (Figure 5) is often divided into upper, middle and lower reaches. Like the Missouri River, the Mississippi River has been anthropogenically altered, beginning in the early portions of the 18th century as the French began to settle along the Mississippi River (Cowdrey 1977). These early efforts were generally localized and limited in scope. It was not until the 19th century that large-scale efforts to improve navigation and flood control began to have more substantial impacts. Snagging (removing dead trees from the river) was one of the first efforts to

facilitate using the river as a transportation corridor. In the early 1800s and funded with Federal appropriations, snag boats removed large woody debris from the middle and lower Mississippi River between St. Louis, Missouri and New Orleans, Louisiana (Simons et al. 1974; Cowdrey 1977).

The next major efforts to improve navigation involved maintaining navigable channels. In the mid-1800s, construction of jetties and dredging provided the first successful large-scale reduction of sediment deposition and the subsequent forming of sandbars that blocked shipping routes (Cowdrey 1977). Flood control became an increasingly important focus of the United States Congress as more people settled in the Mississippi River valley and the human costs of flood damage increased. Small and localized levee systems were in existence in the 1700s; however, it was not until the 19th and 20th centuries that levee networks increased in size and scope. As the levee system was completed, flood stages increased resulting in the need to shunt flood waters from the river (Cowdrey 1977). Following the flood of 1927, the Flood Control Act of 1928 included provisions for strengthening and raising existing levees and included floodways and spillways (Cowdrey 1977); examples of the latter being the Birds Point-New Madrid floodway, the Old River Control Complex, the Morganza floodway, and the Bonnet Carré spillway (Figure 5).

In addition to the dams on the upper Missouri River, flows into the middle and lower Mississippi River also are influenced by a series of locks and dams in the upper Mississippi and Ohio rivers. The earliest lock and dam structures were constructed in 1867 near Keokuk, Iowa. By 1940, the locks and dams from Minneapolis, Minnesota down to Alton, Illinois, were in place and operational. Finally, revetments and various structures have been used to reduce erosion and restrict flows in many areas. Willow mattresses and cypress pilings, later replaced by articulated concrete mats and rock riprap, were used to prevent loss of riparian land and control flow patterns (Cowdrey 1977). This reduction in river bank erosion has reduced the amount of sediments and large woody debris entering the system. Subsequent loss of connectivity and channel sinuosity occurred as habitats were channelized and off-channel habitats became isolated from normal riverine flow. Modifications to the Mississippi River occurred largely from construction of the locks and dams, levees, tributary alterations, channel cut-offs, and channel maintenance structures.

Upper Mississippi River

The upper Mississippi River, as it relates to Pallid Sturgeon, is defined as being upstream of the confluence of the Missouri and Mississippi rivers to Lock and Dam 19 near Keokuk, Iowa (Figure 5). This reach is approximately 260 Rkm (162 Rmi) in length. The lower most lock and dam (Lock and Dam 26 near Alton, Illinois) is located approximately 8 Rkm (5 Rmi) upstream of the Missouri-Mississippi river confluence (Figure 5). Although fish passage through the six lock and dam structures is impeded for many species, it can occur through the lock chamber or the dam gates during flood events. A single historical Pallid Sturgeon observation in the upper Mississippi River near Keokuk, Iowa (Coker 1929) was considered as "dubious" and likely to represent "stragglers" (Bailey and Cross 1954). Recent sampling, however, has documented the movement of several Pallid Sturgeon through the lowermost locks and dams from the middle Mississippi River into the pools of the upper Mississippi River (Herzog in litt., 2009; Herzog

2010). The extent of use within this impounded reach of the upper Mississippi River is poorly understood and further research is needed to assess its role in species recovery.

Middle Mississippi River

The middle Mississippi River is defined as the Missouri-Mississippi river confluence near St. Louis, Missouri to the Mississippi-Ohio river confluence near Cairo, Illinois (Figure 5). This reach is approximately 313 Rkm (195 Rmi) in length.

In 1881, Congress approved plans to regulate the middle Mississippi River, and by 1973 this reach of the Mississippi River had experienced levee construction, more than 160 km (100 mi) of revetments, and installation of more than 800 dikes to maintain a minimum navigation channel depth of 2.7 meters (9 feet) (Simons et al. 1974). Lock and Dam 27, (Chain of Rocks dam and canal) is located at Rkm 298.5 (Rmi 185.5) near Granite City, Illinois. The canal structure was completed to facilitate navigation around the shallow bedrock that occurred in this reach. Large quantities of rock were dumped over the existing bedrock to create a low-head dam necessary to make the lock canal navigable. Although no Pallid Sturgeon have been documented in the canal, both Pallid and Shovelnose sturgeon concentrate below the Chain of Rocks dam during fall and winter low-flow events (Killgore et al. 2007a).

The cumulative effects of these alterations include an average reduction in river width, river bed degradation, a slight increase in the maximum river stage, a reduction in minimum river stage, and a constricted flood plain (Simons et al. 1974).

Lower Mississippi River

The lower Mississippi River (LMR) is defined as the Mississippi River from the Mississippi-Ohio rivers confluence to the Gulf of Mexico (Figure 5). This reach of the contemporary river is approximately 1,541 Rkm (958 Rmi) in length.

Between 1929 and 1942, bendway cutoffs shortened the LMR by 245 Rkm (152 Rmi) over a 809 km (503 mi) reach (Winkley 1977). The LMR was reduced an additional 88.5 Rkm (55 Rmi) between 1939 and 1955 by constructing artificial channels that bypassed natural river meanders (Winkley 1977). This channel length reduction resulted in the river entrenching in steeper gradient reaches and eroding large amounts of material from the channel banks and bed. Deposition of this material in the lower gradient reaches resulted in a semi-braided channel, and by the 1970s, the river began to reestablish a meandering condition (Winkley 1977). Dikes and bank armoring have been employed in the LMR to stabilize the channel and direct flows to reduce the need for dredging.

Levee construction began in the New Orleans area in the 1700s. Today, excluding a few tributary mouths, levees line the west side of the river and fill in low areas between natural bluffs on the east side (Cowdrey 1977; Baker et al. 1991). These levees are estimated to have reduced the floodplain area by as much as 90% depending on flood magnitude (Baker et al. 1991). Although the LMR channel has been enclosed by levees, numerous and extensive sandbars, vegetated and seasonal islands, and secondary channels remain, equating to a 1.6 million acre floodplain that retains floodplain backwaters and sloughs that are seasonally connected to the river (Schramm et al. 1999). Despite extensive alteration, the lower Mississippi River retains significant amounts of in-channel complexity and floodplain connectivity thought to be important to Pallid Sturgeon.

MISSISSIPPI RIVER TRIBUTARIES

As previously stated, data post-listing indicate that main-stem tributaries and tributary confluences may be used more frequently than previously recognized. Several captures of Pallid Sturgeon have occurred within tributaries, near the mouth of tributaries, and within close proximity to tributary confluences with the Mississippi River. These habitats may be important to the Pallid Sturgeon during certain times of the year or perhaps during certain life stages.

Meramec River

This tributary to the middle Mississippi River, located near Rkm 254 (Rmi 158) (Figure 5), is a large river within Missouri that contains transitional habitats within its lower reaches. There are no historical accounts of Pallid Sturgeon in this river; however, Pallid Sturgeon have been documented in the Mississippi River near the Meramec River confluence (Koch et al. 2006a). It is not known whether Pallid Sturgeon historically migrated within this system, and additional data are necessary to determine what role this tributary serves for the recovery of Pallid Sturgeon.

Kaskaskia River

The Kaskaskia River is located near Rkm 188 (Rmi 117) near Chester, Illinois (Figure 5). This is Illinois' second largest river system at 515 Rkm (320 Rmi) long draining about 10% of the State. Several Pallid Sturgeon have been documented at the confluence with the Mississippi River (Koch et al. 2006a). While movement into the Kaskaskia River by Pallid Sturgeon has not been documented, movement into this river may be impeded by a lock and dam near the mouth. In addition, the watershed of the Kaskaskia River has been modified over the last 100 years by urbanization, channelization, and levee and dam construction. It is unknown whether Pallid Sturgeon historically migrated within this system, and additional data are needed to determine if this tributary serves any role for the recovery of Pallid Sturgeon.

Ohio River

The Ohio River (Figure 5) is the largest tributary to the Mississippi River system within the range of Pallid Sturgeon. While Pallid Sturgeon have been collected from the Mississippi River near the Ohio River confluence, there are no recent reports of Pallid Sturgeon and no confirmed records of presence in this system. It is possible Pallid Sturgeon could occur in this river up to the Olmstead Lock and Dam (Figure 5), but additional data are needed to determine if this tributary serves any role for the recovery of Pallid Sturgeon.

Obion River

A single Pallid Sturgeon has been documented in the Obion River (Figure 5). This fish was originally tagged in the Mississippi River near Osceola, Arkansas and was subsequently recaptured in the Obion River near Bogota, Tennessee (Killgore et al. 2007b). It is unknown whether Pallid Sturgeon historically migrated within this system and additional data are needed to determine if this tributary serves any role for the recovery of Pallid Sturgeon.

Saint Francis River
The Saint Francis River (Figure 5) flows through south-east Missouri into Arkansas where it confluences with the Mississippi River. In 1994 hatchery-reared Pallid Sturgeon were documented in the lower Saint Francis River (Graham in litt., 1994) downstream from the W. G. Huxtable Pumping Plant (Figure 5). Subsequently, a tagged female Pallid Sturgeon was found to have entered the Saint Francis River in 2013. This fish remained in the river April 14-17. (Lewis in litt., 2013). Additional data are necessary to better understand use of this river by Pallid Sturgeon and what role this river serves in Pallid Sturgeon recovery efforts.

Arkansas River
The Arkansas River (Figure 5) confluences with the Mississippi River near Rkm 933 (Rmi 580). Pallid Sturgeon currently can access the lower 64 Rkm (40 Rmi) from the confluence with the Mississippi River upstream to the Wilbur D. Mills Dam. To date, three Pallid Sturgeon have been documented entering this lower reach during the late-winter through spring (February – April) (Kuntz in litt., 2012). Additional efforts are ongoing to better understand usage of this tributary by Pallid Sturgeon and what role this tributary serves for the recovery of Pallid Sturgeon.

Red River
The Red River (Figure 5) was a tributary to the Mississippi River during the 19th and early 20th centuries. However, anthropogenic alterations in the 1960s connected the Red River with the Atchafalaya River when the Old River Control Complex was completed. While historical Pallid Sturgeon presence data are lacking, contemporary observations have documented a limited number of Pallid Sturgeon in the lower Red River; specifically the reaches downstream from Lock and Dam 3 (Slack et al. 2012). Additional data are necessary to better understand use of this river by Pallid Sturgeon and what role this river serves in Pallid Sturgeon recovery efforts.

Atchafalaya River
The Atchafalaya River (Figure 5) is a distributary of the lower Mississippi River that begins just south of Cochie, Louisiana and extends downstream to Morgan City, Louisiana (Rkm 180/Rmi 112), where it flows into the lower Atchafalaya River and ultimately to the Gulf of Mexico. At approximately Atchafalaya River Rkm 156 (Rmi 97), the Wax Lake Outlet was constructed in 1942, providing a shorter route for flood waters to leave the Atchafalaya River. Prior to 1859, the Atchafalaya River received Mississippi River water from overbank flooding. Snagging and channel excavation to support of navigation during the late 19th and early 20th centuries resulted in channel enlargement and increased flows into the Atchafalaya River from the Mississippi and Red rivers. By the 1950s the Atchafalaya River threatened to capture most of the lower Mississippi River flow and in 1963 the U.S. Army Corps of Engineers constructed the Old River Control Complex to prevent this capture by regulating flows into the Atchafalaya River.

The Old River Control Complex (i.e., Low Sill, Overbank, and Auxiliary) at approximately Mississippi Rkm 505 (RM 314) can carry a combined maximum discharge of 700,000 cfs. With the completion of the Sidney A. Murray, Jr. Hydroelectric Station in 1990, just upstream of the Old River Control Complex, the flows are now split between the hydroelectric station and the Old River Control Complex structures with flows released to maximize hydro-power production.

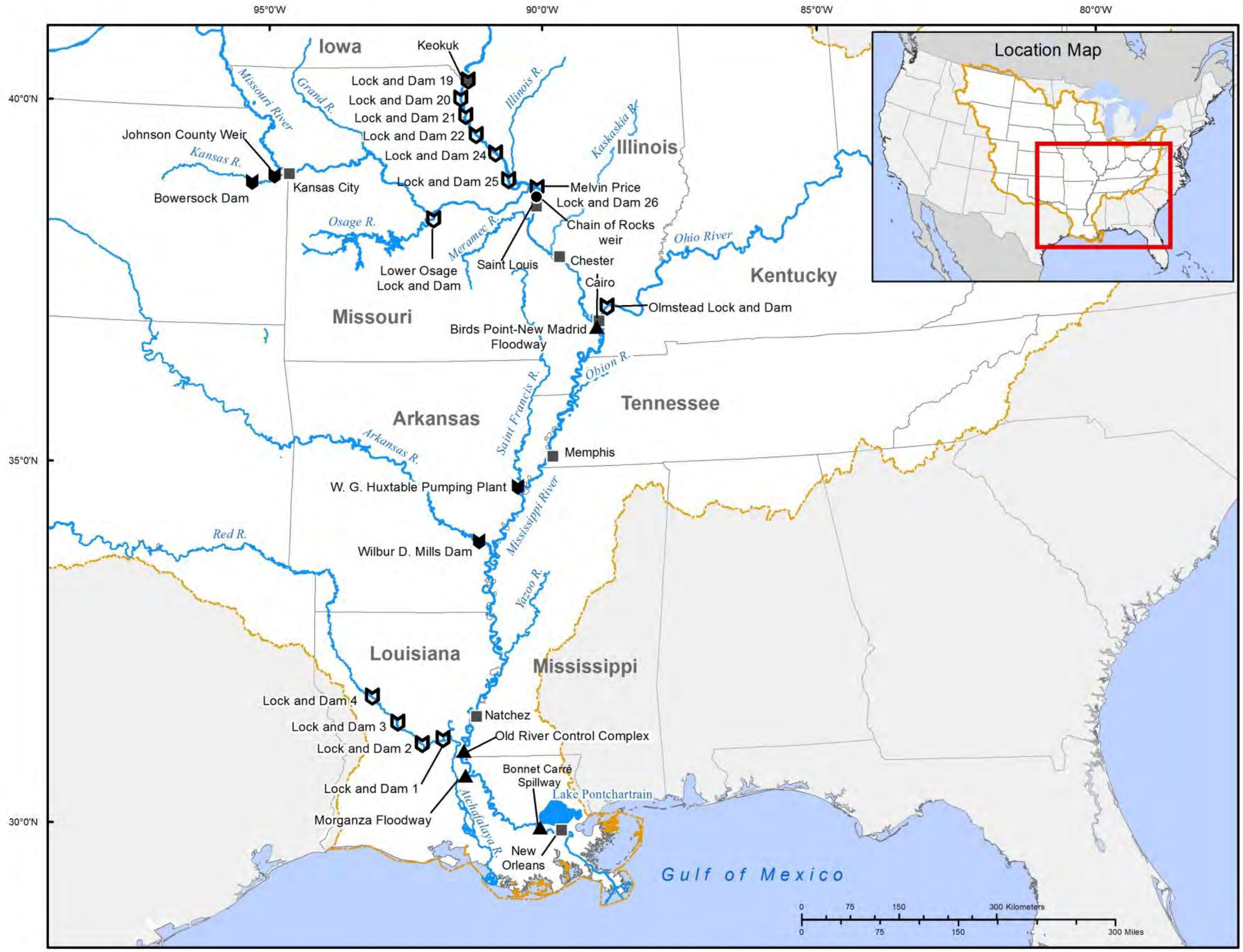

Figure 5 Map of prominent structures in the Mississippi River Basin.

The Old River Control Complex, in coordination with the hydro-power plant, carries 30% of the combined discharge from the Mississippi and Red rivers, maintaining Mississippi River discharge into the Atchafalaya River at levels comparable to the 1950s. The Atchafalaya River has been leveed to prevent flooding of communities and agricultural lands from Rkm/Rmi 0 to Rkm 85 (Rmi 53). Downstream of Rkm 85, the river levees only contain flows less than the average annual discharge; all greater discharges flow overbank. Most Pallid Sturgeon reported from this river have been captured immediately below the Old River Control structures where almost all sampling occurs (Reed and Ewing 1993). However, Pallid Sturgeon use of the middle and lower Atchafalaya River has been documented (Constant et al. 1997; Schramm and Dunn 2007, Herrala and Schramm 2011).

There is no evidence that Pallid Sturgeon occupied the Atchafalaya River distributary prior to the mid-20th century capture of Mississippi River flows. To date, hatchery fish released in the Mississippi River below Natchez, Mississippi (2 specimens), and above Memphis, Tennessee (1 specimen) have been captured in the Atchafalaya River; confirming that Pallid Sturgeon can be entrained from the Mississippi River into the Atchafalaya River. It is possible that many of the Pallid Sturgeon observations in the Atchafalaya River are the result of entrainment from the Mississippi River; the magnitude of which has not been quantified.

Summary of Impacts from River Channelization, Bank Stabilization, Impoundment, and Altered Flow Regimes

The species was essentially extirpated from approximately 28% of the historical range due to impoundment, and the remaining unimpounded range has been modified by channelization and bank stabilization, or is affected by upstream impoundments that alter flow regimes, turbidity, and water temperatures (Hesse et al. 1989; Keenlyne 1989; USFWS 2000a). River channelization, bank stabilization, impoundment, altered flow regimes, and their effects are documented throughout the range of the Pallid Sturgeon and each can negatively affect Pallid Sturgeon life history requirements. The most obvious effects to habitat are associated with the six main-stem Missouri River dams. These dams and their operations have: 1) truncated drift distance of larval Pallid Sturgeon (Kynard et al. 2007; Braaten et al. 2008), 2) created physical barriers that block normal migration patterns, 3) degraded and altered physical habitat characteristics, 4) greatly altered the natural hydrograph (Hesse et al. 1989), and 5) produced subtle changes in river function that influence both the size and diversity of aquatic habitats, connectivity (Bowen et al. 2003), and benthos abundance and distribution (Morris et al. 1968). Moreover, these large impoundments have replaced large segments of riverine habitat with lake conditions. River channelization, and bank stabilization within the Missouri River basin has altered river features such as channel morphology, current velocity, seasonal flows, turbidity, temperature, nutrient supply, and paths within the food chain (Russell 1986; Unkenholz 1986; Hesse 1987). In addition to the main-stem Missouri River dams, important tributaries like the Yellowstone, Platte, and Kansas rivers have experienced similar affects due to dams and water resource development, as well as bank stabilization efforts within their respective watersheds. Other issues that have influenced habitat formation and maintenance are associated with maintaining navigation channels on portions of the Missouri River and efforts to control flooding. The Mississippi River has received a substantial amount of anthropogenic modification through time, and some changes resulting from those modifications have likely been detrimental to Pallid Sturgeon. These anthropogenic habitat alterations likely adversely affect Pallid Sturgeon by altering the natural form and functions of the Mississippi River (Simons et al. 1974; Baker et al. 1991; Theiling 1999; Wlosinski 1999). Anthropogenic alterations to tributaries may have contributed to habitat degradation in the Mississippi River as well. Impoundment of major tributaries reduced sediment delivery to the main channel (Fremling et al. 1989) resulting in channel degradation and reduction in shallow water habitats (Simons et al. 1974; Bowen et al. 2003). Thus, the effects from dams, bank stabilization, and channelization activities, individually and cumulatively when implemented within the range of Pallid Sturgeon, should be considered threats to the species.

WATER QUALITY

Much of the available information regarding the likely effects to Pallid Sturgeon from contaminants comes from information obtained for Shovelnose Sturgeon, which can be used as a surrogate species to evaluate environmental contaminant exposure. Shovelnose Sturgeon are considered a suitable surrogate species for Pallid Sturgeon in that they live for 20 years or longer, inhabit the same river basins, spawn at similar intervals and locations, and accumulate similar inorganic and organic contaminants (Ruelle and Keenlyne 1994; Buckler 2011). However, while inferences can be drawn from data related to Shovelnose Sturgeon, limitations of using this species as a surrogate for Pallid Sturgeon are based on life history differences between the two species. Pallid Sturgeon have a longer life-span, attain a larger size, are more piscivorous, and contain a higher percentage of body fat (Ruelle and Keenlyne 1994). These differences may contribute to different contaminant effects or pathways; Pallid Sturgeon may be at greater risk than Shovelnose Sturgeon to contaminants that bioaccumulate and cause reproductive impairment because they have a more piscivorous diet, greater maximum life-span, and a longer reproductive cycle than Shovelnose Sturgeon.

Contaminants /Pollution: Contaminants detected in Shovelnose Sturgeon throughout the Missouri, Mississippi, Platte, and Atchafalaya rivers include: organochlorines, metals, aliphatic hydrocarbons, polycyclic aromatic hydrocarbons, polychlorinated biphenyls (PCBs), and elemental contaminants (Allen and Wilson 1991; Welsh 1992; Welsh and Olson 1992; Ruelle and Henry 1994; Palawski and Olsen 1996; Conzelmann et al.1997; Coffey et al. 2003; Schwarz et al. 2006).

A few field studies have included Shovelnose Sturgeon health assessments in an effort to evaluate environmental contaminant exposure and effects to Pallid Sturgeon (Coffey et al. 2003; Schwarz et al. 2006). Organochlorine pesticides and PCBs were detected at concentrations of concern in Mississippi River Shovelnose Sturgeon tissue samples. Adverse health problems observed included abnormal reproductive biomarkers and enlarged livers (Coffey et al. 2003). A similar evaluation in the lower Platte River identified PCBs, selenium, and atrazine as contaminants that may adversely affect sturgeon reproduction (Schwarz et al. 2006).

Shovelnose Sturgeon collected from the Platte, lower Missouri and Mississippi rivers have exhibited intersexual characteristics (having both male and female gonad tissue) (Harshbarger et al. 2000; Wildhaber et al. 2005; Koch et al. 2006b; Schwarz et al. 2006). Intersexual Shovelnose Sturgeon from the middle Mississippi River were found to have higher concentrations of organochlorine compounds when compared to normal male Shovelnose Sturgeon (Koch et al. 2006b). One Pallid Sturgeon exhibited both male and female reproductive organs (DeLonay et al. 2009). Although the effects of intersex on sturgeon reproduction are unknown, intersex in other fish species has been linked to decreased gamete production, lowered sperm motility, and decreased egg fertilization (Jobling et al. 2002). Koch et al. (2006b) observed reduced numbers of spermatozoa in highly contaminated and intersexual Shovelnose Sturgeon that may suggest limited reproductive success.

Laboratory studies also have evaluated environmental contaminant exposure and effects to Shovelnose Sturgeon. Papoulias et al. (2003) injected unhatched Shovelnose Sturgeon larvae with PCB 126 and Tetrachlorodibenzo-p-dioxin. They found yolk sac and pericardial swelling, hemorrhaging of the eyes and head, shortened maxillaries, and delayed development. While the experimental exposure concentrations of PCB 126 was at levels beyond what might be found in the wild, the negative effects from Tetrachlorodibenzo-p-dioxin exposure concentrations were at levels that are conceivable in the Mississippi River (Papoulias et al. 2003)

To date, few studies have measured environmental contaminant concentrations in Pallid Sturgeon. Tissue samples from three Missouri River Pallid Sturgeon and 13 other Pallid Sturgeon, mostly collected from the Mississippi River had metals (e.g., mercury, cadmium, and selenium), PCBs, and organochlorine pesticides (e.g., chlordane, dichloro-diphenyl-trichloroethane, and dieldrin) at concentrations of concern (Ruelle and Keenlyne 1993; Ruelle and Henry 1994). In addition to the previously mentioned reports on contaminants in Pallid Sturgeon, raw contaminants data for Pallid Sturgeon from North Dakota, Illinois, and Louisiana are currently being compiled.

Point-source discharges may adversely affect Pallid Sturgeon and their habitat. Wastewater treatment plant effluent can contain hormonally active agents. Endocrine disruption in fish exposed to estrogenic substances discharged by wastewater treatment plants is well documented (Purdom et al. 1994; Routledge et al. 1998; Cheek et al. 2001; Schultz et al. 2003). In addition to wastewater treatment plants, drinking water treatment plants also are a concern. In April 2004, several radio-tagged Pallid Sturgeon were repelled from the mouth of the Platte River immediately following a milky discharge from a drinking water treatment facility upstream (Parham et al. 2005). Further investigation found that the facility was not in compliance with its discharge permit which expired in 1993, and that the discharge likely contained several toxic irritants including ferric sulfate, calcium oxide, hydrofluosilicic acid, chlorine, and ammonia.

Several fish consumption advisories within the range of Pallid Sturgeon are attributable to contaminants (Buckler 2011). The State of Tennessee closed commercial fishing on portions of the Mississippi River because of concerns over chlordane and other contaminants (Tennessee 2008 a and b). The Missouri Department of Health and Senior Services has issued a “do not eat” advisory for Shovelnose Sturgeon eggs and recommends consuming no more than one Shovelnose Sturgeon per month because of concerns over PCB, mercury, and chlordane levels (Missouri 2010). Illinois issued a sturgeon consumption advisory due to PCBs and chlordane levels on the Mississippi River between Lock and Dam 22 to Cairo, Illinois (Illinois 2010). The Kansas Department of Health and Environment (2010) has issued a consumption advisory for bottom-feeding fish, including sturgeon, due to PCB levels in the Kansas River downstream of

Bowersock Dam to Eudora. Fish consumption advisories have been issued for the Missouri River from Omaha to Rulo, Nebraska (Nebraska 2010). Although fish consumption advisories are for the protection of human health, river segments with such designations also have been associated with adverse health effects in the Shovelnose Sturgeon themselves, including enlarged livers, abnormal ratios of estrogen to testosterone, and intersexual characteristics (Coffey et al. 2003; Schwarz et al. 2006).

Because more information is needed to evaluate the exposure and effects of environmental contaminants to Pallid Sturgeon, a basin-wide contaminants review for Pallid Sturgeon was initiated in 2008. To date, this investigation has identified pesticides, metals, organochlorines, hormonally active agents, and nutrients as contaminants of concern throughout the species' range. Further assessments should be targeted in these areas to evaluate the exposure and effects of the impairing contaminants on Pallid Sturgeon and their reproductive physiology.

Additionally, injuries resulting from chance encounters with discarded human-made objects like gaskets and rubber bands have been documented in the Mississippi River; approximately 5% of Shovelnose Sturgeon and 9% of Pallid Sturgeon exhibit scars or deformities from such injuries (Murphy et al. 2007b). Mortalities have not been reported or estimated.

Dissolved Oxygen: Little is known about Pallid Sturgeon tolerances of low dissolved oxygen concentrations and limits have not been quantified for all life stages. However, data from other sturgeon species are insightful. In general, sturgeon are not as tolerant of hypoxic conditions (very low dissolved oxygen levels) as are other fishes (Secor and Gunderson 1998; Niklitschek and Secor 2005). Temperature and dissolved oxygen levels can affect sturgeon survival, growth and respiration with early life stages being more sensitive than adults (Secor and Gunderson 1998).

Like many sturgeon species, Pallid Sturgeon are primarily benthic organisms within 10-12 days post hatch (Kallemeyn 1983; Kynard et al. 2007). This benthic life history strategy can result in sturgeon encountering hypoxic. Like most organisms that encounter unsuitable habitats, juvenile and adult sturgeon have some ability to avoid unfavorable environmental conditions via migration (Auer 1996). In reservoirs, White Sturgeon will avoid those areas where riverine features become more lake like (transition zone) and oxygen levels approach 6 mg/l (Sullivan et al. 2003). Under hypoxic conditions, juvenile Atlantic Sturgeon will move upward in the water column to access more oxygen-rich water (Secor and Gunderson 1998).

Anthropogenic changes within the range of Pallid Sturgeon that affect dissolved oxygen concentrations could be affecting survival and recruitment. Measurements on the lower Missouri River from 2006-2009 showed that large rises in the river during spring and summer may result in dissolved oxygen levels falling to < 2 mg/l and remaining below 5 mg/l for several days (Blevins 2011). Dissolved oxygen levels of 3 mg/l and water temperatures of 22-26 ^{o}C (71.6-78.8 ^{o}F) appeared lethal for juvenile Atlantic Sturgeon and Shortnose Sturgeon (Secor and Gunderson 1998; Campbell and Goodman 2004). Reduced growth was observed in Atlantic Sturgeon at lower non-lethal levels (Secor and Gunderson 1998). In the upper Missouri River basin, larval Pallid Sturgeon are likely transported into or through reservoir transition areas. Because they are weak swimmers at this early life stage (Kynard et al. 2007), they are less able to migrate away from any encountered hypoxic conditions. Study efforts have been initiated to better evaluate the effects of riverine to reservoir transition areas on Pallid Sturgeon survival.

Temperature: The Pallid Sturgeon is ectothermic, that is its body temperature is dependent on water temperatures. As a result, water temperatures influence nearly every aspect of the Pallid Sturgeon's life history requirements. As described previously, water temperatures affect rates of sexual maturity, spawning migrations, gonad development, rates of embryonic development, larval drift distances, and habitat quality (Keenlyne 1995; Kynard et al. 2002; U.S. Geological Survey 2007; Braaten et al. 2008; DeLonay et al. 2009; Webb in litt., 2011).

Anthropogenic changes within the range of Pallid Sturgeon that have substantially affected historical water temperatures are bottom release dams. The water in deep reservoirs thermally stratifies resulting in a colder and denser water layer at depth. When this cold water is released, it substantially cools the riverine environments downstream. As an example, average and maximum water temperatures immediately downstream of Fort Peck Dam can be reduced by as much as 6° C (10.8° F) and 10.4° C (18°F), respectively (Fuller and Braaten 2012). While the magnitude of these effects decrease with increased distance from the dam, these cooling effects still influence 290 Rkm (180 Rmi) of the Missouri River downstream. Even at this distance, the average and maximum temperatures are still 1° C (1.8° F) cooler than Missouri River reaches above Fort Peck Reservoir (Fuller and Braaten 2012).

Thus, the altered temperature profiles of riverine habitats downstream from large bottom-release dams influence nearly every aspect of the life-history requirements and habitats of Pallid Sturgeon. While the magnitude of effects from altered temperature profiles vary by dam, they may be the most problematic in the inter-reservoir reservoir reaches of the impounded Missouri River.

Summary of Impacts related to Water Quality

Overall water quality can have both immediate and long-term effects on the species. New information, post-listing suggests that water quality can impact Pallid Sturgeon during many life phases and localized and/or regionally poor or degraded water quality should be viewed as a threat to the species. However, additional data are needed to quantify and qualify the magnitude of these threats in some river reaches.

ENTRAINMENT

Another issue that can cumulatively have negative consequences for Pallid Sturgeon range-wide is entrainment loss. The loss of Pallid Sturgeon associated with cooling intake structures for power facilities, towboat propellers, dredge operations, irrigation diversions, and flood control points of diversion has not been fully quantified, but entrainment has been documented for both Pallid and Shovelnose sturgeon.

Adult Shovelnose Sturgeon (and likely adult Pallid Sturgeon) exhibit relatively high prolonged swimming speeds (Adams et al. 1997; Parsons et al. 2003) and would be at lower entrainment risk than young fish. Juvenile Pallid and Shovelnose sturgeon exhibit comparable swimming abilities (Adams et al. 2003). They are not strong swimmers relative to other species and are at greater risk of entrainment (Adams et al. 1999a), but they also exhibit a variety of complex swimming behaviors which may increase their ability to resist flow (Hoover et al. 2005). *Scaphirhynchus* larvae are weak swimmers and experience high rates of mortality under simulated propeller entrainment and high rates of stranding under simulated vessel-induced drawdown (Adams et al. 1999b; Killgore et al. 2001).

Water Cooling Intake Structures: Preliminary data on the Missouri River indicate that these structures may be a threat that warrants more investigation. Initial results from work conducted by Mid-America at their Neal Smith power facilities located downstream of Sioux City, Iowa, found hatchery-reared Pallid Sturgeon were being entrained (Burns & McDonnell Engineering Company, Inc. 2007a and 2007b). Over a 5-month period, four known hatchery-reared Pallid Sturgeon were entrained, of which two were released alive and two were found dead.

Towboat propellers: Empirically derived propeller entrainment data for Pallid Sturgeon are lacking. However, available propeller entrainment data for Shovelnose Sturgeon collected in the Mississippi River upstream of Lock and Dam 26 (Figure 5), indicates it occurs and can be lethal (Killgore et al. 2011; Miranda and Killgore 2013) with mortality estimates being as high as 0.53 Shovelnose Sturgeon per 1 Rkm (0.6 Rmi) of towboat travel (Gutreuter et al. 2003). Because barge operation occurs in waters occupied by Pallid Sturgeon and propeller entrainment induced mortality has been documented for Shovelnose Sturgeon, it is reasonable to conclude that towboat propellers can entrain and harm Pallid Sturgeon. However, comparable studies have not been conducted in waters commonly occupied by Pallid Sturgeon, thus, the magnitude of this threat is difficult to assess and additional research is needed.

Dredge Operations: The U.S. Army Corps of Engineers has initiated work to assess dredge entrainment of fish species and the potential effects that these operations may have on larval and juvenile *Scaphirhynchus.* Available data collected in the middle Mississippi River near the Chain of Rocks weir (Figure 5) indicate that Shovelnose Sturgeon can be entrained and this entrainment is relatively lethal (Ecological Specialists, Inc. 2010). However, the risk of dredge entrainment is likely to vary by dredge design (i.e., mechanical or hydraulic) and swimming capabilities (Hoover et al. 2011). Dredging in locations where Pallid Sturgeon congregate could result in entrainment and mortality. Small Pallid Sturgeon likely are at risk of being entrained in dredges and additional data for escape speed, position-holding ability, orientation to the current and response to noise, and dredge flow fields are being used to develop a risk assessment model for entrainment of sturgeon by dredges (Hoover et al. 2005).

Irrigation Diversions: Entrainment of hatchery-reared Pallid Sturgeon has been documented in the irrigation canal associated with the Lower Yellowstone Irrigation Project's Intake Diversion Dam on the Yellowstone River (Figure 4) where some of these fish are believed to have perished (Jaeger et al. 2004).

Flood control points of diversions: Two hatchery-reared juvenile Pallid Sturgeon released in the Mississippi River and one adult hatchery-reared Pallid Sturgeon released in either the lower Missouri or middle Mississippi river were entrained by the Old River Control Complex as they were subsequently collected in the Atchafalaya River. During May and June 2008, 14 Pallid Sturgeon were collected behind the Bonnet Carré spillway (Reed in litt., 2008; USFWS 2009a).

Subsequently, in 2011, the Bonnet Carré spillway was opened again to alleviate flooding. Following closure, 20 Pallid Sturgeon were collected behind the spillway (U.S. Army Corps of Engineers 2012) indicating that entrainment occurs at this facility during the rare occasions when flood waters need to be shunted from the Mississippi River to Lake Pontchartrain. One interesting observation in 2011 was the collection of a tagged Pallid Sturgeon from behind the Bonnet Carré spillway that was previously collected behind the spillway and released into the Mississippi River in 2008 (U.S. Army Corps of Engineers 2012). Additionally, the Birds Point–New Madrid and the Morganza Floodways (Figure 5) were also opened in 2011. While subsequent sampling did not document Pallid Sturgeon within either floodway, 26 Shovelnose Sturgeon were reported as entrained in the Birds Point–New Madrid Floodway and no sturgeon were reported in the Morganza Floodway (U.S. Army Corps of Engineers 2012). Additional smaller structures exist or are planned for diverting water and sediments from the Mississippi River for marsh enhancement and hurricane protection in coastal Louisiana. Pallid Sturgeon entrainment potential and significance is unknown.

Summary of Impacts of Entrainment

Entrainment of juvenile and adult Pallid Sturgeon has been documented to occur in the few instances it has been studied. Thus, it is a greater threat than anticipated in the original version of this plan. The level of larval sturgeon entrainment is unknown. The overall effects from entrainment are variable and depend on population demographics, exposure time, quantity of un-screened diversion points, and duration of diversion point usage (i.e., year-round versus seasonal or sporadic operation). Further evaluation of entrainment associated with towboat propellers, dredging operations, water diversion points, and commercial navigation is necessary across the Pallid Sturgeon's range to adequately evaluate and quantify this threat.

CLIMATE CHANGE

Although not a threat specifically identified in the Pallid Sturgeon listing package (55 FR 36641-36647), our analyses under the Endangered Species Act include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change. "Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (Intergovernmental Panel on Climate Change 2007). The term "climate change" refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (Intergovernmental Panel on Climate Change 2007). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of climate interactions with other variables (e.g., habitat fragmentation) (Intergovernmental Panel on Climate Change 2007). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change. Both the Intergovernmental Panel on Climate Change and U.S. Global Change Research Program identify that the trend in global climate patterns is one of warming; average temperatures in the United

States are at least 1.1°C (2°F) higher than they were 50 years ago (Intergovernmental Panel on Climate Change 2007; U.S. Global Change Research Program 2009).

Within the range of Pallid Sturgeon, predicted affects appear to be shifts in runoff patterns: discharge peaks are anticipated to occur earlier and potentially be larger, late season river flows may be reduced, and water temperatures may rise (Intergovernmental Panel on Climate Change 2007). These changes to the water cycle are anticipated to affect water use (U.S. Global Change Research Program 2009), which may alter existing reservoir operations. Broadly, these potential effects to Pallid Sturgeon could be altered spawning behavior (i.e., movement and timing), reduced survival of early life stages and young-of-year, and reduced late-season habitat suitability due to reduced flows and presumably warmer temperatures. Another predicted outcome is increased or prolonged periods of drought (Intergovernmental Panel on Climate Change 2007; U.S. Global Change Research Program 2009). Increased water demand coupled with reduced late-season flows could significantly affect in-channel habitats which in turn may affect other species that are food items for Pallid Sturgeon.

These effects would likely occur first, or be most pronounced, in the more northern portion of the Pallid Sturgeon range; the Intergovernmental Panel on Climate Change (2007) study suggests that in general, temperature increases correlate with latitude. Thus, higher northern latitudes appear to have relatively higher predicted warming trends. However, reduced annual runoff predicted in the Missouri River basin may be offset by the anticipated increased runoff in the upper Mississippi River basin (U.S. Global Change Research Program 2009) resulting in minimal effects within the middle and lower Mississippi River basins.

Summary of Impacts of Climate Change

At this time, it is difficult to evaluate long-term effects from climate change as there have been many anthropogenic influences across the species' range. Assessing this potential threat and teasing out relationships associated with climate change will be difficult without careful consideration of other already confounding factors.

Factor A Summary

The present or threatened destruction, modification or curtailment of its habitat or range, remains a threat. However, the magnitude of this threat varies across the species' range, due in part to on-going efforts to mitigate anthropogenic effects and the proportion of perturbations relative to the volume of habitat available. For example, the effects from dams (i.e., altered hydrographs and temperature profiles, altered ecologic processes, habitat fragmentation, and conversion of riverine reaches to reservoir) may be the single greatest factor affecting the species in the upper Missouri River basin. While in the middle and lower Missouri River, as well as the middle Mississippi River, water quality, entrainment, and maintenance of the channel for navigation purposes and the associated impacts are significant threats. Additionally, the effects from other threats described below, may be more limiting to the species in these areas. The same applies to the lower Mississippi River. Currently main-stem riverine habitat is not fragmented by dams and many natural ecological processes can still create a diversity of physical habitats believed important for the species. However, data are limited related to overall water quality.

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization for commercial, recreational, scientific, or educational purposes is one of the threats to Pallid Sturgeon identified in the listing determination (55 FR 36641-36647). Given the endangered status of Pallid Sturgeon, use for scientific or educational purposes is regulated under section 6 cooperative agreements or under section 10 of the Act. All recreational and commercial harvest of Pallid Sturgeon is prohibited by Section 9 of the Endangered Species Act as well as State regulations throughout its range.

While these regulations effectively protect Pallid Sturgeon from recreational harvest and overutilization for scientific and educational purposes, they do not prevent lethal take of Pallid Sturgeon as a result of species misidentification associated with commercial Shovelnose Sturgeon fishing. To address this threat, beginning in 2010, Shovelnose Sturgeon are treated as threatened where the two sturgeon species coexist, under the similarity of appearance provisions of the Endangered Species Act (75 FR 53598-53606). This rule extends take prohibitions to Shovelnose Sturgeon, Shovelnose-Pallid Sturgeon hybrids, and their roe when associated with a commercial fishing activity in areas where Pallid Sturgeon and Shovelnose Sturgeon commonly coexist. Continued monitoring will provide data on the effectiveness of this regulation.

Factor B Summary

Current State regulations and protections afforded under the Endangered Species Act, including the similarity of appearance rule, coupled with adequate enforcement, appear sufficient to manage, to the maximum extent practicable, the threat from overutilization for commercial, recreational, scientific, or educational purposes. However, absent protections under the Endangered Species Act, adequate State harvest regulations and enforcement will be necessary to protect the species from overharvest.

Factor C: Disease or Predation

DISEASE

Fish pathogens have the potential to produce severe disease outbreaks, but they may also simply exist in a carrier state. Fish pathogens include viral, bacterial, and parasitic agents. In some instances, disease outbreaks can severely deplete local populations, but these extreme events have not yet been documented in wild Pallid Sturgeon populations. Some pathogens of notable importance for Pallid Sturgeon recovery include Viral Hemorrhagic Septicemia Virus and the Missouri River sturgeon iridovirus.

Viral Hemorrhagic Septicemia Virus is a fish disease that has caused large-scale mortalities in numerous species (Kim and Faisal 2010) and has been described as an "extremely serious pathogen of fresh and saltwater fish" (APHIS 2006). While it has not been documented to affect Pallid Sturgeon, it also has not been found within the range of the species. However, Viral Hemorrhagic Septicemia Virus has been documented in the Great Lakes (APHIS 2006). Various shipping canals have created a connection between the Great Lakes and the Mississippi River so it is possible that through time, this virus could reach areas occupied by Pallid Sturgeon.

Because this pathogen can cause large-scale mortalities in fish populations, and it has a wide range of potential carriers, we believe it is important to monitor for Viral Hemorrhagic Septicemia Virus within the range of Pallid Sturgeon.

Missouri River sturgeon iridovirus is a concern in the context of Pallid Sturgeon recovery because it causes mortality in hatchery-reared Pallid Sturgeon (Kurobe et al. 2011) and its effect on free-ranging sturgeon populations is unknown. The Missouri River sturgeon iridovirus was originally documented during artificial propagation efforts of Shovelnose Sturgeon at the Gavins Point National Fish Hatchery in 1999. However, this iridovirus also can infect Pallid Sturgeon (Kurobe et al. 2011). This disease is known to cause substantial mortality in hatchery-rearing environments (Kurobe et al. 2011). Study fish surviving initial viral outbreaks still harbor the virus even though they may appear healthy (Hedrick et al. 2009; Kurobe et al. 2011). While initially identified in a hatchery environment, additional testing has documented that this virus is found in the wild; of 179 *Scaphirhynchus* tested from the Atchafalaya River between November 2003 and May 2004, 8 (4%) were confirmed as positive for the virus and 5 (2.8%) were suspected of carrying the virus. Subsequent testing with more sensitive methods also confirmed the presence of the virus in the wild (Hedrick et al. 2009), suggesting that it may be endemic in the Missouri River. The effect of the virus on wild populations is not known.

PREDATION

Little information is available implicating piscivory as a threat affecting the Pallid Sturgeon. Predation on larval and juvenile fishes of all species occurs naturally. However, habitat modifications that increase water clarity and artificially high densities of both nonnative and native predatory fishes could result in increased rates of predation. Pallid Sturgeon larvae and fry passively drift post-hatch (Kynard et al. 2007; Braaten et al. 2008). This behavior exposes naturally-spawned Pallid Sturgeon to predation which was moderated historically by high fecundity and turbid waters. However, anthropogenic changes that affect habitats could result in increased vulnerability to predation. In the impounded areas of the upper Missouri River, larvae may be transported into the clear headwaters of reservoirs like Fort Peck and Lake Sakakawea. These reservoirs are or have been artificially supplemented with predatory species like Walleye (*Sander vitreus*).

Maintaining artificially elevated populations of certain species in these reservoirs has been hypothesized as a contributing factor in poor survival of larval and juvenile Pallid Sturgeon. Walleye and Sauger (*S. canadensis*) are capable of eating wild paddlefish up to 167 mm (6.6 inch (in.) body length, 305 mm (12 in.) total length) and, thus, likely could consume naturally-produced Pallid Sturgeon larvae, fry, and fingerlings (Parken and Scarnecchia 2002). When looking at data for sample locations closest to reservoir headwaters, it appears that no age-0 paddlefish were found in Walleye, but were present in Sauger, a native species closely related to walleye. Though Braaten and Fuller (2002, 2003) examined 759 stomachs from 7 piscivore (fish eating) fishes in Montana, they found no evidence of predation on sturgeon. Other studies have, however, documented *Scaphirhynchus* sturgeon as food items. Hogberg and Pegg (2013) found sturgeon in the stomachs of Flathead Catfish (*Pylodictis olivaris*) studied in the lower Missouri River. Predation vulnerability of Pallid Sturgeon (> 40 mm) by Channel Catfish (*Ictalurus punctatus*), Smallmouth Bass (*Micropterus dolomieu*), and Walleye appears to be low, provided other prey species are available (French 2010; French et al. 2010). More data are needed to adequately assess predation effects on eggs, and larval Pallid Sturgeon in order to evaluate implications on recruitment success (see also Invasive Species/Aquatic Nuisance Species under Factor E Other Natural or Manmade Factors Affecting its Continued Existence).

Factor C Summary

When listed, neither disease nor predation were discussed as threats, primarily due to limited information. New data have highlighted both disease and predation as issues of potential concern and they should be considered as likely threats. At this writing, data are inadequate to quantify the magnitude of the threat either may pose.

Factor D: Inadequacy of Existing Regulatory Mechanisms

Regulatory mechanisms are required for Pallid Sturgeon recovery and to ensure long-term conservation of the species. These mechanisms affect many aspects of legal protection, such as habitat and flow protection, regulation and/or control of nonnative fishes, regulation of hazardous-materials spills, and harvest. In determining whether the inadequacy of existing regulatory mechanisms constitutes a threat to Pallid Sturgeon, our analysis focused on existing State and Federal laws and regulations that could potentially address the main threats to the species described under Factors A and B, and potential new threats described under Factor E.

State Regulations

Water Quality
All States whose waters are occupied by Pallid Sturgeon have enacted legislation intended to preserve water quality. Generally these State regulations (see Appendix A) parallel comparable Federal legislation; in some cases, State statutes may impose requirements that are more stringent than the Federal law. In all cases, Clean Water Act requirements must be adhered to and are enforced in conjunction with State statutes and regulations implemented by the State administrative agencies.

Water Quantity
Many States have enacted legislation and processes specifically to allocate water resources (see Appendix A). Generally, water use permits are obtained from the appropriate State or local administrative agencies. Most States have instream-flow laws intended to maintain “beneficial use” of water left in streams for wildlife. However, these laws typically only protect minimum flows believed necessary to maintain the fishery and, in some states, may afford little protection. For example, water development/usage in Montana is governed by western water law. Under this system, in-stream water rights held by Montana Fish Wildlife and Parks are newer (junior) to many water users with an older (senior) water right. As a result, during extreme drought situations, senior water right owners have priority rights to water, in other words, their rights will be met prior to those of Montana Fish Wildlife and Parks. Once senior rights are satisfied, the remainder can be left in the river and used for fish and wildlife. This could lead to a water depletion situation in areas occupied by Pallid Sturgeon. Additionally lacking in many states, are completion of adjudication processes and full inventories of all water allocations. Without these

data it is difficult to determine if important rivers and tributaries for Pallid Sturgeon have been or could become over-allocated resulting in future adverse effects.

Harvest

In addition to Federal protection under the Endangered Species Act, Pallid Sturgeon are protected by State designations such as “endangered,” “threatened,” or “sensitive.” These designations typically prohibit intentional take and harvest of any Pallid Sturgeon. Depending on local demographic conditions, these designations may need to remain in place within some States after the species is delisted. When delisted, States within the Pallid Sturgeon’s range have the authority to continue State protections or to manage and establish commercial and recreational harvest limits for the species within their borders. Long-range migratory species are often considered ‘interjurisdictional’ and may be co-managed with neighbor States or through organizations like the Mississippi Interstate Cooperative Resources Association; an organization of 28 State agencies that formed a partnership to improve management of aquatic resources in the Mississippi River Basin. State regulations currently provide protections against take of Pallid Sturgeon associated with commercial, recreational, scientific, and educational purposes. For the most part, these regulations are adequate to protect Pallid Sturgeon from direct intentional taking. However incidental harvest of Pallid Sturgeon during commercial Shovelnose Sturgeon harvest has been documented in several States where Pallid and Shovelnose sturgeon are sympatric. This resulted in a Federal rule treating Shovelnose Sturgeon as threatened under the Endangered Species Act due to similarity of appearance to Pallid Sturgeon (75 FR 53598-53606). To be delisted, State regulatory mechanisms and/or designations will need to ensure continued long-term management and protection for the species.

Summary of State Regulations

While States have implemented many regulations to protect and conserve resources through a mechanism of project proposal review and permitting, these efforts likely are limited by a lack of biological and/or ecological data on Pallid Sturgeon and their ecological thresholds. For example, levels of contaminants that generate negative effects in Pallid Sturgeon have not been fully quantified, limiting the ability to establish protective State standards. Another limitation of State permitting processes is cumulative effects evaluations. Considering cumulative environmental effects in the permitting process requires an understanding of ecological thresholds, baseline conditions, and life history requirements for many species, as well as their response to multiple environmental stressors. Unfortunately, with respect to the Pallid Sturgeon, much of this remains unknown. Finally, when the species is delisted, State regulations will be necessary to manage and protect the species.

Federal Regulations

In addition to State regulations, activities that affect either Pallid Sturgeon or its habitat are regulated under Federal laws. Notable Federal regulations that address Pallid Sturgeon and their habitat are; the Clean Water Act, River and Harbors Act of 1899, Federal Power Act, National Environmental Policy Act, and the Fish and Wildlife Coordination Act .

The Clean Water Act (33 U.S.C. §§1251 et seq.) regulates pollutant discharges into the nation’s waters. This is accomplished through defining, monitoring, and regulating water quality standards for all surface waters, establishing industry wastewater standards, and protecting aquatic life and habitats through permitting. Pertinent regulations can be found at 40 C.F.R., CH 1, subchapter D-water programs (§§ 110, 112, 116, 117, 122-125, 129-133), 40 C.F.R., CH 1, subchapter N-effluent guidelines and standards (§§ 401-471), and 40 C.F.R., CH 1, subchapter O-Sewage sludge (§§ 501, and 503). The Clean Water Act affords substantial protections to the Pallid Sturgeon, its habitat, and life history requirements through establishing water quality standards and reducing the effects from the discharge of harmful pollutants, contaminants and discharge of dredge or fill material. However, residual effects from historical practices and a lack of species specific information on the sensitivity of the Pallid Sturgeon to common industrial and municipal pollutants may be limiting the full conservation potential of the Clean Water Act as it relates to pollutant discharge and water quality standards.

In addition to regulating pollutant discharges, the Clean Water Act also allows the U.S. Environmental Protection Agency to establish regulations for cooling water intake structures (§ 316b). Losses of Pallid Sturgeon through impingement or entrainment from these structures have been documented (see Factor A: Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range, above). Section 316(b) of the Clean Water Act requires the U.S. Environmental Protection Agency to provide reasonable assurances that aquatic organisms are protected from impingement or entrainment. In 2004, the agency issued regulations (69 FR 41575-41624) to minimize entrainment and impingement mortality associated with cooling water intakes at power production facilities. However, these regulations were suspended in 2007 (72 FR 37107-37109). In 2011, the public comment period was reopened for proposed Section 316(b) requirements for all existing power generating facilities and existing manufacturing and industrial facilities (76 FR 43230-43231). While data are limited or lacking, providing reach-specific information on Pallid Sturgeon population size, habitat use, and behavior would be necessary to expect reasonable assurances that the species is protected under subsequent 316(b) provisions of the Clean Water Act. For example, local effects to Pallid Sturgeon associated with entrainment loss may be proportional to species abundance and/or habitat use, as well as intake design and/or location. Additionally, at low population levels or in areas heavily used by the species, the threat from entrainment may be highest. Conversely, entrainment losses may have little or no impact when population levels are robust or in areas seldom frequented by the species.

The Rivers and Harbors Act (33 U.S.C. §§401,403,407 et seq.) prohibits the construction of any bridge, dam, dike or causeway over or in navigable waterways of the U.S. without Congressional approval. Structures authorized by State legislatures may be built if the affected navigable waters are totally within one State, provided that the plan is approved by the Chief of Engineers and the Secretary of Army (33 U.S.C. 401).

The Federal Power Act (16 U.S.C. §§791-828) provides for cooperation between the Federal Energy Regulatory Commission and other Federal agencies, including resource agencies, in licensing and relicensing power projects. The Federal Energy Regulatory Commission is authorized to issue licenses to construct, operate and maintain dams, water conduits, reservoirs, and transmission lines to improve navigation and to develop power from any streams or other bodies of water over which it has jurisdiction which includes many of the rivers inhabited by Pallid Sturgeon. An amendment in1986, the Electric Consumers Protection Act, required several provisions to benefit fish and wildlife. Specifically, each license is to contain conditions to protect, enhance, and mitigate fish and wildlife affected by the project (16 U.S.C. §§803 et seq.). These conditions are to be based on recommendations received from the USFWS, the National Marine Fisheries Service, and State fish and wildlife agencies pursuant to the Fish and Wildlife Coordination Act. Additionally, there are requirements under 16 U.S.C. §81, related to operation of navigation facilities, they specify " The Commission shall require the construction, maintenance, and operation by a licensee at its own expense …such fishways as may be prescribed by the Secretary of the Interior or the Secretary of Commerce, as appropriate." The Federal Power Act has facilitated conservation of Pallid Sturgeon and their habitats through improved coordination with fish and wildlife management agencies and has the ability, where applicable, to restore connectivity for Pallid Sturgeon through mandated fish passage requirements.

The National Environmental Policy Act (42 U.S.C. §§4321-4347 as amended) requires all Federal agencies in the executive branch to consider the effects of their actions on the environment. This act allows cooperating agencies and interested parties to assess proposed Federal projects and their potential significant impacts to the human environment. In general, participants review proposed actions and provide recommendations to the action agency to minimize or avoid environmental impacts. Affects to endangered species are commonly included in these environmental assessments or environmental impact statements; however, endangered status is not required for such considerations. As such, the processes necessary to comply with this act would include considerations of Pallid Sturgeon and their habitats in project planning. However, while this act provides for disclosure of environmental impacts, it does not require minimization. Thus, the degree to which this act offers protection to the Pallid Sturgeon is variable and based upon voluntary adoption of conservation measures. Compliance with this act would be improved and provide increased benefit with better information on habitat use and needs of Pallid Sturgeon within the Missouri and Mississippi river basins.

The Fish and Wildlife Coordination Act (16 U.S.C. §§661-667e as amended) requires that Federal agencies funding, sponsoring, or permitting activities give consideration and coordination of wildlife conservation with respect to water resources development programs. Under the Fish and Wildlife Coordination Act, Federal agencies must consult with the USFWS and the State fish and wildlife agencies where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted . . . or otherwise controlled or modified" under a Federal permit or license. Consultation is to be undertaken for the purpose of "preventing loss of and damage to wildlife resources." Through the Fish and Wildlife Coordination Act, Pallid Sturgeon and their habitats are given due consideration in water development activities. However, while the Fish and Wildlife Coordination Act may result in implementation of conservation measures (i.e., screening of water diversion structures) on new water projects, this act does not afford protections for projects implemented or permitted prior to its enactment.

Summary of Federal Regulations

Federal environmental regulations have substantially increased environmental protections throughout the Pallid Sturgeons' range. However, there are instances where these regulations may not have been adequately followed (Government Accountability Office 2011), possibly resulting in negative effects for the species. In other instances, the implementation of these laws does not offer adequate protection to the Pallid Sturgeon in that it does not address the specific threats that the species faces. In some cases, lack of empirically derived data, specific to Pallid Sturgeon or lack of access to available data may be limiting the efficacy of existing Federal regulations.

Factor D Summary

Federal, State, and local regulatory protections have been developed to minimize and mitigate known and potential threats to fish and other aquatic species, as well as their habitats, from anthropogenic activities. While some of these regulatory mechanisms have been helpful and benefited the species, recovery progress made to date is the result of the Endangered Species Act and its enforceable provisions to ensure conservation of listed species. Absent protections under the Endangered Species Act, current existing State and Federal regulations may be inadequate to ensure long-term protection for the species. However, some of this perceived inadequacy of existing regulatory mechanisms to conserve Pallid Sturgeon primarily relates to a lack of specific information on population size, habitat use, and sensitivity or vulnerability to contaminants, entrainment, and other threats or a lack of easy access to these data where available. As examples:

- State and Federal environmental regulations enacted to reduce or eliminate environmental contaminants and preserve water quality provide regulatory authority to develop and establish standards and implement pollution control programs. The standards established pursuant to these regulations and through State and Federal permitting processes have benefitted the Pallid Sturgeon by protecting and improving water quality. However, data suggest that residual contaminants or their derivatives are still negatively affecting the species (see Factor A: Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range, above). Developing specific information on the sensitivity of the Pallid Sturgeon to common industrial and municipal pollutants and their derivatives will allow for reviewing and if necessary modifying water quality standards specifically to benefit the species.

- Hybridization was identified as a threat to the species when it was listed (55 FR36641-36647) and is discussed further under Factor E below. At the time, the prevailing hypothesis relates hybridization with habitat alterations that resulted in a breakdown of natural reproductive isolating mechanisms. However, more recent information suggests that additional data are needed to fully understand the extent and magnitude of hybridization as a threat (USFWS 2007). If hybridization is related to habitat alterations, conserving and restoring habitats may be the only method to reverse this trend. Use of available regulatory mechanisms to address the threat of hybridization is currently limited by lack of information on the natural reproductive isolating mechanisms between Shovelnose and Pallid sturgeon.

- A number of invasive aquatic species have been introduced into the range of Pallid Sturgeon (see Factor E: Other Natural or Manmade Factors Affecting its Continued Existence, below);

however, the threats they may pose to its conservation are poorly known. Numerous State and Federal regulations, including but not limited to, the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (as amended), Injurious Wildlife provisions of the Lacey Act (18 U.S.C. 42; 50 CFR 16), Asian Carp Prevention and Control Act, and Clean Boating Act of 2008, have been developed to: 1) prevent introduction of new invasive species into the wild; 2) halt the spread of invasive species to unoccupied areas; and 3) to control them in areas where they were introduced. Information on the spread and abundance of invasive species, as well as their effects on reach specific Pallid Sturgeon populations is necessary to determine whether these regulatory mechanisms are adequate to protect the species.

As our knowledge of the species increases, existing regulatory mechanisms can be more effectively evaluated, improved, and implemented.

Factor E: Other Natural or Manmade Factors Affecting its Continued Existence

Potential new threats identified subsequent to the 5-year review (USFWS 2007) or new information has resulted in additional evaluation of: 1) energy development, 2), hybridization, and 3) invasive species/aquatic nuisance species.

ENERGY DEVELOPMENT

Gas and Oil Exploration: Exploration of natural gas and oil deposits occurs in portions of the Pallid Sturgeon's range. Preliminary assessment of the impacts of seismic air guns, a tool used for exploration, suggests that they may have negative effects on larval Pallid Sturgeon (Krentz in litt. 2010). Additional research is necessary to fully evaluate the extent and magnitude of these effects.

Gas and Oil Pipelines: The federal authority for pipeline safety is the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration. This agency reports that there were 2.3 million miles of pipelines in the United States carrying natural gas and hazardous liquids (primarily petroleum, refined petroleum products, and other chemicals). Many pipelines cross rivers within the range of Pallid Sturgeon; some of which are buried under the river bed.

While not directly within the historical range of Pallid Sturgeon, the 2011 rupture of the Silvertip Pipeline crossing under the Yellowstone River serves as a reminder that accidental releases of hazardous materials can occur. Depending on the timing, magnitude, and the material leaked, a ruptured pipeline could pose a threat to Pallid Sturgeon.

Summary of Impacts from Energy Development

Increased demand for energy resources has led to an increased interest in new technology for development and exploration. Oil and gas exploration techniques have the potential to take Pallid Sturgeon yet the ability to evaluate these takings will be nearly non-existent given the nature of the river systems these fish live in.

The conveyance of oil and gas through pipelines could result in localized negative effects should a rupture occur resulting in the substances being transported spilling into waters occupied by Pallid Sturgeon. The U.S. Department of Transportation's Office of Pipeline Safety is responsible for regulating the safety of design, construction, testing, operation, maintenance, and emergency response of domestic oil and natural gas pipeline facilities. Additionally, there are state offices responsible for managing, permitting, and inspecting pipelines.

Strict adherence to existing environmental laws will be necessary to minimize effects and more data will be needed to adequately evaluate and monitor impacts related to energy development.

HYBRIDIZATION

The original version of this recovery plan (USFWS 1993) identified hybridization as a threat to Pallid Sturgeon. This was, in part, based on limited observations of sturgeon (N=12) collected from the middle Mississippi River that appeared morphologically-intermediate to Shovelnose and Pallid sturgeon (Carlson and Pflieger 1981; Carlson et al. 1985) and the belief that hybridization was contemporary (i.e., post 1960 and influenced by anthropogenic changes to habitat). Subsequent genetic and morphological studies have been conducted to explore hybridization between Pallid and Shovelnose sturgeon (Phelps and Allendorf 1983; Carlson et al 1985; Campton et al. 2000; Tranah et al. 2001 and 2004; Kuhajda et al. 2007; Ray et al. 2007; Murphy et al. 2007a). Below is a brief review of the current literature regarding the treatment of intermediate-character sturgeon and putative pallid/shovelnose hybridization in the Mississippi River basin.

Carlson et al. (1985) used principal components analysis based on morphometric measures described in Bailey and Cross (1954) and found that morphologically-intermediate specimens fell in between the Pallid and Shovelnose sturgeon groups leading to their hybridization origin hypothesis. Efforts to confirm hybridization used a suite of allozyme markers (Phelps and Allendorf 1983). These results neither supported nor refuted the hybridization origin hypothesis and only suggested that Pallid and Shovelnose sturgeon share close taxonomic affinities. Tranah et al. (2004) assessed the genetic origins of 10 morphologically intermediate sturgeon collected from the Atchafalaya River. These results were consistent with the hypothesis that hybridization occurs between Pallid and Shovelnose sturgeon. However, this study simply demonstrated that morphologically-intermediate fish had intermediate genotypes. Schrey (2007) analyzed 529 *Scaphirhynchus* samples from the upper Missouri, lower Missouri, middle Mississippi, and Atchafalaya rivers using sixteen microsatellite loci. Like Tranah et al. (2004), the author also found that genetically-intermediate fish tended to also be morphologically-intermediate.

While there are competing hypotheses that may explain morphologically intermediate fish (Murphy et al. 2007a; Ray et al. 2007), there appears to be a positive correlation between genotype and phenotype (Tranah et al. 2004; Schrey 2007). The latest genetic analysis confirms introgressive hybridization between Pallid and Shovelnose sturgeon occurs and likely has been occurring for several generations, perhaps as many as 60 years (Schrey et al. 2011). However, the significance of hybridization as a factor in the status of Pallid Sturgeon is poorly understood. Hybridization between two species could result in the eventual loss of one or both parental forms (Arnold 1992; Allendorf et al. 2001; Rosenfield et al. 2004). Conversely, a few have postulated that hybridization played a role in past sturgeon speciation (Birstein et al. 1997; Vasil'ev 1999; Robles et al. 2005), indicating that hybridization may have always been a process occurring in

the evolution of sturgeon species and it can lead to the creation of new species (Arnold 1992). However, regardless of whether similar events might have led to new sturgeon species in the past, the Endangered Species Act instructs us to address threats to the integrity of listed species. While the mode and rate of *Scaphirhynchus* hybridization is difficult to assess, understanding the evolutionary relationship between Shovelnose and Pallid sturgeon is important to better be able to assess potential threats that hybridization may impose on Pallid Sturgeon recovery.
Summary of Impacts Related to Hybridization

While we know that experimental mating of Pallid Sturgeon with Shovelnose Sturgeon can produce living offspring (Kuhajda et al. 2007), accurate assessment of hybridization in the evolution of *Scaphirhynchus* and its relative threat to Pallid Sturgeon recovery will require statistically testing the hypothesis of hybridization against alternatives. Since hybridization is occurring in *Scaphirhynchus* and likely has been occurring for many decades (Schrey et al. 2011), it is important to determine the cause (i.e., historical/natural or contemporary), extent, and frequency or rate of occurrence of hybridization. Once these processes are elucidated, simulation/modeling exercises can address the actual risks associated with *Scaphirhynchus* hybridization. If it is determined that alteration of habitats has influenced temporal or spatial reproductive isolating mechanisms resulting in increased rates of hybridization, addressing this threat will likely rely on both site-specific and ecosystem improvement efforts; many of which are identified in the Recovery Outline/Narrative section below.

INVASIVE SPECIES/AQUATIC NUISANCE SPECIES
Although not a threat specifically identified in the Pallid Sturgeon listing package (55 FR 36641-36647), the potential impact of invasive and aquatic nuisance species can be applied to Listing Factor A- The present or threatened destruction, modification, or curtailment of its habitat or range and Listing Factor C- Disease or Predation. Several species with the potential for impacting Pallid Sturgeon have become established in parts of the species' range. These include the Asian carps (Common Carp (*Cyprinus carpio*), Grass Carp (*Ctenopharyngodon idella*), Silver Carp (*Hypophthalmichthys molitrix*), Bighead Carp (*Hypophthalmichthys nobilis*) and Black Carp (*Mylopharyngodon piceus*)) as well as the zebra mussel (*Dreissena polymorpha*). Populations of Asian carp appear to be expanding exponentially in parts of the Mississippi River basin; similarly the range of the zebra mussel continues to expand (Kolar et al. 2005).

According to the American Fisheries Society (Policy 15), potential negative impacts by nonnative species have been categorized into five broad categories: habitat alteration, trophic alteration, spatial alteration, gene pool deterioration and disease transmission. Documenting these impacts in large river ecosystems is especially difficult. Few studies have documented the impacts from these species in the Mississippi Basin. However, data are available from other watersheds that shed insight into potential effects from invasive species.

If food resources were limited from the presence of large populations of planktivores (e.g., Asian carps), early life-stage Pallid Sturgeon could face increased competition with native planktivorous fishes such as Gizzard Shad (*Dorosoma cepedianum*), Bigmouth Buffalo (*Ictiobus cyprinellus*) and Paddlefish (Kolar et al. 2005). Several authors have expressed concern that, because nearly all fish feed on zooplankton as larvae and juveniles, Asian carps have high potential to impact native fishes in the Mississippi River basin (Laird and Page 1996; Chick and Pegg 2001; Chick 2002). The diets of Bighead and Silver Carp have significant overlap with those of Gizzard Shad and Bigmouth Buffalo (Sampson et al. 2009). In addition to directly competing for food resources, Asian carps also could affect recruitment by predation on Pallid Sturgeon eggs or drifting larvae. Miller and Beckman (1996) have documented white sturgeon eggs in the stomachs of Common Carp. Additionally, disease or parasites can be spread by Asian carp. Goodwin (1999) noted that Channel Catfish became infested with anchorworm when cultured with Bighead Carp. Heckmann et al. (1986 and 1995) reported that this tapeworm was spread to two endangered species when baitfishes were released into Lake Mead, Arizona and Nevada. Currently, the Asian tapeworm is known to infest native fishes in five States; however, none are in the Mississippi River drainage (Kolar et al. 2005).

Zebra mussel colonization has occurred in areas occupied by Pallid Sturgeon but data are limited on direct effects. In juvenile Lake Sturgeon, data show that zebra mussel occupancy changes the nature of the bottom substrates and a reduced foraging effectiveness with mussel presence resulting in avoidance of those areas by study fish more than 90% of the time (McCabe et al. 2006).

Summary of Impacts From Invasive and Aquatic Nuisance Species

Potential threats from invasive or aquatic nuisance species include increased predation on eggs, larval, or juvenile life stages, competition for food in the case of the carps, exclusion of native species from preferred habitats, spread of diseases or parasites, and alteration of habitat quality. Further study is needed to fully qualify and quantify the magnitude of this probable threat to Pallid Sturgeon.

Factor E Summary

Energy development and invasive species are two threats that may have substantial deleterious effects on Pallid Sturgeon populations. Strict adherence to existing environmental laws will be necessary to minimize effects from these threats and more data will be needed to adequately evaluate the extent and magnitude of these effects.

Conservation Measures

Numerous planning and conservation measures have been implemented range-wide to reduce localized effects from identified threats. The following is not intended to provide a comprehensive list of all conservation activities range-wide, but rather highlight projects and efforts that have been or will be implemented to address some of the threats to Pallid Sturgeon described previously.

MISSOURI RIVER

Within the Missouri River basin, where channelization and dams have fragmented habitats and altered natural riverine processes and no evidence for Pallid Sturgeon recruitment exists, many efforts are being explored or implemented to restore ecological function, as well as utilizing the PSCAP to prevent local extirpation. Restoration efforts include, but are not limited to: creating side channel habitats, restoring connectivity to backwater areas, notching dikes, providing fish passage, and manipulating flows through the dams. In addition to habitat restoration efforts and the PSCAP, a basin-wide Pallid Sturgeon population monitoring program has been established to track changes in species abundance and status.

Fort Benton to Fort Peck Reservoir, Montana

Reservoir operations on tributaries within this reach have been modified from past practices. Releases from Tiber Dam (Figure 4) were modified to occasionally accommodate a high flow discharge period. During 1995, 1997, and 2002, the Bureau of Reclamation provided a June peak release of 4,080, 4,500, and 5,300 cfs, respectively, to benefit downstream fisheries. A response by Pallid Sturgeon was not detected; however, present numbers of Pallid Sturgeon in this reach may be too low to detect or elicit a response. An indirect response to these increased discharges may be the recent establishment of Sturgeon Chub (*Macrhybopsis gelida*) in the lower Marias River. Sturgeon chub are an important prey species of Pallid Sturgeon (Gerrity et al. 2006) and were documented only recently in the Marias River in 2002.

Augmentation and monitoring efforts continue to support and evaluate the Pallid Sturgeon population within this reach.

Fort Peck Dam, Montana to Lake Sakakawea, North Dakota

In addition to artificial supplementation with hatchery-reared Pallid Sturgeon, discussions and exploratory designs have been ongoing in an effort to increase water temperatures in the Missouri River immediately downstream of Fort Peck Dam. Several options have been considered ranging from releasing surface water over the spill-way to modifying the intake structures or installing a large "curtain" around the intakes such that they draw down and release warmer surface waters. To date, warm water releases have not been implemented due in part to insufficient water levels.

The Yellowstone River is the largest tributary to the Missouri River in this reach. A multi-agency effort has been ongoing since the early 2000s to develop and implement fish passage and entrainment protection at Intake Dam. In 2007, the Water Resources Development Act provided the U.S. Army Corps of Engineers the authority to assist the Bureau of Reclamation with design and implementation of fish passage and entrainment protection at Intake Dam. A new water diversion structure, complete with fish screens, was initiated in 2010 and operational in 2012. Final passage options, intended to maximize Pallid Sturgeon passage probabilities to areas upstream of Intake Dam, are still being developed.

Fort Randall Dam to Gavins Point Dam, South Dakota and Nebraska

Augmentation efforts are being implemented to help reestablish a population in this reach. The Niobrara River is the largest tributary in this reach. Spencer Dam is a fish passage barrier on the Niobrara River. To date, preliminary discussions among interested parties have begun to explore passage options at this structure, but there are no substantial efforts yet to address this issue.

Gavins Point Dam South Dakota/Nebraska to the Mississippi River Confluence

At over 1,296 Rkm (800 Rmi), this is the longest unimpounded reach of the Missouri River. Release of hatchery-reared Pallid Sturgeon produced as part of the PSCAP was initiated in 1994 and has occurred annually since 2002 in this reach. Available data indicate the PSCAP has lessened the likelihood of local extirpation, but long-term population viability currently remains uncertain (Steffensen 2012). Additionally, by 2011 an estimated 1,393 hectares (ha) (3,443 acres (ac)) of shallow water habitat has been created by constructing site-specific projects like chutes and revetment chutes, dredging to connect back-water areas, as well as side-channel construction (U.S. Army Corp of Engineers and US Fish and Wildlife Service 2012). Based on current and anticipated commitments, habitat restoration in this reach will continue, effectively increasing the quantity and quality of potential sturgeon habitats.

The Platte River is an important tributary to the Missouri River in this reach. The largest anthropogenic factor affecting habitat in the lower Platte River is upstream water withdrawals. The National Research Council (2005) identified that periods of drought could negatively affect habitats in the lower Platte River. During July 2012, a fish kill incident was reported in the lower Platter River following a period of prolonged drought. One dead hatchery-reared Pallid Sturgeon was confirmed (Nebraska in litt., 2012). A Cooperative Agreement between Nebraska, Colorado, Wyoming, and the U.S. Department of Interior was developed forming the Platte River Recovery Implementation Program to improve and maintain habitat for species, including Pallid Sturgeon. Evaluation of the success of this program is needed to determine if program efforts are indeed meeting the needs of the species.

MISSISSIPPI RIVER

Limited conservation stocking efforts have sporadically occurred in the Mississippi River; however, all stocking was discontinued due to increasing numbers of wild Pallid Sturgeon being collected and evidence for some level of natural recruitment (i.e., Columbo et al. 2007; Killgore et al. 2007a, b). Conservation efforts in the Mississippi River include land procurement; habitat conservation and restoration; sturgeon surveys; population quantification, modeling and monitoring; and habitat use studies. Additionally, commercial Shovelnose Sturgeon fishing has been closed by State and Federal regulations to prevent incidental harvest of Pallid Sturgeon in areas previously open to sturgeon caviar harvest.

UPPER MISSISSIPPI RIVER

While few Pallid Sturgeon have been documented in the Upper Mississippi River, the U.S. Army Corps of Engineers has continued to evaluate fish passage through the locks and dams. In addition, the fish community and habitat diversity is being address through U.S. Army Corps of Engineers elements of the Upper Mississippi River Restoration-Environmental Management Program. These elements include the Habitat Rehabilitation and Enhancement Projects and Long Term Resource Monitoring (U.S. Army Corp of Engineers in litt., 2013). Habitat enhancement projects include dike modifications, construction of chevron dikes, side channel enhancement, island construction, and reconnection of the river to the floodplain. Furthermore, since 1943 the Upper Mississippi River Conservation Committee (see http://www.umrcc.org/) has partnered with agencies and others to further cooperative conservation efforts for fish and habitat within the Upper Mississippi River.

MIDDLE MISSISSIPPI RIVER

The U.S. Army Corps of Engineers has initiated a program to restore side channel connectivity and improve habitat diversity in this reach. Projects include dike modifications, construction of chevron dikes, side channel enhancement, placement of woody debris piles, and incorporation of woody debris into dikes. More than 1,700 ha (4,200 ac) of flood-prone land have been purchased from willing sellers (USFWS 2009b). This land has been placed into conservation status by inclusion into the National Wildlife Refuge System. The Middle Mississippi National Wildlife Refuge has resulted in improved floodplain connectivity along 96 km (60 mi) of the Mississippi River downstream from St. Louis, Missouri. Pallid Sturgeon population quantification and monitoring efforts have been conducted in the Middle Mississippi River over the past decade, adding greatly to knowledge of habitat use and species abundance in this river reach.

LOWER MISSISSIPPI RIVER

During the 1980s, the U.S. Army Corps of Engineers established the Lower Mississippi River Environmental Program to develop methods to minimize effects of channel maintenance activities on fisheries and other natural resources in the lower Mississippi River. This program evaluated and modified revetment design, as well as dike design and placement to increase fishery habitat complexity. In 2001, the U.S. Army Corps of Engineers Mississippi Valley Division, initiated informal consultation with the USFWS under section 7(a)(1) of the Endangered Species Act to use Lower Mississippi River Environmental Program designs and additional measures to conserve and manage listed species associated with the lower Mississippi River navigation channel. Annual meetings with the U.S. Army Corps of Engineers, the USFWS, and State agencies are held to evaluate planned construction and maintenance activities, and to identify habitat restoration and improvement opportunities.

In addition, the Mississippi Valley Division and the Districts work with the Lower Mississippi River Conservation Committee (a Federal and State agency partnership) to identify and initiate secondary channel restoration opportunities within the leveed floodplain. Under its Mississippi River Conservation Initiative, this group has identified approximately 220 priority restoration opportunities in the Lower Mississippi River. Over the past decade, more than 64 km (40 mi) of secondary channel habitats have been rehabilitated helping to restore hundreds of acres of seasonally flooded habitats and over 200 dike notches have been constructed to maintain and/or increase in-channel habitat complexity (DuBowy 2010). Other construction modifications implemented to protect and enhance habitats include the construction of hardpoints in lieu of revetment and chevrons to encourage small island formation.

The U.S. Army Corps of Engineers' Engineer Research and Development Center has been conducting distribution and abundance studies on Pallid Sturgeon for more than 10 years. This center has evaluated susceptibility of sturgeon to entrainment through dredging and diversion structures, identified engineering modifications to minimize entrainment potential, assessing the benefits of dike notching, sturgeon utilization of in-river engineered structures, seasonal and spatial distribution of young-of-year sturgeon, and young-of-year sturgeon diets. Other research and monitoring efforts include a multi-agency, multi-year telemetry study to identify Pallid Sturgeon habitat associations and movements in the Atchafalaya River and in a short reach of the Mississippi River. Additionally, the USFWS is funding and coordinating research efforts to improve identification of river sturgeon species, and to quantify hybridization levels and trends in sturgeon of the Lower Mississippi River.

Part II: Recovery

Recovery Strategy

The primary strategy for recovery of Pallid Sturgeon is to: 1) conserve the range of genetic and morphological diversity of the species across its historical range; 2) fully quantify population demographics and status within each management unit; 3) improve population size and viability within each management unit; 4) reduce threats having the greatest impact on the species within each management unit; and, 5) use artificial propagation to prevent local extirpation within management units where recruitment failure is occurring. Pallid Sturgeon recovery will require an increased understanding of the status of the species throughout its range; developing information on life history, ecology, mortality, and habitat requirements; improving our understanding of some poorly understood threat factors potentially impacting the species; and using that information to implement management actions in areas where recovery can be achieved (see *Recovery Outline/Narrative*).

Management Units

Suitable habitat for Pallid Sturgeon is typically found within the flowing reaches of the Missouri, middle and lower Mississippi, and Atchafalaya rivers, and in portions of major tributaries like the Yellowstone and Platte rivers. However, some recovery tasks include actions at main stem dams/reservoirs and in other major tributaries when those actions would benefit Pallid Sturgeon in downstream reaches.

Originally, the U.S. Fish and Wildlife Service established six recovery priority management areas to focus recovery efforts at locales believed to have the highest recovery potential in 1993 (USFWS 1993). Since that time, our understanding of the species has improved and warrants redefining those management areas into four management units. These management unit boundaries are based on: 1) genetic data (Campton et al. 2000; Tranah et al. 2001; Schrey and Heist 2007); 2) morphological differences (Kuhajda et al. 2007; Murphy et al. 2007a); 3) biogeography of other fish species and speciation associated with physiographic provinces (Metcalf 1966; Wiley and Mayden 1985; Burr and Page 1986; Cross et al. 1986); 4) common threats; and 5) the potential need and ability to implement differing management actions to address varying threats within a management unit. As genetic and stock structure data are further refined, these management units may be correspondingly adjusted.

Like the original recovery priority management areas, these management units possess riverine reaches that are currently occupied habitats and typically represent the least degraded areas that retain the highest configuration of sandbars, side channels, and varied depths (Pallid Sturgeon Recovery Team 2006 and 2007). However, differing threats may affect each management unit independently (e.g., main-stem impoundments are a threat in the upper portion of the species' range but are not implicated as a threat in the most downstream reaches of the species' range). All river reaches within the species' historical range not specifically identified in the following management unit descriptions should not immediately be excluded from recovery activities if new information indicates these areas are deemed necessary to either prevent local extirpation or to facilitate recovery.

The management units (Figure 6) identified in the recovery strategy described above are defined as:

> The Great Plains Management Unit (GPMU) (Figures 6 and 7) is defined as the Great Falls of the Missouri River, Montana to Fort Randall Dam, South Dakota. This unit includes important tributaries like the Yellowstone River, as well as the Marias and Milk rivers. The upper boundary is at the Great Falls of the Missouri River as this is a natural barrier above which Pallid Sturgeon could not migrate historically. The lower boundary was defined as Fort Randall Dam to ensure consistent management practices on an inter-reservoir reach of the Missouri River.
>
> The Central Lowlands Management Unit (CLMU) (Figures 6 and 8) is defined as the Missouri River from Fort Randall Dam, South Dakota to the Grand River confluence with the Missouri River in Missouri and includes important tributaries like the lower Platte and lower Kansas rivers.
>
> The Interior Highlands Management Unit (IHMU) (Figures 6 and 9) is defined as the Missouri River from the confluence of the Grand River to the confluence of the Mississippi River, as well as the Mississippi River from Keokuk, Iowa to the confluence of the Ohio and Mississippi rivers.
>
> The Coastal Plain Management Unit (CPMU) (Figures 6 and 10) is defined as the Mississippi River from the confluence of the Ohio River downstream to the Gulf of Mexico including the Atchafalaya River distributary system.

Recovery Criteria

Section 3 of the Endangered Species Act, defines an endangered species as one that is in danger of extinction throughout all or a significant portion of its range, and a threatened species as one that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Accordingly, a recovered species is one that no longer meets these definitions. Determining whether a species should be reclassified from endangered to threatened or delisted requires assessment of the same five categories of threats which were considered when the species was listed.

Recovery criteria define those conditions that are believed necessary to indicate that a species should be reclassified from endangered to threatened or delisted. Thus, when satisfied, recovery criteria are mileposts that measure progress toward recovery. Recovery criteria are provided below. Because the appropriateness of downlisting or delisting is assessed by evaluating the five threat factors identified in the Endangered Species Act, the recovery criteria below pertain to and are organized by these factors. These recovery criteria are our best assessment, at this time, of what needs to be completed so that the species may be downlisted to threatened status or removed from the list entirely. Because we cannot envision the exact course that recovery may take and because our understanding of the vulnerability of a species to threats is very likely to change as more is learned about the species and its threats, it is possible that a status review may indicate that downlisting or delisting is warranted although not all recovery criteria are met. Conversely, it is possible that the recovery criteria could be met and a status review may indicate

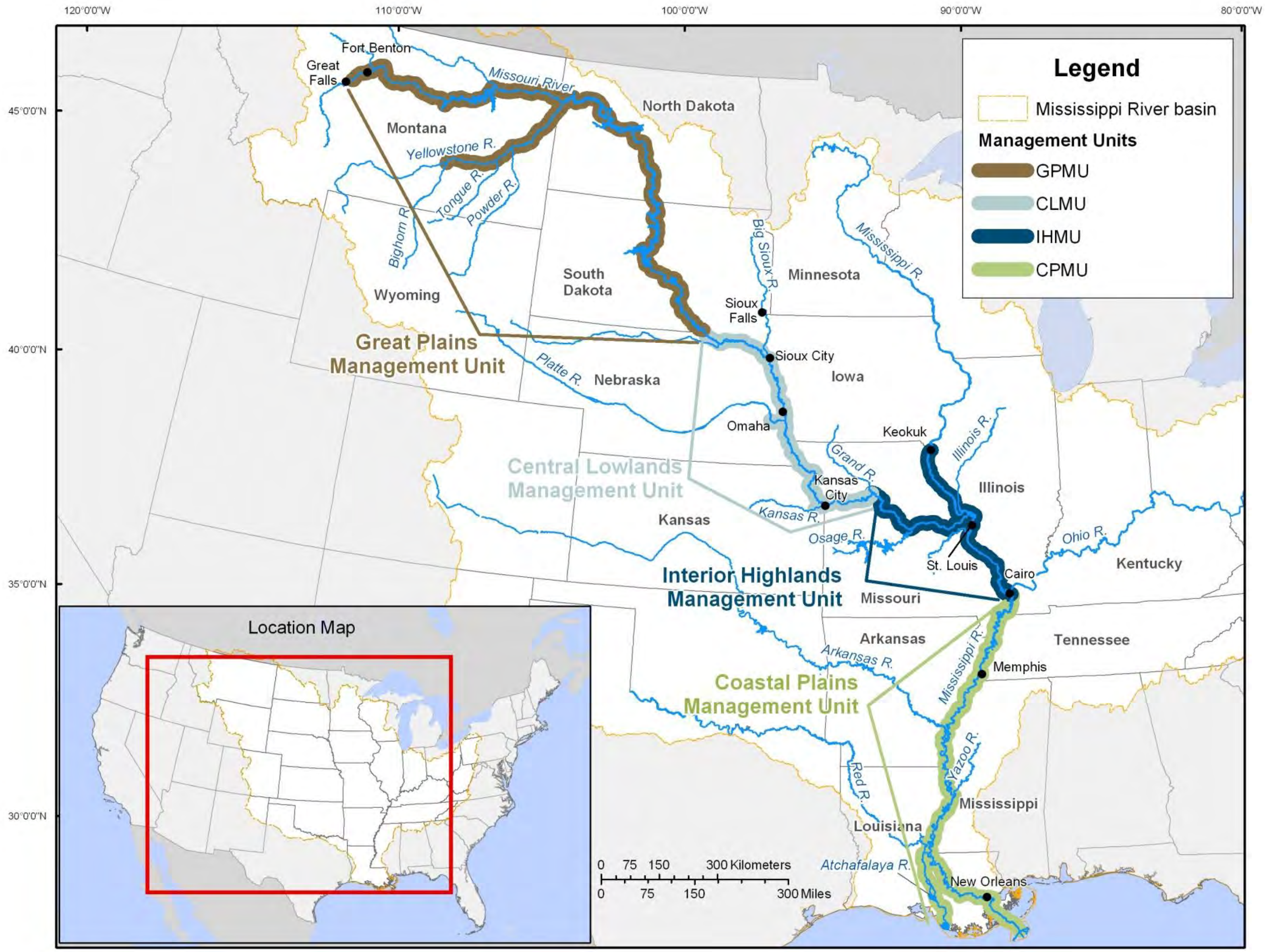

Figure 6 Map depicting Pallid Sturgeon management units.

Figure 7 Map depicting the Great Plains Management Unit.

Figure 8 Map depicting the Central Lowlands Management Unit.

Figure 9 Map depicting the Interior Highlands Management Unit.

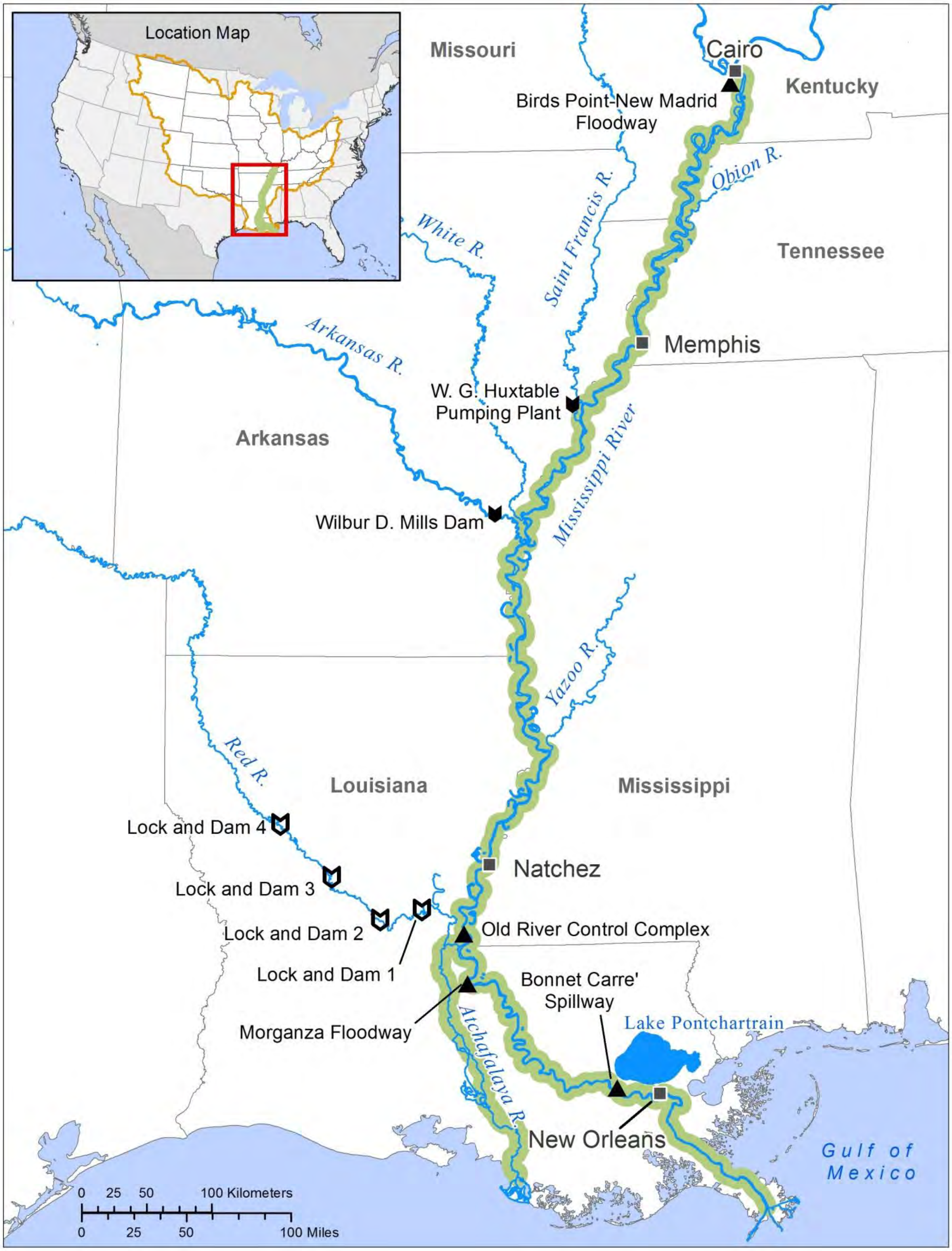

Figure 10 Map depicting the Coastal Plains Management Unit.

that downlisting or delisting is not warranted; for example, a new threat may emerge that is not addressed by the recovery criteria below that causes the species to remain threatened or endangered.

Criteria for Reclassification to Threatened Status

Pallid Sturgeon will be considered for reclassification from endangered to threatened when the listing/recovery factor criteria are sufficiently addressed such that a self-sustaining genetically diverse population of 5,000 adult Pallid Sturgeon is realized and maintained within each management unit for 2 generations (20-30 years). In this context, a self-sustaining population is described as a spawning population that results in sufficient recruitment of naturally-produced Pallid Sturgeon into the adult population at levels necessary to maintain a genetically diverse wild adult population in the absence of artificial population augmentation. Metrics suggested to define a minimally sufficient population would include incremental relative stock density of stock-to-quality-sized naturally produced fish (Shuman et al. 2006) being 50-85 over each 5-year sampling period, catch-per-unit-effort data indicative of a stable or increasing population, and survival rates of naturally produced juvenile Pallid Sturgeon (age 2+) equal to or exceeding those of the adults (see Justification for Population Criteria below for details). Additionally, in this context a genetically diverse population is defined as one in which the effective population size (N_e) is sufficient to maintain adaptive genetic variability into the foreseeable future ($N_e \geq 500$), conserve localized adaptions, and preserve rare alleles.

Criteria for Delisting Species

Pallid Sturgeon will be considered for delisting when the criteria for reclassification to threatened status have been met and sufficient regulatory mechanisms are established to provide reasonable assurances of long-term persistence of the species within each management unit in the absence of the Act's protections.

Listing/Recovery Factor Criteria

The following listing factors (A through E) are applicable to the reclassification and delisting criteria described above, although differences may apply in the methods used to achieve them. Addressing these criteria to sufficient levels can be facilitated by implementing the recovery tasks described under the RECOVERY OUTLINE/NARRATIVE section.

Listing Factor A: **Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range.**
This factor will be considered addressed when:

(1) Habitat conservation and restoration efforts establish and maintain riverine habitats capable of meeting and sustaining all life history requirements of the species (i.e., sufficient habitat is available to support a self-sustaining population within each management unit as described under "Criteria for Reclassification to Threatened Status");

(2) Regulations and enforcement provide reasonable assurances that water quality parameters and contaminants of concern meet or exceed the latest national recommended water quality criteria (e.g., U.S. Environmental Protection Agency 2009);

(3) Entrainment losses from all sources (i.e., water cooling intake structures, dredge operations, irrigation diversions, etc.) are minimized such that attributable mortality does not impair maintenance of self-sustaining populations;
(4) The potential effects associated with changes in climate are assessed and mitigated or minimized.

Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes.
This factor shall be considered addressed when take of Pallid Sturgeon associated with commercial, recreational, scientific or educational uses is fully controlled by State regulation, and has little to no effect upon the sustainability of the species within each management unit.

Listing Factor C: Disease or Predation
Disease and Predation were not implicated in the reduction of the species. Existing State and Federal regulations have been established to minimize pathogen introduction from outside the Pallid Sturgeon's range. The threat from predation will be considered addressed when sufficient data to assess the effects of intraspecific competition from nonnative/invasive species are available, and, if needed, regulations and management measures are established to minimize competition and predation threats to the species.

Listing Factor D: Inadequacy of Existing Regulatory Mechanisms
This factor shall be considered addressed when adequate mechanisms are in place and enforcement provide reasonable assurance that excessive non-natural mortality is reduced to sustainable levels and adequate regulations protect habitat and habitat forming processes sufficient to maintain self-sustaining populations within each management unit or when the underlying threat has been addressed such that regulatory mechanisms are no longer needed. For example, overutilization must be addressed for either downlisting or delisting to occur. Under the current protections afforded by the Endangered Species Act and similarity of appearance regulations, existing protections may be sufficient to support downlisting. However, delisting will require State harvest regulations that will provide adequate protection from overutilization in the absence of the Act's protections.

Listing Factor E: Other Natural or Manmade Factors Affecting its Continued Existence
This factor shall be considered addressed when:
(1) Energy development and new technologies are evaluated and assessed and, if necessary, measures are implemented to minimize any adverse effects from these activities;
(2) Once simulation studies can assess if alterations of habitats have influenced temporal or spatial reproductive isolating mechanisms resulting in increased rates of hybridization, this threat will likely be addressed by both site-specific and ecosystem improvement efforts such that actual risks associated with pallid/shovelnose hybridization are mitigated.
(3) Invasive species or aquatic nuisance species are regulated and reduced such that deleterious effects (i.e., predation and competition) are minimized.

Justification for Population Criteria

The following targets, when met, should provide sufficient assurances that the population criteria for recovery have been met.

ADULT POPULATION TARGETS:

The requirements of a minimum adult population capable of maintaining adaptive genetic variability long-term will need an effective population size (N_e) of at least 500 (Franklin and Frankham 1998) to perhaps as high as 5000 (Lande 1995). To estimate the census size (N) necessary to meet these criteria, one needs to understand how N_e relates to N. The relationship between N_e and N can be affected by a variety of factors, however, values for N_e /N averaged 0.10-0.11 based on published estimates from 102 species (Frankham 1995). Using Frankham's average values (1995) and the following formula, a theoretical minimum estimate of breeding adults can be obtained.

$$\frac{Ne}{N} = 0.1 \text{ or } N = \frac{Ne}{0.1}$$

If the desired N_e is 500 to 1,000 as suggested by Franklin and Frankham (1998) or 5000 as described in Lande (1995), a theoretical range of 5,000-50,000 adults would constitute a desired adult Pallid Sturgeon population. Reed et al. (2003) used population viability analysis to estimate minimum viable population sizes of many vertebrate taxa (n=102). They found, on average, that 7,000 breeding adults, along with sufficient habitat to support them, was a minimum requirement for long-term maintenance of a species.

Based on the above data, the minimum desired adult Pallid Sturgeon population within each management unit will be 5,000.

Because empirically derived data have not been analyzed for Pallid Sturgeon, this minimum target should be considered interim until Pallid Sturgeon specific data are evaluated and incorporated into an appropriate population viability analysis to derive management unit or, if designated, DPS specific minimum viable adult population estimates. In this fashion, the delisting and downlisting targets will be modified in an adaptive fashion based on available data and analyses.

Measuring Natural Recruitment

Recruitment failure has been documented in the Great Plains Management Unit, and only limited evidence of recruitment exists within the other management units (USFWS 2007). Concerns over limited recruitment (i.e., potential for local extirpation) resulted in the establishment of the PSCAP. While artificial propagation and stocking measures are helping to maintain the species, successful natural spawning and recruitment is necessary for recovery. To evaluate when this has been achieved, reliable population trend estimates will be needed.

Annual survival rates of hatchery-reared Pallid Sturgeon are relatively high ($\geq$ 0.8) for age 2+ fish (Hadley and Rotella 2009; Steffensen et al. 2010). These rates likely are comparable to those of age 2+ wild fish given that most age 2+ hatchery-reared fish were at large for at least 1 year and subject to comparable selection pressures as wild fish; the presence of wild juvenile

Pallid Sturgeon (age 2+) can provide inferences into potential adult recruitment levels. Thus, documenting presence or absence of wild juvenile Pallid Sturgeon in annual survey efforts is one approach to help assess if short-term natural recruitment is occurring within a management unit.

Because length frequency data are commonly collected in fishery surveys, these data remain useful and provide a cost-effective index to monitor a fish population and are more suitable long-term than the short-term presence/absence method described above. The general applicability and limitations of using stock density indices as a tool for assessment of length frequency data are described by Willis et al. (1993). The applicability of stock density indices to Pallid Sturgeon data are discussed in Shuman et al. (2006 and 2011). Additionally, stock density indices also have been applied to monitor trends in Shovelnose Sturgeon (Quist et al. 2002). In the context of long-term fish population monitoring, incremental relative stock densities (RSD) are appropriate to use (Willis et al. 1993); thus, incremental-RSD values of stock-sized fish as described by Shuman et al. (2006) likely will provide a useful measure to monitor recruitment. In addition to length frequency data, catch-per-unit effort data and survival rates also will be important data (Willis et al. 1993) to identify when natural recruitment is sufficient to sustain the species long-term.

Interim long-term targets for Pallid Sturgeon recruitment will be based on indices indicative of adequate recruitment; (i.e., incremental-RSD of stock to quality-sized naturally produced fish (Shuman et al. 2006) being 50-85 over each 5-year sampling period, catch-per-unit-effort data indicative of a stable or increasing population, and survival rates of naturally produced juvenile Pallid Sturgeon fish (age 2+) equal to or exceeding those of the adults).

Distinct Population Segment Overview

We may consider splitting this species-level listing into multiple DPSs in the future. Section 3 of the Endangered Species Act defines "species" to include "any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." Pursuant to the Act, the USFWS considers if information is sufficient to indicate that listing, reclassifying, or delisting any species, subspecies, or, for vertebrates, any DPSs of these taxa may be warranted. In 1996, the USFWS and National Marine Fisheries Service published a joint policy guiding the recognition of DPSs of vertebrate species (61 FR 4722-4725). Under this policy, we consider two factors to determine whether the population segment is a valid DPS—1) discreteness of the population segment in relation to the remainder of the taxon, and 2) the significance of the population segment to the taxon to which it belongs. If a population meets both tests, it is a DPS, and then the population segment's conservation status is evaluated according to the standards in section 4 of the Endangered Species Act for listing, delisting, or reclassification (i.e., is the DPS endangered or threatened).

Analysis for Discreteness

A population segment of a vertebrate taxon may be considered discrete if it satisfies either one of the following conditions—(1) is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors (quantitative measures of genetic or morphological discontinuity may provide evidence of this separation); or (2) is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.

Analysis for Significance
If we determine a population segment is discrete, we next consider available scientific evidence of its significance to the taxon to which it belongs. The DPS policy states that this consideration may include, but is not limited to, the following factors: 1) persistence of the discrete population segment in an ecological setting unusual or unique for the taxon; 2) evidence that loss of the discrete population segment would result in a significant gap in the range of the taxon; 3) evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range; and/or 4) evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

If DPS are designated in the future, the criteria for reclassification and delisting would then be applicable to each designated DPS rather than to all management units as now indicated. Any determination to divide the currently listed entity into DPSs would go through the rulemaking process, which means that we would request public comments and peer review on our proposed course of action before we would make a final determination.

Recovery Outline/Narrative
The following recovery tasks were developed in concert with the Upper, Middle, and Lower Basin Pallid Sturgeon Workgroups and depict those items believed necessary to recover Pallid Sturgeon within each management unit. The following section is written to cover both broad scale approaches and, where possible, provide management unit specific details.

1. CONSERVE AND RESTORE PALLID STURGEON HABITATS, INDIVIDUALS AND POPULATIONS

1.1 RESTORE HABITATS AND FUNCTIONS OF THE MISSOURI AND MISSISSIPPI RIVER ECOSYSTEMS AT SUFFICIENT LEVELS AND QUALITY TO MEET THE LIFE HISTORY REQUIREMENTS OF THE SPECIES.

Anthropogenic alterations to the Missouri and Mississippi Rivers and their tributaries have affected natural riverine processes that Pallid Sturgeon evolved with. These anthropogenic habitat alterations adversely affect Pallid Sturgeon by altering the natural form and functions of these rivers (Simons et al. 1974; Fremling et al. 1989; Baker et al. 1991; Theiling 1999; Wlosinski 1999; Bowen et al. 2003). Restoration activities that return lost ecological process are necessary for the species to satisfy its life history requirements. However, the extent needed to accomplish this is currently not quantifiable. Thus, it will be necessary to improve our understanding of critical life history needs and tailor restoration efforts that will improve ecological conditions to address them.

1.1.1 DETERMINE EFFECTS OF DAMS ON LIMITING RECRUITMENT AND SURVIVAL OF PALLID STURGEON

Dams greatly reduced the river's ability to satisfy the life history requirements of Pallid Sturgeon by: 1) blocking movements to spawning and feeding areas; 2) affecting historical genetic exchange among reaches, (i.e., affecting emigration and immigration); 3) decreasing turbidity levels by trapping sediment in reservoirs; 4) reducing distances available for larvae to drift; 5) altering water temperatures; 6) altering conditions and flows in spawning areas; 7) altering flows and temperatures associated with spawning movements; and 8) possibly reducing food sources by lowering productivity (Hesse et al. 1989; Keenlyne 1989; USFWS 2000a; Bowen et al. 2003).

Modifying current dam operations to restore a more natural hydrograph can facilitate meeting the species' life history requirements to promote species recovery. Modifying dam releases (increasing or decreasing), at the appropriate time, may improve spawning cues over baseline conditions and lowered discharges in the summer may reduce larval drift rates in truncated reaches. Additionally, lower pool elevations in some key reservoirs, (i.e., Fort Peck Reservoir and Lake Sakakawea) could increase the amount of available habitat for drifting larvae and provide additional rearing habitat for juvenile Pallid Sturgeon (Bramblett 1996; Gerrity 2005). Because drift rates of larval Pallid Sturgeon are related to water velocity and temperature (i.e., larval Pallid Sturgeon drift distance increases with increased velocity) (Kynard et al. 2007; Braaten et al. 2008), reducing dam releases during the larval drift period to levels that mimic the natural hydrograph may benefit Pallid Sturgeon by reducing channel velocities with a corresponding decrease in total larval drift distance. Additional features that may reduce drift distances are slower velocity seasonal secondary channels or other off channel low velocity areas. A reduction in drift rate and distance could help retain larvae in suitable riverine habitats rather than them being transported into downstream reservoirs.

Additional studies are needed to fully understand the effects main-stem Missouri River and tributary dams have on disrupting various life history requirements of the species and to implement actions to mitigate these effects. Spillway releases and altered flow scenarios should be evaluated to assess their ability to improve habitats (i.e., flow conditions, increase sediment transport, floodplain access, and normalize temperature profiles) in downstream reaches. Areas specifically identified for study are:

GPMU

(1) Determine reservoir pool elevations at Fort Peck Reservoir and Lake Sakakawea necessary to provide adequate larval drift distance.
    (a) If pool level elevation modifications will increase larval survival, adjust reservoir operations to maintain pool elevations necessary to provide adequate larval drift distances and to maximize juvenile rearing habitat.

(2) Evaluate spillway releases from Fort Peck Dam to improve flow, turbidity, and temperature conditions downstream.
    (a) If necessary, implement spillway releases to improve flow, turbidity, and temperature conditions downstream.

(3) Evaluate flow scenarios from Fort Peck Dam to increase retention times and/or reduce larval development times (i.e., reduce drift rates and/or increase water temperatures) for larval Pallid Sturgeon.
    (a) If necessary, modify releases from Fort Peck Dam to increase retention times and/or reduce larval development times (i.e., reduce drift rates and/or increase water temperatures) for larval Pallid Sturgeon.

(4) Evaluate temperature control options on Fort Peck Dam to improve temperature conditions downstream.
    (a) If necessary, implement temperature control options to improve temperature conditions downstream.

(5) Evaluate flow scenarios from dams (Canyon Ferry, Tiber and others) upstream of Fort Peck Reservoir to improve habitat conditions and drift rates for larval Pallid Sturgeon.
    (a) If necessary, modify flows from dams (Canyon Ferry, Tiber and others) upstream of Fort Peck Reservoir to improve habitat conditions and drift rates for larval Pallid Sturgeon.

(6) Evaluate flow-release scenarios from Yellowstone River tributary dams (Yellowtail Dam and Tongue River Reservoir) to improve habitat conditions and drift rates for larval Pallid Sturgeon.
    (a) If necessary, modify flows from Yellowstone River tributary dams to improve habitat conditions and drift rates for larval Pallid Sturgeon in the Yellowstone River.

CLMU

(1) Evaluate spillway releases and/or flow-release scenarios from Missouri River dams (Fort Randall and Gavins Point dams) to improve habitat conditions in downstream reaches.
    (a) If necessary, implement spillway releases and/or alter flows to improve turbidity and temperature conditions in downstream reaches.

(2) Evaluate temperature control options on Fort Randall Dam to improve temperature conditions downstream.
    (a) If necessary, implement temperature control options on Fort Randall Dam to improve temperature conditions downstream.

(3) Evaluate the feasibility of increasing sediment transport downstream from Gavins Point Dam (i.e., assess the feasibility of: relocating the dam to a point upstream of the Niobrara River confluence, re-routing the Niobrara River to confluence with the Missouri River downstream of Gavins Point Dam, modifying flows from the dam, or removing Gavins Point Dam).
    (a) If feasible and necessary, implement method of increasing sediment transport downstream from Gavins Point Dam.

(4) Modify flows from Gavins Point Dam to facilitate successful migration, spawning, and survival of pallid sturgeon upstream of the Platte River confluence.
    (a) If feasible and necessary, implement flow modifications re-create elements of the hydrograph necessary for the appropriate and successful migration and spawning of pallid sturgeon above the Platte River.

1.1.2 RESTORE HABITAT CONNECTIVITY WHERE BARRIERS TO FISH MOVEMENT OCCUR

Evaluating the degree to which a structure may impede movements is necessary to determine if passage is needed at a particular structure. Additionally, existing structures that are barriers to fish movement likely prevent spread of aquatic nuisance species so careful analysis is need to consider the tradeoffs associated with removing barriers. Passage assessments must consider this as well as the importance for recovery. Following is a list of barriers by management unit that either have been assessed for passage needs or need to be further evaluated.

GPMU

(1) Restore fish passage at Intake Diversion Dam, Yellowstone River.
   - (a) Evaluate success of fish passage at Intake Dam once completed.

(2) Evaluate need for passage of Pallid Sturgeon at Cartersville Diversion Dam, Yellowstone River.
   - (a) Restore passage at Cartersville Dam if deemed necessary for Pallid Sturgeon recovery.

(3) Evaluate need for passage of Pallid Sturgeon at Vandalia Diversion Dam, Milk River.
   - (a) Restore passage at Vandalia Diversion if deemed necessary for Pallid Sturgeon recovery.

CLMU

(1) Evaluate need for passage of Pallid Sturgeon at Spencer Dam, Niobrara River.
   - (a) Restore passage at Spencer Dam if deemed necessary for Pallid Sturgeon recovery.

(2) Evaluate need for passage of Pallid Sturgeon at the, Johnson County Weir, Kansas River.
   - (a) Restore passage at Johnson County weir if deemed necessary for Pallid Sturgeon recovery.

(3) Evaluate need for passage of Pallid Sturgeon at the Bowersock Dam, Kansas River.
   - (a) Restore passage at Bowersock Dam if deemed necessary for Pallid Sturgeon recovery.

IHMU

(1) Evaluate need for passage of Pallid Sturgeon at Chain of Rocks Weir, Mississippi River.
   - (a) Restore passage at Chain of Rocks Weir if deemed necessary for Pallid Sturgeon recovery.

(2) Evaluate need for passage of Pallid Sturgeon at Melvin Price Locks and Dam, Mississippi River.
   - (a) Restore passage at Melvin Price Locks and Dam if deemed necessary for Pallid Sturgeon recovery.

(3) Evaluate need for passage of Pallid Sturgeon at Lower Osage Lock and Dam #1, Osage River.
    (a) Restore passage at Lower Osage Lock and Dam #1if deemed necessary for Pallid Sturgeon recovery.

CPMU

(1) Evaluate need for passage of Pallid Sturgeon at the Wilbur D. Mills Dam on the Arkansas River.
    (a) Restore passage at the Wilbur D. Mills Dam if deemed necessary for Pallid Sturgeon recovery.
(2) Evaluate need for passage of Pallid Sturgeon at the W. G. Huxtable Pumping Plant on the St. Francis River.
    (a) Provide passage at the W. G. Huxtable Pumping Plant if deemed necessary for Pallid Sturgeon recovery.
(3) Evaluate the potential need for passage at the Old River Control Complex, Atchafalaya River.
    (a) Restore passage at the Old River Control Complex if deemed necessary for Pallid Sturgeon recovery.

1.1.3 CREATE PHYSICAL HABITAT AND RESTORE RIVERINE FUNCTION

The loss of physical habitat needed by Pallid Sturgeon has been documented. However, not all efforts to restore habitat will generate equal benefits. As an example, the practice of modifying dikes has been implemented at various locations within the Missouri and Mississippi rivers as means to create habitat and restore riverine function. However, evaluation of these practices suggests that the intended benefits may not be fully manifesting themselves (Ridenour et al. 2009: Schloesser et al. 2012). Thus, it is essential to evaluate existing efforts to create habitat as compared to using natural processes associated with flow and sediment manipulation from dams to form instream habitats. Additionally, when habitat restoration sites are cleared and grubbed, it may be beneficial to leave clearing and grubbing material in the project site as a source of woody debris. Important activities by management unit are identified below. Finally, operation of dams upstream of spawning areas can influence total drift distance needed for larval fish (Kynard et al. 2007). Reduction in flows at Fort Peck Dam also may assist with reducing total drift distance of larval fish.

GPMU, CLMU, IHMU

(1) Assess relationship of discharge to physical habitat creation and larval fish drift (shallow water habitat, sand bars) in river reaches important for recovery.
    (a) Monitor the outcomes of flow manipulations from dams, and use resulting information to improve techniques, using adaptive management principles.
    (b) Decrease releases from Fort Peck Dam during the larval drift period (based on monitoring and research, this drift likely occurs in late June to early July) to reduce larval drift rates.

(2) Maintain lower reservoir pool levels downstream from important spawning areas to increase larval drift distance and provide both juvenile and adult habitats (see also Recovery Task 1.1.1).

GPMU, CLMU, IHMU, CPMU

(1) Protect, enhance, and restore habitat diversity and connectivity.
    (a) Pursue options to incorporate levee setbacks to increase flood plain connectivity.
    (b) Reconnect perched or disconnected side channels.
    (c) Develop programs that increase woody debris in these systems.
(2) Develop and maintain standardized monitoring programs to evaluate effects of habitat manipulation and annual variations to determine degrees of response in Pallid Sturgeon.
    (a) Monitor the outcomes of habitat manipulations, and use resulting information to improve habitat restoration and construction techniques, using adaptive management principles.

1.1.4 PROVIDE AND PROTECT INSTREAM FLOWS

Instream flows can be affected by water withdrawal. Over allocation of water resources can affect instream habitats by reducing the hydrograph or extreme flow depletions can render river reaches as uninhabitable for portions of the year. Understanding existing water allocations and projected withdrawal patterns is essential to evaluating the magnitude of effects associated with depletions and implementing flow protection strategies necessary to meet the life history needs of Pallid Sturgeon. Additionally, instream flows also can be affected daily and seasonally through reservoir operations. The following tasks are intended to increase the understanding of the effects of water depletion and reservoir operations on Pallid Sturgeon and their habitats and may be useful in better understanding the effects of climate change.

GPMU, CLMU, IHMU

(1) Develop an instream flow plan for riverine reaches important to Pallid Sturgeon recovery.
    (a) Assess tributary water allocations to determine depletion effects on habitat formation and maintenance.
    (b) Determine what flows are necessary to meet Pallid Sturgeon life history requirements.
        (i) Consider precipitation pattern models and climate change forecasts when developing flow requirements.
    (c) Implement flow protection strategies based on instream flow plan.
(2) Evaluate dam discharges during spring, summer, and fall (both main-stem and tributaries) to protect instream flows.
    (a) Manipulate reservoir releases if needed to protect or restore flows for recovery of Pallid Sturgeon.

1.1.5 QUANTIFY AND MINIMIZE EFFECTS OF ENTRAINMENT

Studies at water diversion points have documented entrainment of Pallid Sturgeon. However, not all sites have been assessed to determine and quantify entrainment effects. Thus, it will be necessary to assess and quantify entrainment losses of Pallid Sturgeon at industrial, municipal, and agricultural water intakes, pumping facilities, and other diversion structures. The U.S. Environmental Protection Agency administers the Clean Water Act and should develop and implement section 316 (b) standards that will minimize entrainment of adult and juvenile Pallid Sturgeon. The Bureau of Reclamation and Natural Resources Conservation Service develop and operate many irrigation projects within the range of Pallid Sturgeon. Where necessary these projects should be fitted with screens that will minimize or prevent entrainment.

GPMU, CLMU, IHMU, CPMU

(1) Assess potential for entrainment losses at industrial, municipal, and agricultural water intakes, pumping facilities, and other diversion structures.
    (a) Implement strategies to prevent/minimize entrainment.

CLMU, IHMU, CPMU

(1) Assess potential for entrainment losses associated with commercial navigation/towboat entrainment.
    (a) Implement strategies to prevent/minimize entrainment.
(2) Inventory and assess potential for entrainment losses associated with dredging and gravel mining operations.
    (a) Implement strategies to prevent/minimize entrainment.

1.1.6 PROVIDE PROTECTION FOR IMPORTANT HABITAT FORMING PROCESSESS

Natural erosion and deposition processes create dynamic and diverse riverine habitats. Protecting these ecological processes will facilitate naturally creating habitats important for Pallid Sturgeon. There are tools being developed that can help guide these actions. Examples include the land Capability Potential Index (Jacobsen et al. 2007) and the Channel Migration Zone delineation developed as part of the cumulative effects study on the Yellowstone River (Thatcher et al. 2009) This measure will involve developing new programs and expanding existing ones to develop partnerships necessary to conserve these important areas.

GPMU, CLMU, IHMU, CPMU

(1) Develop and implement non-regulatory mechanisms to retain natural riverine ecological processes.
    (a) Develop programs that provide conservation incentives to willing participants.
        (i) Establish easements to reduce bank armoring in reaches important for Pallid Sturgeon.

(ii) Enroll adjacent riparian lands from willing participants in long-term conservation easements.

(iii) Purchase land from willing sellers and place in public trust (i.e., refuges, State parks).

(iv) Establish water conservation programs to offset anticipated lower late-season flows associated with climate change.

(b) Develop additional landscape-level tools to improve assessment and prioritization of non-regulatory conservation efforts.

1.2 MINIMIZE THREATS FROM EXISTING AND PROPOSED HUMAN-CAUSED ACTIVIES

Current State and Federal regulations generally benefit Pallid Sturgeon by providing oversight on anthropogenic activities. However, not all State and Federal regulations have established standards that are applicable to Pallid Sturgeon. In many instances, necessary data are lacking to establish thresholds or for comprehensive review. However where empirically derived Pallid Sturgeon data exist, improving data exchange, (i.e., a centralized easily accessible repository for Pallid Sturgeon data accessible by agency regulatory personnel) will allow for improved evaluation of effects within the permitting processes.

1.2.1 ENSURE COMPLIANCE WITH EXISTING STATE AND FEDERAL ENVIRONMENTAL REGULATIONS

The U.S. Environmental Protection Agency and State environmental divisions have rules and regulations designed to maintain water quality standards. These standards may need to be modified to protect Pallid Sturgeon based on Task 2.1.4.

The U.S. Army Corps of Engineers is responsible for administering Section 404 of the Clean Water Act. Efforts conducted to fulfill components of Tasks 1.1.1-1.1.3 will need to be considered in future 404 permits to limit inputs into those areas where habitats have been restored or protected to benefit Pallid Sturgeon.

The Federal Energy Regulatory Commission regulates interstate transmission of electricity as well as licensing hydropower projects. As part of the licensing process, Federal Energy Regulatory Commission should evaluate projects and their potential effects on Pallid Sturgeon life history requirements.

Any future introductions of nonnative fish species (i.e., aquaculture) may introduce diseases, increase competition, or result in predation on Pallid Sturgeon. Stocking new nonindigineous species anywhere in the Missouri and Mississippi river watersheds must not occur until after a risk assessment is completed that considers potential adverse effects to Pallid Sturgeon.

GPMU, CLMU, IHMU, CPMU

(1) Develop a viable data sharing platform that will enable both regulatory and action-agencies access to the best available science for improved species consideration in consultations, permit issuance, and restoration efforts.

(2) Work with States to develop a policy that will establish risk assessment evaluations prior to introduction of new nonindigenous and exotic species in the Missouri and Mississippi river basins. Only introductions proved not to be deleterious to Pallid Sturgeon should be allowed.

(3) Continue to enforce State and Federal water quality standards.

1.2.2 EVALUATE INVASIVE SPECIES/AQUATIC NUISANCE SPECIES

Potential threats from invasive or aquatic nuisance species include increased predation on eggs, larval, or juvenile life stages, competition for food in the case of the carps, exclusion of native species from preferred habitats, spread of diseases or parasites, and alteration of habitat quality. Further study is needed to fully qualify and quantify the magnitude of this probable threat to Pallid Sturgeon. The results of these investigations should be used to implement eradication or control efforts consistent with Pallid Sturgeon recovery.

GPMU, CLMU, IHMU, CPMU

(1) Where applicable, assess the effects of invasive or aquatic nuisance species to increase the understanding of these organisms and the magnitude of their status as a threat to Pallid Sturgeon.
    (a) If necessary, implement control measures to minimize adverse effects resulting from of invasive or aquatic nuisance species.

2. **CONDUCT RESEARCH NECESSARY FOR SURVIVAL AND RECOVERY OF PALLID STURGEON**

2.1 RESOLVE SPECIES IDENTIFICATION ISSUES IN THE LOWER MISSOURI AND MIDDLE MISSISSIPPI RIVERS.

The lower Missouri and Mississippi rivers contain sturgeon specimens that appear phenotypically and genotypically intermediate between Pallid and Shovelnose sturgeon. Development of accurate species classification indices and genetic tests are essential to ensure correct species assignment for population status evaluations.

2.1.1 DEVELOP METHODS FOR ACCURATE SPECIES ASSIGNMENT

IHMU, CPMU

(1) Use genetic and morphological data to test for significant agreement among these methods.

(2) If no association exists, reevaluate morphological characters in light of the genetic data.
    (a) Develop improved morphological based identification methods.

2.2 OBTAIN INFORMATION ON LIFE HISTORY AND HABITAT REQUIREMENTS OF ALL LIFE STAGES OF PALLID STURGEON

While much has been learned about the species since it was listed, data gaps still exist that prevent us from understanding how to recover the Pallid Sturgeon. Filling these gaps will facilitate management actions and improve efforts to address the five listing factors. Where spawning has been found to occur, spawning habitats must be characterized. If spawning habitats are limited or found to be excessive due to system alterations in certain reaches, this information should be considered when habitat restoration projects are developed (see Task 1.1.3). After spawning success has been documented, spawning success/failure should be quantified in each management unit based on collections of eggs, larvae and young-of-year. These data will help guide adaptive programs to improve efficiency in habitat conservation and restoration efforts.

2.2.1 EVALUATE SEXUAL MATURITY AND SPAWNING LIFE HISTORY PARAMETERS

GPMU, CLMU, IHMU, CPMU

(1) Evaluate if spawning occurs, identify spawning areas, and characterize spawning habitat within each management unit.
(2) Estimate sex ratios, spawning periodicity, and reproductive structure of adult population.
(3) Identify and evaluate spawning site fidelity.

2.2.2 FILL INFORMATION GAPS FOR AGE-0 TO AGE-1 PALLID STURGEON

GPMU, CLMU, IHMU, CPMU

(1) Improve methods to better distinguish larvae and juvenile Pallid Sturgeon from larvae and juvenile Shovelnose Sturgeon.
(2) Quantify spawning success/failure in the Missouri and Mississippi rivers and tributaries based on collections of larvae and/or young-of-year.
(3) Quantify drift-transport distance/retention of larvae in the Missouri and Mississippi rivers and tributaries.
(4) Test the hypothesis that larvae and juveniles cannot survive in reservoirs.
(5) Investigate imprinting during the early life history stages as a mechanism to stimulate homing/spawning site fidelity.
(6) Quantify growth and survival rates from hatch through the transition to exogenous feeding, and from the onset of exogenous feeding through the termination of the growing season as related to environmental conditions (e.g., temperature, dissolved oxygen, food type, and ration size).
(7) Identify and describe habitat requirements for larvae and age-0 juveniles.
    (a) Use this information to determine if habitat is limiting this life stage.

2.2.3 FILL INFORMATION GAPS FOR AGE-1 TO SEXUAL MATURITY PALLID STURGEON

GPMU, CLMU, IHMU, CPMU

(1) Identify and describe habitat requirements for juvenile Pallid Sturgeon.
    (a) Use this information to determine if habitat is limiting this life stage.
(2) Diet information;
    (a) Obtain appropriate diet information
    (b) Quantify diets and describe trophic linkages.
    (c) Assess if food/feeding is limiting this life stage.

2.2.4 INVESTIGATE EFFECTS OF ENVIRONMENTAL CONTAMINANTS ON ALL PALLID STURGEON LIFE HISTORY STAGES

Current data are lacking to adequately quantify this threat under existing environmental laws. Research suggests a link between environmental contaminants and potential reproductive problems in several sturgeon species (Feist et al. 2005; Koch et al. 2006b). Research on the effects of contaminants on Pallid Sturgeon reproductive mechanisms should continue as part of Pallid Sturgeon recovery efforts. Once contaminants affecting Pallid Sturgeon are identified and their effects are understood, plans may need to be developed to eliminate point and non-point sources into the Missouri and Mississippi river watersheds. These actions will need to be coordinated with the U.S. Environmental Protection Agency, State agencies with jurisdiction over water quality, and the USFWS' contaminants program. These data will be necessary to evaluate current water quality parameters and contaminants of concern relative to Pallid Sturgeon. If necessary, these data will help establish water quality standards sufficient to meet the life history requirements of the species.

GPMU, CLMU, IHMU, CPMU

(1) Monitor contaminant levels in wild populations to identify problem contaminants.
(2) Determine effects of problem contaminants on growth, survival, and reproduction of Pallid Sturgeon.
    (a) Evaluate contaminant effects on adult fish, gamete development, and reproductive success.
    (b) Evaluate contaminant effects on embryo/larval and juvenile development and survival.
(3) Identify and remedy sources of problem contaminants.

3. OBTAIN INFORMATION ON POPULATION GENETICS, STATUS, AND TRENDS

Having adequate information on this species' demographic structure and trends through time is fundamental to evaluate when recovery criteria requirements have been met. Consistent range-wide monitoring efforts are essential to evaluating the species responses to recovery tasks as well as threats as they are addressed.

3.1 DEVELOP AND IMPLEMENT STANDARD MONITORING PROCEDURES FOR PALLID STURGEON THROUGHOUT THE RANGE

Monitoring is essential to understanding the species' status, evaluating responses to management actions, and tracking recovery progress (Campbell et al. 2002). Currently, there is no funded systematic monitoring program. Existing monitoring efforts on the Missouri River are primarily conducted through the Pallid Sturgeon Population Assessment Program and are focused on detecting changes in Pallid Sturgeon and other species' population trends in response to habitat restoration practices. Data from these efforts have been useful in evaluating success of some recovery tasks like stocking, survival, distribution, and population growth; however, geographic expansion of this program could provide much or all of the data necessary to facilitate evaluating delisting and downlisting criteria. While assessment efforts on the Missouri River are a good foundation for monitoring, large river reaches fall outside of existing funded monitoring efforts, including; the middle and lower Mississippi River, the Atchafalaya River, the Missouri River upstream of Fort Peck Dam, and the Yellowstone River. Thus, large portions of the range have limited or no standardized monitoring.

GPMU, CLMU, IHMU, CPMU

(1) Develop and implement a range-wide Pallid Sturgeon monitoring program that will provide adequate data to evaluate progress toward downlisting and delisting criteria.
(2) Implement range-wide standardized reporting requirements for population monitoring projects.
(3) Continue to update, as needed, and implement the "Biological procedures and protocols for researchers and managers handling Pallid Sturgeon" range-wide.
(4) Develop a range-wide standardized database to integrate monitoring, propagation, stocking, and genetic data to meet reporting requirements that measure progress toward recovery.

3.2 MONITOR GENETIC MAKEUP OF PALLID STURGEON

Additional research is necessary to evaluate genetic differences across the species' range. Currently, there is a data gap in the lower Mississippi River and portions of the lower Missouri River. These data are essential for defining genetically meaningful management units and for understanding evolutionary trends, reproductive exchange among areas, and hybridization.

GPMU, CLMU, IHMU, CPMU

(1) Develop and implement a range-wide monitoring program that will provide adequate genetic data to guide stocking practices.
(2) Implement range-wide standardization among genetic labs work with Pallid Sturgeon.
(3) Implement range-wide standardized analysis and reporting requirements for all genetic data.

(4) Integrate archival catalogs of genetic samples and genetic results with standardized monitoring and stocking databases.
(5) Continue to assess relationship and justification of management units.
(6) Continue to maintain a range-wide tissue sample archiving as described in the "Biological procedures and protocols for researchers and managers handling Pallid Sturgeon".

3.3 ASSSESS STRUCTURE OF PALLID STURGEON POPULATION RANGE-WIDE FOR CONSIDERATION OF DISTINCT POPULATION SEGMENTS.

When Pallid Sturgeon were listed in 1990 (55 FR 36641-36647), data were not available regarding range-wide population structure, and a policy on DPSs did not exist. Subsequently, the Departments of Interior and Commerce jointly developed a DPS policy in 1996 (61 FR 4722-4725). This policy describes elements necessary to identify a DPS: 1) population discreteness and 2) population significance.

Data indicate that the population of Pallid Sturgeon in the upper Missouri River may meet the DPS policy criteria of discreteness (61 FR 4722-4725). They are genetically distinct from Pallid Sturgeon in the middle and lowermost portions of the range (Campton et al. 2000; Tranah et al. 2001; Schrey 2007; Schrey and Heist 2007), and they are physically separated by multiple dams. However, these studies lack adequate samples from portions of the Mississippi River, making it difficult to discern if additional discrete populations exist.

GPMU
(1) Evaluate population significance as defined in the DPS policy
(2) Evaluate conservation status as defined in the DPS policy.
(3) If conservation status assessment indicates a change is appropriate which will meaningfully advance conservation or significantly limit unnecessary regulation, identify and list appropriate DPS(s), if appropriate.

CLMU, IHMU, CPMU
(1) Continue collection and evaluation of genetic, ecological, behavioral, and physiological data to identify if additional populations meet the discreteness criteria as defined in the DPS policy.
(2) If additional discrete populations exist, evaluate their significance as defined in the DPS policy.
(3) If additional discrete and significant populations exist, evaluate their conservation status as defined in the DPS policy.
(4) If conservation status assessment indicates a change is appropriate which will meaningfully advance conservation or significantly limit unnecessary regulation, identify and list appropriate DPS(s), if appropriate.

3.4 CONDUCT A POPULATION VIABILITY ANALYSIS

A population viability analysis (PVA) should be conducted to further quantify population levels for recovery goals.

Criteria addressing minimum viable population size and demography will be useful in assessing if populations can persist through natural reproduction and, thus, will be an important component to evaluate the criteria for downlisting or delisting Pallid Sturgeon. A PVA also can be a useful tool for developing minimum viable population size estimates (Reed et al. 2003). All monitoring activities (see task 3.1) should consider the data requirements necessary to conduct PVA and should be designed to provide these data (Morris et al. 2002).

GPMU, CLMU, IHMU, CPMU

(1) Identify and collect data necessary to develop management unit or DPS (if designated) specific PVAs.
(2) Estimate management unit or DPS (if designated) specific minimum viable population size.
(2) Update PVA models as new data are available to facilitate downlisting and delisting criteria evaluations.

4. IMPLEMENT AND EVALUATION A CONSERVATION PROPAGATION AND STOCKING PROGRAM

4.1 IMPLEMENT CONSERVATION PROPAGATION AND STOCKING PROGRAM

Current stocking efforts are conducted in accordance with a range-wide stocking plan (USFWS 2008). This plan should be amended if necessary using adaptive management principles as new data become available from Tasks 3.1-3.3 and 4.2.

GPMU, CLMU, IHMU, CPMU

(1) Annually review, update if necessary, and implement range-wide stocking and propagation plans using the most recent information.

(2) Annually review and update the tagging plans with the most recent information.
    (a) Improve tagging mechanisms to minimize tag loss/failure in hatchery produced fish.
        (i) Ensure that genetic samples are collected from all fish used in propagation efforts.
        (ii) Continue to evaluate tag placement location for improved PIT tag retention.
        (iii) Ensure that all monitoring crews have appropriate tag reading equipment.
    (b) Ensure that all field crews throughout the Missouri and Mississippi River drainages have appropriate equipment to read tags.
    (c) Implement tagging plan.

4.2 EVALUATE SUCCESS OF PROPAGATION AND STOCKING PROGRAM

GPMU, CLMU, IHMU, CPMU

(1) Evaluate Pallid Sturgeon supplementation using various age classes of progeny.
  (a) Use data to derive Pallid Sturgeon specific survival rates where stocking occurs.
  (b) Use data to refine stocking strategies:
    (i) Determine optimal stocking numbers,
    (ii) Determine optimal stocking size,
    (iii) Determine optimal stocking time and location.
  (c) Evaluate dispersal of hatchery progeny.
  (d) Evaluate effectiveness of hatchery products within each management unit.
  (e) Determine when stocking is no longer needed.

(2) Ensure that hatchery stocking and propagation records are incorporated into integrated a range-wide species recovery database.

4.3 RESEARCH METHODS TO IMPROVE SPAWNING, CULTURING, REARING, AND STOCKING OF PALLID STURGEON

GPMU, CLMU, IHMU

(1) Continue to refine efficient, effective spawning techniques in the hatcheries and in the field.
(2) Conduct trials to determine spawning requirements of broodstock (e.g., optimal spawning temperature) and methods for maximizing survival and growth of progeny collected from broodstock.
(3) Continue to refine techniques to improve hatchery product quality and survivability.
(4) Continue to refine and improve cryopreservation techniques.
  (a) Insure cryopreservation program is adequately funded to maintain preserved sperm as long as necessary.

5. COORDINATE AND IMPLEMENT CONSERVATION AND RECOVERY OF PALLID STURGEON

5.1 WORK WITH STAKEHOLDERS/PARTNERS TO MAINTAIN AND / OR INCREASE PALLID STURGEON NUMBERS RANGE-WIDE (IN ALL MANAGEMENT UNITS).

GPMU, CLMU, IHMU, CPMU

(1) Collaborate with governmental agencies at all levels; local universities, land managers, private land owners, industry, and the general public to recover the Pallid Sturgeon.
  (a) Enlist State agencies / State managers in regional and range-wide recovery efforts for the Pallid Sturgeon.
  (b) Determine ways to improve communication and find innovative methods to work closely with Federal and State regulatory partners to improve upon recovery efforts for this fish.

(c) Engage local communities, businesses, aquariums, non-governmental organizations, and others to support Pallid Sturgeon.

5.2 COMMUNICATE WITH STURGEON RESEARCHERS, MANAGERS, AND THE PUBLIC

GPMU, CLMU, IHMU, CPMU

(1) Develop a method to integrate and incorporate information from all researchers and biologists working with Pallid Sturgeon.
- (a) Ensure that Federal endangered species permits are reviewed in a timely manner and coordinated such that annual reporting requirements are met and that Pallid Sturgeon collection and morphologic data and genetic tissue samples are provided to the appropriate repositories.
- (b) Identify disparate data sources necessary to evaluate progress toward downlisting and delisting criteria.
  - (i) Develop a range-wide data management and archiving strategy/plan to relationally link data necessary to evaluate progress toward downlisting and delisting criteria.
  - (ii) Implement data management and archiving strategy/plan.
  - (iii) Review and update data management and archiving strategy/plan as data needs and as technology changes.
- (c) Annually update central database using permit reporting data.
- (d) Improve and maintain central clearinghouse of Pallid Sturgeon bio-data and encounter history.

(2) Develop a web-based application related to Pallid Sturgeon life history that has direct links to scientific literature and current research.

(3) Improve dissemination of up-to-date information on Pallid Sturgeon (including research, new program updates, etc.).
- (a) Hold a range-wide "*Scaphirhynchus*" conference at least every 5 years.
- (b) Produce and share basin specific reports on Pallid Sturgeon through a user friendly outlet.
- (c) Encourage and support publication of research, management, and other recovery-related information.

(4) Collaborate with partners and develop an outreach program that highlights the Pallid Sturgeon and its ecosystem and the importance of protecting this fish
- (a) Develop and distribute information and education materials on Pallid Sturgeon and its ecosystem.
- (b) Increase public awareness of the laws and needs for protecting Pallid Sturgeon and their habitats.
- (c) Provide cultured Pallid Sturgeon to aquaria and comparable facilities where they can be viewed by the public.
- (d) Develop activities and materials for grade, middle, and high school teachers.

(e) Establish signs at all public boat ramps accessing the Missouri and Mississippi rivers describing Pallid Sturgeon.

6.0 POST DOWNLISTING OR DELISTING PLANNING

(1) Work with partners (including State and Federal agencies and others) to develop a post delisting management and monitoring strategy as progress is gained toward full recovery of this species.
(a) Develop and implement a post downlisting or delisting range-wide monitoring plan.

Part III: Implementation Schedule

Recovery plans are intended to assist the USFWS and potential Federal, State, and private partners in implementing actions to recover and/or protect endangered species. The following Implementation Schedule outlines recovery tasks, task priorities, task descriptions task duration, and estimated task costs for this recovery plan (2014-2047).

Parties with authority, responsibility, or expressed interest to implement specific recovery tasks are identified in the Implementation Schedule. The identification of agencies within the Schedule does not imply a requirement or that prior approval has been granted by that party to participate nor does it constitute and additional legal responsibilities beyond existing authorities, i.e., Endangered Species Act, Clean Water Act, Federal Land Policy and Management Act, etc. Recovery plans do not obligate other parties to implement specific tasks and may not represent the views, official positions, or approval of any individuals or agencies involved with developing the plan, other than the USFWS.

Recovery tasks are assigned numerical priorities to highlight the relative contribution they may make to species recovery. Priority numbers in column 1 of the schedule are defined as follows:

Priority 1 All actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 All actions that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 All other action necessary to provide for reclassification or full recovery of the species.

The cost estimates provided in the Schedule identify foreseeable expenditures that could be made to implement the specific recovery tasks. Accurate cost estimates were not practicable to derive for some recovery tasks due to the complex nature of the action (i.e., availability of willing sellers of private property rights, changes in existing laws, etc.). Additionally, some of the costs of identified tasks may be wholly or partially funded under existing State or Federal programs intended to fulfill the requirements of existing laws or regulations outside of the Endangered Species Act, but ultimately may provide benefits to Pallid Sturgeon. As such, these costs are difficult to estimate and not included in the calculation of the costs estimates for downlisting and delisting.

Actual expenditures by identified agencies/partners will be contingent upon appropriations and other budgetary constraints.

Key to acronyms used in Implementation Schedule

BOR	U.S. Bureau of Reclamation
COE	U.S. Army Corps of Engineers
ES	Ecological Services Division (USFWS)
EPA	U. S. Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FR	Fisheries Division (USFWS)
NRCS	Natural Resources Conservation Service, U.S. Department of Agriculture
LE	Law Enforcement (USFWS)
RF	Refuge Division (USFWS)
STATES	State agencies located within the range of the species
USGS	U. S. Geological Survey
WAPA	Western Area Power Administration

Implementation Schedule

Pallid Sturgeon Recovery Plan Implementation Schedule												
Priority	Task #	Task Description*	Task Duration	RESPONSIBLE PARTY			COST ESTIMATES (thousands of dollars)					COMMENTS/NOTES
				USFWS		OTHER	2014 -2018	2019 -2024	2025 -2030	2031 -2040	2040 -2047	
				REGION	DIVISION							
1	1.1.1	Determine effects of dams on limiting recruitment and survival of Pallid Sturgeon	3	6	FR, ES	BOR, COE, STATES	300	600				Costs estimate based on focused research projects for evaluation of identified structures.
1	1.1.2	Restore habitat connectivity where barriers to fish movement occur	5+	6	FR, ES, RF	BOR, COE, STATES	43,000	40,000	27,000			Cost estimates impossible to derive as each barrier will likely require a unique solution.
1	1.1.3	Create physical habitat and restore riverine function	5+	3,4,6	FR, ES	COE, BOR,	6,000	6,000	3,000			
1	1.1.4	Provide and protect instream flows	5+	3,4,6	FR, ES	COE, BOR, NRCS,USFWS, STATES						Cost estimates impossible to derive.
1	1.1.5	Quantify and minimize effects of entrainment	5+	3,4,6	FR, ES	COE, BOR, EPA, NRCS, FERC, STATES	27,000	18,000	17,000			
1	1.1.6	Provide protection for important habitat forming processes	5+	3,4,6	FR, ES, RF	COE, BOR, EPA, NRCS,STATES	5,000	5,000	5,000	5,000	5,000	
1	1.2.1	Ensure compliance with existing State and Federal environmental regulations	ongoing	3,4,6	ES	COE, BOR, EPA, FERC, STATES						Cost may be absorbed under existing programs.
2	1.2.2	Evaluate invasive species/ Aquatic Nuisance Species	3+	3, 4, 6	FR, ES	USFWS, STATES						Cost may be absorbed under existing programs.
1	2.1.1	Develop methods for accurate species assignment	3	3,4,6	FR, ES	USFWS, COE	150	150				
1	2.2.1	Evaluate sexual maturity and spawning life history parameters	3	3,4,6	FR, ES	USGS, COE, BOR, STATES	750	750				
1	2.2.2	Fill information gaps for - Age-0 to Age-1 Pallid Sturgeon	3	3,4,6	FR, ES	USGS, COE, BOR, STATES	750	750				
1	2.2.3	Fill information gaps for - Age-1 to sexually mature Pallid Sturgeon	3	3,4,6	FR, ES	USGS, COE, BOR, STATES	750	750				

Implementation Schedule (continued)

Pallid Sturgeon Recovery Plan Implementation Schedule												
Priority	Task #	Task Description*	Task Duration	RESPONSIBLE PARTY			COST ESTIMATES (thousands of dollars)					COMMENTS/NOTES
				USFWS		OTHER	2014 - 2018	2019 - 2024	2025 - 2030	2031 - 2040	2040 - 2047	
				REGION	DIVISION							
1	3.1	Monitor Pallid Sturgeon population	5+	3,4,6	FR	COE, BOR, USGS, STATES	3,000	3,000	3,000	3,000	3,000	
1	3.2	Monitor genetic makeup of Pallid Sturgeon	5+	3,4,6	FR, ES	COE, USFWS, STATES	200	200	200	200	200	
3	3.3	Assess population for consideration of DPSs	5+	3,4,6	FR,ES	USFWS		20				Some cost may be absorbed under existing programs.
2	3.4	Conduct a population Viability Analysis	4	3,4,6	FR, ES	USGS, COE, BOR		100	100			Data analysis. Data collection costs absorbed under existing programs
1	4.1	Conservation propagation and stocking program	5+	3,6	FR	COE, BOR, STATES	925	1025	550			
1	4.2	Evaluate success of propagation and stocking program	5+	3,4,6	FR	COE, BOR, STATES	75	75	50	50		Data analysis. Data collection costs absorbed under existing programs
2	4.3	Research to improve spawning, culturing, rearing and stocking	3	3,4,6	FR, ES	USGS, COE, BOR, STATES	150	150				Cost may be absorbed under existing programs
1	5.1	Work with stakeholders/partners to maintain and/or increase Pallid Sturgeon numbers range-wide.	ongoing	3,4,6	FR, ES, RF	USGS, COE, BOR, STATES	200	200	200	200	200	Cost may be absorbed under existing programs
3	5.2	Communicate with sturgeon researchers, managers, and the public.	5+	3,4,6	FR, ES	USGS, COE, BOR, STATES	200	200	200	200	200	Cost may be absorbed under existing programs
3	6.1	Post downlisting or delisting planning.	3	3,4,6	FR, ES	USGS, COE, BOR, USFWS, STATES, WAPA, NRCS			100	100		

*detailed description available in Recovery Outline/Narrative section.

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APPENDIX A: *State Regulatory Requirements*

The table that follows lists the major state laws that establish requirements, permits, approvals, or consultations that may apply to projects in or near waterways that may affect water quality or quantity.

The citations in this table are those of the general statutory authority that governs the indicated category of activities to be undertaken.
Under such statutory authority, the lead state agencies may have promulgated implementing regulations that set forth the detailed procedures for permitting and compliance.

Definitions of abbreviations used in the table are provided here.

ACA Arkansas Code, Annotated
IAC Iowa Code
ILCS Illinois Compiled Statutes
KAR Kentucky Administrative Regulations
KSA Kansas Statues Annotated
LAC Louisiana Administrative Code
MCA Montana Code Annotated
MSC Mississippi Code
MRS Missouri Revised Statutes
NDCC North Dakota Century Code
NRS Nebraska Revised Statute
SDAR South Dakota Administrative Rules
TCA Tennessee Code Annotated

Table B State Statues Related to Water Quality and Usage.

	AUTHORITY CITATION
Arkansas	Arkansas Water and Air Pollution Control Act (ACA §§ 8-4-101 et seq.) Arkansas Water Resources Development Act of 1981 (ACA §§ 15-22-601 to 15-22-622) Arkansas Natural and Scenic Rivers System Act (ACA §§ 15-23-301 to 15-23-315) Flood Control (ACA §§ 15-24-101 et seq,)
Illinois	Environmental Protection Act (ILCS §§ 415-5-1 et seq.) Water Pollutant Discharge Act (ILCS §§ 415-25-.01 et seq.) Watershed Improvement Act (ILCS §§ 505-140-.01 et seq.) Water Use Act of 1983 (ILCS §§ 525-45-1 et seq.)
Iowa	Surface Water Protection and Flood Mitigation Act (IAC §§ 466B.1 to 466B.9) Initiative on Improving Our Watershed Attributes (I on IOWA) (IAC §§ 466-1 to 466-9) Protected Water Area Systems (IAC §§ 462-B.1 to 462-B.16) Public Lands and Waters (IAC §§ 461-A.1 to 462-A.80) Soil Conservation Districts Law (IAC §§ 161-A.1 to 161-A.80)
Kansas	State Water Resource Planning (KSA §§ 82a-901 to 82a-954) Bank Stabilization Projects (KSA §§ 82a-1101 to 82a-1103)
Kentucky	Designation of uses of surface waters (401 KAR 5:206) Anti-degradation policy (401 KAR 5:030) Surface Water Standards (401 KAR 5:031)
Louisiana	Louisiana Environmental Quality Act (LAC §§30-II-2001 to 2566) Surface Water Quality Standards (LAC §§ 33-IX-1101 et seq.)
Mississippi	Mississippi Air and Water Pollution Control Law (MSC §§ 49-17-1 to 49-17-43)
Missouri	Missouri Clean Water Law (MRS §§ 640.010 et seq. and §§ 644.006 et seq.)
Montana	Aquatic Ecosystem Protections (MCA §§ 75-7-101 et seq.) Flood Plain and Floodway Management (MCA §§ 76-5-101 et seq.) Surface Water and Groundwater (MCA §§ 85-2-101 et seq.) Public Water Supplies, Distribution and Treatment (MCA §§ 75-6-101 et seq.) Water Quality (MCA §§ 75-5-101 et seq.) Montana Water Use Act (MCA § 85-2-101 et seq.).
Nebraska	Environmental Protection Act (NRS §§ 81-1501 et seq.)
North Dakota	Control, prevention, and abatement of pollution of surface waters (NDCC §§ 61-28-01 et seq.)
South Dakota	Surface Water Quality Standards (SDAR §§ 74-51-01 et seq.)
Tennessee	Tennessee Water Quality Control Act of 1977 (TCA §. 69-3-101 et seq.) General Water Quality Criteria (§§1200-4-3-01 et seq.) Use Classification for Surface Waters (§§1200-4-4-01 et seq.)

APPENDIX B: *Summary of Public Comments*

On March 15, 2013, we published a notice in the Federal Register soliciting public comments on our release of a draft revised recovery plan for the endangered Pallid Sturgeon (51 FR 16526).

The new revised recovery plan constitutes the first revision of the recovery plan since 1993. The revised recovery plan documents the current understanding of the species' life history requirements, identifies probable threats that were not originally recognized, includes revised recovery criteria, and based on improved understanding of the species, describes those actions believed necessary to eventually delist the species.

In our announcement, we request assistance in the recovery plan revision effort by providing the public with the opportunity to review the revised plan and solicited any additional information related to Pallid Sturgeon that was not already included in the draft revision. Specifically, we requested any new information, analyses, or reports that summarize and interpret: population status and threats, demographic or population trends; genetics and competition; dispersal and habitat use; habitat condition or amount; and adequacy of existing regulatory mechanisms, management, and conservation planning.

Concurrent with the public comment period, we solicited independent peer review of the document from four individuals prominent in the field of sturgeon biology, ecology, and/or large river ecosystems.

The 60-day public comment period closed on May 14, 2013 and we are grateful for the contributions from those who provided information during this review and comment period. This input ultimately improved the information contained within this revision to our 1993 Pallid Sturgeon Recovery Plan.

Peer-review and public comments ranged from minor editorial suggestions to providing new information. As appropriate, we have incorporated all applicable comments into the text of this revised recovery plan. All comment letters are on file at the Montana Fish and Wildlife Conservation Office, 2900 4th Ave. North, Suite 301, Billings, Montana 59101.

List of Commenters:

PEER REVIEWERS:

Dr. Craig Paukert
Missouri Cooperative Fish
and Wildlife Research Unit
University of Missouri
302 Anheuser-Busch Nat Res
Bldg.,
Columbia, MO 65211

Dr. Mark Pegg
School of Natural Resources
University of Nebraska
402 Hardin Hall
Lincoln, NE 68583

Dr. Kenneth J. Sulak
U.S. Geological Survey
Southeast Ecological Science
Center
7920 NW 71st St.
Gainesville, FL 32653

ADDITIONAL COMMENTERS:

Montana Fish Wildlife and Parks

Missouri Department of Conservation

National Park Service,
Biological Resource Management Division

Nebraska Game and Parks Commission

South Dakota Dept. of Game, Fish, and Parks

U.S. Army Corps of Engineers,
Mississippi Valley Division

Following are those substantive comments that were not addressed in the final Pallid Sturgeon Recovery Plan, along with our response to each comment. Comments are arranged into the following categories – general information, downlisting/delisting criteria, and recovery tasks.

GENERAL INFORMATION

Comment 1: One reviewer questioned how we can conclude the Pallid Sturgeon population is stable when very large sections of the range have no population estimates?

Response 1: In this context, a stable population is one that is in a relatively steady-state either artificially or naturally. A stable designation, however, is not meant to imply that the population is viable, self-sustaining, or recovered. Our conclusion that the Pallid Sturgeon population is stable is based on a variety of factors including, but not limited to:

1) The success of the Pallid Sturgeon Conservation Augmentation Program (PSCAP). As a result of the PSCAP, multiple year-classes have been established and current survival estimates suggest that long-term persistence of the species is anticipated to occur in those reaches where localized extirpation appeared imminent prior to implementation of the PSCAP.

2) Long-term sampling data in many portions of the range with relatively consistent catch-per-unit-effort data;

3) Population abundance estimates, where available; and

4) Implementation of the Similarity of Appearance Rule to reduce or eliminate harvest of Pallid Sturgeon in association with commercial shovelnose sturgeon harvest.

Comment 2: One commenter suggested the section describing the diets of Pallid Sturgeon should mention the importance of native large-river minnow species.

Response 2: We acknowledge that limited data suggest that native turbid-adapted cyprinid species have been documented as a food item for Pallid Sturgeon and several species of these minnows have declined coincident with Pallid Sturgeon. However, while it has been documented that Pallid Sturgeon consume native large-river minnow species, where they are relatively abundant, their overall importance to Pallid Sturgeon is difficult to ascertain. Future research will attempt to examine species relationships and dependencies.

Comment 3: One reviewer questioned whether the Kansas River was ever historically occupied by Pallid Sturgeon and one commenter indicated support for increased emphasis on the potential importance of tributaries to the recovery of Pallid Sturgeon.

Response 3: Information gained following the original version of this plan warrants further investigation into the potential roles tributary rivers play in overall Pallid Sturgeon recovery. One explanation of the low observations of Pallid Sturgeon in tributaries, post-listing, could be attributable to low sampling efforts, low population sizes, or both. Currently, increased sampling and monitoring efforts across the species' range have resulted in more tributary observations including those in the Kansas River. Additionally, in portions of the range, hatchery-reared Pallid Sturgeon account for many of the observations in tributaries. Thus, more information is needed to fully assess the role of certain tributaries in Pallid Sturgeon recovery.

Comment 4: One reviewer noted that fundamental empirical knowledge of how many Pallid Sturgeon exist for major portions of the species' range are lacking (i.e., between Gavins Point Dam and St. Louis, Missouri and the Mississippi River downstream of the Ohio River confluence). Additionally, it was noted that no population segment currently exceeds either the 500 or 5000 minimum adequate population size explained within the plan. Finally, it was suggested that Pallid Sturgeon in the northern most reaches of its range should be considered as critically endangered, since abundance estimates do not approach the lower threshold of 500 individuals in the effective breeding population.

Response 4: We summarized the available information related to abundance estimates in the Present Distribution and Abundance section within the draft version of this plan. Based on additional information received during the comment period on the draft version of this plan, this section was updated in the final version.

The recommendation for considering population segments as critically endangered as compared to endangered may be the result of terminology used by different groups. While the International Union for Conservation of Nature distinguishes between critically endangered and endangered species by defining a critically endangered species as one being at an extremely high risk of extinction in the wild and an endangered species as one being at a very high risk of extinction in the wild, the Endangered Species Act does not. Under the Endangered Species Act, an endangered species is one defined as "…any species which is in danger of extinction throughout all or a significant portion of its range...", thus, in accordance with Federal law we use the latter definition for Pallid Sturgeon.

Comment 5: Several commenters discussed proposed hydrokinetic installations in the Mississippi River. The comments ranged from concerns over what effects these structures may have on Pallid Sturgeon and how they would be monitored to providing references for research efforts that may offer insight into the probable effects from these structures.

Response 5: Between the completion of the first draft and final draft revision to this plan, the large numbers of preliminary permits issued for exploration of hydrokinetic power in the Mississippi River were withdrawn by the permit holders. Thus, the section on hydrokinetic power was removed from the energy development discussion in the final version of this plan. However, if future permit applications suggest this potential threat may re-emerge, it will be reconsidered in the context of species recovery planning.

Comment 6: One reviewer indicated that not enough attention has been given to looming problems due to global warming and climate change.

Response 6: We agree that there are many uncertainties associated with the possible effects from climate change. Given these uncertainties, it is difficult to predict what future conditions might be and how those conditions may affect currently recommended practices. However, recovery plans can and should be updated, as needed, to ensure that both new and changing threats are acknowledged, described, and suitable recovery tasks are identified.

Comment 7: One commenter suggested adding additional language to the Water Quantity section under Factor D: Inadequacy of Existing Regulatory Mechanisms to clarify various nuances related to water rights held by Montana Fish Wildlife and Parks, and water reservations held by County Conservation Districts and municipalities.

Response 7: The intent of this section within the plan is not to provide a thorough account of the nuances associated with instream flow reservations, nor to discuss the nuances of water rights and reservations, but rather to provide a very simple illustrations to the reader such that they may better understand the relationship between junior and senior water rights under western water law. Our recommendations to resolve the concerns identified above are discussed in the Recovery Outline/Narrative under section 1.1.4.

Comment 8: One reviewer indicated that important placenames or landmarks used in the text and important in delineating the extent of listed reaches are not shown in some figures (e.g., Figure 2 and 3).

Response 8: Due to the scale of the maps used in various figures (e.g., Figure 2 and 3) some prominent landmarks were not labeled in order to prevent overcrowding of feature labels. We chose instead to highlight the contemporary range of the species within the map (bold and red line) to visually illustrate the reaches being described within the text.

Comment 9: One commenter expressed concern over the Platte River Recovery Implementation Program's ability to improve and maintain habitat for species, including Pallid Sturgeon and described a fish kill on the Lower Platte River during the late summer of 2012 which included two confirmed Pallid Sturgeon. The commenter attributed this fish kill to water withdrawal and low flows during a prolonged drought and concluded that flows are not always sufficient to maintain Pallid Sturgeon in the Platte River. Additional information provided included modeling efforts at the University of Nebraska suggesting river discharge and the daily variability in discharge were the biggest factors leading to the occurrence of Pallid Sturgeon in the lower Platte River and that maintenance of adequate flows and a natural hydrograph are vital to the management of the Platte River to aid Pallid Sturgeon recovery.

Response 9: The Platte River Recovery Implementation Program was developed to offset the adverse effects to federally listed species resulting from federal water-related activities in the Platte River basin above the Loup River confluence (i.e., central Platte River). One of the goals of the Platte River Recovery Implementation Program is to test the assumption that, by managing flows for federally listed species in the central Platte River, benefits would accrue to Pallid Sturgeon habitat located downstream in the lower Platte River. Members of the Platte River Recovery Implementation Program have committed to provide 130,000-150,000 acre feet of managed flows for central Platte River species by the end of calendar year 2019. As a partner in the Platte River Recovery Implementation Program, we are committed to ensuring defined benefits for all federally listed species in the Platte River basin including the Pallid Sturgeon in the lower Platte River.

We acknowledge the commenter was correct when they stated that a fish kill on the lower Platte River during the summer of 2012 resulted in the confirmed death of at least two Pallid Sturgeon and many Shovelnose Sturgeon. This fish kill was likely the result of high temperatures and low flows, which led to unfavorable conditions for fish. We will work with Platte River Recovery Implementation Program partners and water users in the lower Platte River basin to minimize the death of additional Pallid Sturgeon by avoiding low flow conditions.

Comment 10: One reviewer noted the terms "sub-adult" and "juvenile"were used in the draft plan, but never defined and recommended it might be useful to define the terms "juvenile" and "sub-adult" to distinguish these from one another, and from adults.

Response10: In the draft version of this plan, we used sub-adult and juvenile synonymously. In the final version of this plan we use the term juvenile in reference to all fish that are not considered embryos or larvae, and those that have not reached sexual maturity.

DOWNLISTING/DELISTING CRITERIA

Comment 11: One commenter recognized the current difficulties with identifying small Pallid Sturgeon and expressed concerns that identifying natural recruitment based on young-of-year or juvenile Pallid Sturgeon as a recovery criteria may not be realistic.

Response 11: As described in this plan under the General Description heading, Pallid Sturgeon are similar in appearance to Shovelnose Sturgeon and taxonomic (i.e., morphomerisitic) characters and ratios can vary with age of the fish (allometric growth), making identification of juvenile fish difficult. This lack of uniform applicability of morphometric indices also may be attributable to greater morphological differences documented between the upper Missouri River Pallid Sturgeon and Pallid Sturgeon inhabiting the middle and lower Mississippi and Atchafalaya rivers. Another confounding factor is genetic introgression between Shovelnose and Pallid sturgeon. Genetic analysis confirms introgressive hybridization between Pallid and Shovelnose sturgeon occurs and likely has been occurring for several generations, perhaps as many as 60 years, however; it is poorly understood how this may affect identification accuracy based on taxonomic (i.e., morphomerisitic) characters. To better resolve these issues, we have funded a comprehensive study within the lower Mississippi River to independently compare genomic species identification with identification based on taxonomic (i.e., morphomerisitic) characters to better evaluate concordance among these two methods. Until these results are completed, we consider that a combination of genetic and taxonomic (i.e., morphomerisitic) characters is more reliable than taxonomic character identification alone.

Comment 12: Several reviewers and commenters discussed the current goal of 5,000 adults per management. In general the nature of these comments were:

1) One reviewer sought clarity on if this was achievable or measurable and if we would use confidence intervals in determining whether the goal was met.

2) One reviewer indicated that the goal was reasonable.

3) One commenter sought clarity on how the adult population size would be determined and defined three possible analytical approaches.

4) One commenter expressed concern about this goal and the carrying capacity of currently available habitat.

Response 12: As part of the recovery planning process, we are required to provide objective and measurable recovery criteria. In this plan (see Adult Population Targets section), we defined a minimum target of 5,000 adult fish in each management. This target was determined by using the minimum effective breeding population size to derive an initial minimum target for each management unit. However, we also recognize that this target should be considered interim until empirically-derived Pallid Sturgeon specific data are developed, evaluated, and incorporated into an appropriate population viability analysis to derive management unit or, if designated, DPS specific minimum viable adult population estimates. Thus, the delisting and downlisting targets defined in this plan can and should be updated and modified in subsequent plan revisions, as appropriate, in an adaptive fashion based on available data and analyses.

Finally, at present, there is not a universal standard approach to deriving reliable population estimates for Pallid Sturgeon. We are, however, required to review and consider the best commercially and scientifically available data when making listing-related decisions. As such, we will consider the validity of the methods used based on the data available, the variability in the data (i.e., confidence intervals surrounding a population point estimate), assumptions made, and appropriateness of methodology employed as population estimates are developed.

Through the above process, we anticipate that future management unit specific, or, if designated, DPS specific minimum viable adult population targets, would account for and consider carrying capacity of available suitable habitats during the estimation development.

Comment 13: Two reviewers and several commenters raised questions or concerns about the use of stock density indices as a measure of recruitment. In general, the nature of these comments or questions were to seek clarity on:

1) How does an incremental-RSD equate to a specific number of adult pallid sturgeon?

2) The application of Shuman et al. (2006) to calculate stock density estimates range-wide and the applicability of these to all management units due to latitudinal gradients in growth and morphology.

3) Stock density indices and Catch-per-unit-effort are useful tools to assess population structure and recruitment, but how do they fit into the recovery criteria?

Response 13: We specified incremental-RSD values for stock to quality sized fish (as described by Shuman et al. (2006)) being 50-85 over each 5-year sampling period as a means to monitor and assess if adequate recruitment was occurring within each management unit. Thus, the incremental-RSD values specified are not intended to be directly related to a specific number of adults. However, with the application of appropriate survival rate information, inferences in predicted future adult trends maybe possible to derive.

We have concluded that the application of Shuman et al. (2006) to calculate stock density estimates are appropriate because relative stock density indices are a valid method to quantify length frequency data. The length categories utilized in stock density development are derived from and based upon percentages of the world-record length of the species in question (Willis et al. 1993). The values described in Shuman et al. (2006) were derived as a percentage of the largest fish on record. Therefore, the stock density length categories are expected to be appropriate across the range of the species. Additionally, in developing this interim target, we considered reach-specific variability across the Pallid Sturgeon's range and identified the interim target incremental-RSD of stock to quality-sized naturally produced fish as a range from 50-85, rather than a set value, to account for range-wide variability.

Finally, we also recognize that the utility of the incremental-RSD index relies on the ability to accurately discern small Pallid Sturgeon from Shovelnose Sturgeon which seems to become increasingly harder to do in the lower reaches of the species' range and can require genetic testing. Thus, we included other variables that are not solely dependent on identification of the smaller-sized Pallid Sturgeon (i.e., catch-per-unit-effort data indicative of a stable or increasing population and survival rates of naturally produced fish (age 2+) equal to or exceeding those of the adults). These indices, used in conjunction with incremental-RSD of stock to quality-sized naturally produced fish being 50-85, should provide sufficient confidence when evaluating if the downlisting or delisting criteria have been met.

Comment 14: One commenter suggested the stated Pallid Sturgeon generation time (20-30 years) is too short.

Response 14: The definition we used for generation length is defined as the average age of parents of individuals in a cohort of offspring. Generation length (IUCN 2010) offers insights into the turnover rate of breeding individuals in a population, and is considered greater than the age at first breeding and less than the age of the oldest breeding individual. Additionally, based on the IUCN guidelines (2010) we agree with their assertion that in the context of this plan that it is appropriate to extrapolate generation length from closely related well-known taxa (Shovelnose Sturgeon in the case of this plan) and to apply it to lesser-known and potentially threatened taxa.

Given the limited data on management-unit-specific age structure for this species, we estimated the generation length for each species as age at first reproduction + 1/natural mortality rate as defined by the IUCN (2010). We assumed a stable age structure with an earliest age of maturity, averaged over both sexes, of 10 for Pallid Sturgeon (Keelyne & Jenkins 1993) and 5 for shovelnose sturgeon (Keenlyne 1997). The annual mortality rate for both species was assumed to be 5% for adults after reaching sexual maturity (Bratten et al. 2009, Keenlyne 1997). The estimate for Pallid Sturgeon and Shovelnose Sturgeon, using primarily upper basin information, generated a generation length time of 22 and 12, respectively. The range provided is given to reflect variance across the species' range (i.e., anticipated shorter generation lengths and possible earlier maturity in the lower portions of the species' range).

Comment 15: One commenter agreed that the potential application of the DPS policy could provide a mechanism to reconsider reach-specific listing status for the Pallid Sturgeon while keeping full Endangered Species Act protection for identified DPSs that have not yet experienced recovery. However, they expressed concerns that the criteria used to designate a DPS (i.e., discreteness and significance) may be biased towards listing rather than downlisting.

Response 15: We appreciate the expression of support for our inclusion of the Distinct Population Segment Overview section in this plan. We recognize that the DPS policy provides flexibility under the Endangered Species Act and that there may be current data gaps that will need to be filled in order to make an adequate determination under the DPS policy.

RECOVERY TASKS

Comment 16: Several reviewers commented on the lack of recovery task prioritization.

Response 16: Identified recovery tasks are assigned numerical priorities to highlight the relative contribution they may make towards species' recovery. The following ranking schema is utilized in Part III: Implementation Schedule in this plan.

The priority numbers found in column 1 of the implementation schedule are defined as follows:

Priority 1	All actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
Priority 2	All actions that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.
Priority 3	All other action necessary to provide for reclassification or full recovery of the species.

Through this process we have identified a general prioritization of recovery actions.

Comment 17: One reviewer questioned the availability of data to support the plan's recommendation to provide fish passage, while another commenter agreed that fish passage was an important concept for assisting with Pallid Sturgeon Recovery.

Response 17: Numerous lines of evidence indicate that increasing habitat connectivity can provide benefits and facilitate recovery. Newly hatched Pallid Sturgeon larvae are predominantly pelagic, drifting in the currents for 11 to 13 days and dispersing 245 to 530 km (152 to 329 mi), depending on water column velocity and temperature. Within portions of the species' range, requisite drift distances are lacking due to fragmentation (e.g., Intake Dam on the Yellowstone and Fort Peck Dam on the Missouri). Thus, providing access to spawning areas upstream of some barriers can increase the available drift distances. Additionally, historical and current data indicate suitable habitats exist upstream of several known barriers. These are some examples of the data leading us to conclude, that for some barriers providing fish passage is a reasonable recovery tasks which, if implemented, will help to address the threats of habitat loss, alteration, and degradation within the historical range of the species. Where possible, we tried to identify and highlight areas where fish passage efforts may assist overall recovery by increasing access to tributary habitats.

Comment 18: One commenter questioned the need to provide fish passage at the Wilbur D. Mills Dam constructed to block the old Arkansas River channel and indicated that restoring fish passage at this site would be challenging.

Response 18: At this time, we have not concluded whether Pallid Sturgeon passage at the Wilbur D. Mills Dam is necessary or essential for recovery of Pallid Sturgeon. In both the draft and final version of this plan, we recognized this barrier on a large tributary to the Mississippi River as a possible recovery option. However, we have not recommended doing anything at this structure at the present time. We believe this issue (the need to provide passage of Pallid Sturgeon at the Wilbur D. Mills Dam) should be further evaluated. If data were to indicate that providing passage would further conservation of the species and is deemed necessary for recovery, then we would recommend that passage be restored at this site.

Comment 19: One commenter indicated they were unaware of any published studies documenting Pallid Sturgeon utilizing woody debris, or that woody debris is essential to their forage base.

Response 19: While direct data defining linkages between Pallid Sturgeon and/or their common forage base directly using woody debris may be unavailable, it should not be simply discounted. Natural riverine processes, prior to anthropogenic alteration, included bank erosion that recruited large woody debris into the riverine environment. The important ecological role of woody debris in river environments is well documented in numerous publications (e.g., Fishcenich and Morrow 1999; Boyer et al. 2003; Archer 2009) some of which include: contributing organic matter, providing substrate for invertebrates, generating hiding cover and velocity breaks for fishes, as well as affecting river channel morphology, sediment deposition, hydraulic characteristics, and increased habitat diversity.

Given that historical snag removal efforts were effective at removing woody debris from extensive portions of Missouri and Mississippi rivers and bank stabilization activities have limited natural erosion process that would allow woody debris recruitment, we have identified the need to develop programs or efforts that can help restore woody debris to these rivers as a means of restoring riverine function or creating habitats. This recommendation then focuses more on ecosystem restoration to benefit the species; a fundamental purpose defined within the Endangered Species Act. The three studies cited in the above paragraph include:

Archer, M. W. 2009. Retention, movement, and the biotic response to large woody debris in the channelized Missouri River. Master's thesis. University of Nebraska, Lincoln.

Boyer, K. L., D. R. Berg, and S. V. Gregory. 2003. Riparian management for wood in rivers. Pages 407-420 in S. V. Gregory, K. L. Boyer, and A. M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland.

Fischenich, C., and J. Morrow, Jr. 1999. "Streambank Habitat Enhancement with Large Woody Debris," EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR- 13), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Comment 20: One reviewer and two commenters expressed concerns related to the Pallid Sturgeon Conservation Augmentation Program. The concerns ranged from stocking taking up resources that could be used to implement other recovery tasks, the need to begin shifting emphasis from the propagation program to monitoring of introduced, hatchery-reared pallid sturgeon (i.e., dispersal of hatchery progeny into the Mississippi River, effects on genetic diversity and fitness, and general behavior as they mature), and risks of introducing or amplifying pathogens into the river systems through hatchery-reared fish.

Response 20: From a recovery planning perspective, priority is given to those actions that must be taken to prevent extinction, local extirpation, or populations declining to an irreversible level. In the context of this plan, the use of artificial propagation is identified as a method to prevent localized extirpation. Where appropriate, we prioritized efforts in developing and implementing the Pallid Sturgeon Conservation Augmentation Program. The focus of this program is to preserve the remaining wild genetic diversity before it is lost due to recruitment failure and localized extirpation, as well as to bolster population numbers within reaches where conservation augmentation is deemed necessary. These efforts have been successful at preventing local extirpation and capturing genetic diversity; essentially providing additional time to implement other necessary aspects of the recovery program.

Additionally, in this plan we discuss the use of artificial propagation, where deemed necessary, in the Recovery Outline/Narrative. Specifically, we identified the need to annually review, update if necessary, and implement range-wide stocking and propagation plans using the most recent information, as well as using the best available information to evaluate effectiveness of hatchery products within each management unit, and to determine when stocking is no longer warranted. We will continue to work closely with our partners and seek input and guidance from the Pallid Sturgeon recovery team and basin working groups to help ensure the range-wide stocking and augmentation plan is governing stocking efforts appropriately.

Comment 21: One reviewer commented on the development of a population viability analysis (Task 3.4) cautioning that there must be fundamental empirical pallid Sturgeon population data in place from a multi-year mark-recapture research effort. Additionally, this reviewer identified other data deficiencies for developing a population viability analysis, including; population size, population structure (modes and valleys), and mortality rate.

Response 21: We generally agree that there are prerequisite data that must be acquired before a population viability analysis should be attempted. As such, we ranked the recovery tasks to reflect this. For example, in the implementation schedule, the items under Task 3.1 Monitor Pallid Sturgeon Population, e.g., developing and implement a range-wide Pallid Sturgeon monitoring program that will provide adequate data to evaluate progress toward downlisting and delisting criteria, are identified as priority 1. Whereas task 3.4 Conduct a Population Viability Analysis is ranked as a priority 2 item.

Comment 22: One reviewer and two commenters highlighted what they see as apparent deficiencies in fundamental knowledge and suggested an outline of priority needs as follows:

1) Develop the fundamental knowledge of population abundance and structure for each major reach occupied by the species over its range (i.e., a range-wide population assessment),

2) Finding bottlenecks to recruitment,

3) Identify spawning grounds, and

4) Identify important habitats used by key life history stages.

Response 22: We agree and believe our prioritization list provided in the Implementation Schedule aligns with and addresses the general concern identified. It should also be noted that many of the specific items mentioned are included in ongoing research activities (i.e., developing population estimates, survival rate estimation, studying spawning movements and locations, etc.).

Comment 23: One commenter questioned why some recovery tasks under Section 1.1.1 use the word "evaluate" and inferred from this that potential implementation of restoration efforts is not a focus of near-term conservation efforts. The commenter ultimately recommended increased emphasis on implementation over evaluation to address issues related to dams that are well understood and documented.

Response 23: As part of the recovery planning process, we identify limiting biology or life history requirements, the recognized and probable threats to the species relative to the identified listing factors, and delineate reasonable measures believed necessary to assure sustainable recovery. Through this process, we have identified that dams are one of the primary anthropogenic landscape-level alterations associated with Listing Factor A: Present or Threatened Destruction, Modification or Curtailment of its Habitat or Range. To help address the threat from dams, we have outlined a series of reasonable potential actions to facilitate achieving a self-sustaining population of Pallid Sturgeon within each management unit such that downlisting and eventual delisting can be realized.

For example, looking at the recommendation under the Recovery Outline/Narrative under section 1.1.1 (2), we recommend evaluating spillway releases from Fort Peck Dam to improve flow, turbidity, and temperature conditions downstream, specifically to benefit Pallid Sturgeon in terms of promoting species recovery, and further identify actively implementing this activity if it proves feasible and useful in facilitating recovery of the species. However, the exact magnitude, duration, and timing of spillway releases necessary to improve flow, turbidity, and temperature conditions specifically necessary for Pallid Sturgeon recovery are unknown. Thus, we conclude that this action should be evaluated such that necessary prescribed flows can be developed and subsequently implement if feasible.

Comment 24: One commenter recommended inclusion of language in the plan that emphasizes the importance of Pallid Sturgeon recovery in all historically occupied river reaches that currently are considered suitable Pallid Sturgeon habitat, or can be restored to such levels through habitat restoration and that the success criterion for the fish passage project at Intake Dam on the Yellowstone River be based on Pallid sturgeon measures (e.g., passage, spawning, and recruitment).

Response 24: When this plan was developed, there was a strong emphasis from the Upper Basin Pallid Sturgeon Workgroup to seek and implement fish passage and entrainment protection measures at Intake Dam and sufficient data are available to warrant this management action. Thus, this plan identifies the need to restore fish passage at Intake Dam as mentioned above. However, this plan does not define the exact mechanism through which fish passage and entrainment protection would be achieved. Those specifics are being developed in coordination and cooperation with recovery partners and are subject to various processes (i.e., National Environmental Policy Act).

We are committed to working with partners to help ensure defined benefits for this federally listed species in the Missouri and Mississippi River basins are met, but want to reiterate that the goal of this species recovery program is to sufficiently address the threats to Pallid Sturgeon such that the species no longer fits the definition of threatened or endangered.

Comment 25: One commenter questioned if levee setbacks have been implemented within the range of the Pallid Sturgeon and acknowledge that the concept of increasing floodplain connectivity can improve aquatic habitat conditions. However, this commenter indicated that this type of restoration would have limited applicability because of cost and that benefits would be very reach specific. This commenter concluded that there is no published evidence to support the contention that Pallid Sturgeon require floodplain connectivity because they are main-channel inhabitants and the majority of the food items observed in the digestive tract of Pallid Sturgeon, at least in the Lower Mississippi River, originate in main-channel environments.

Response 25: We agree that increasing floddplain connectivity can improve aquatic habitat conditions and, ultimately, improving the ecosystem upon which Pallid Sturgeon depend. We also recognize that restoring this connectivity will have varying degrees of benefit which may be largely dependent upon levee proximity to the existing channel, the degree of localized channelization, and existing riparian habitat features. The Recovery Task category this is listed under is Create Physical Habitat and Restore Riverine Function which specifically relates to protecting, enhancing, and restoring habitat diversity and connectivity. It is anticipated that site specific planning and evaluation will be required to implement the various components associated with this task. Finally, while data documenting Pallid Sturgeon usage of the inundated floodplain is currently unpublished, Nebraska Game and Parks Commission has documented Pallid Sturgeon usage of floodplain habitats associated with the Missouri River flooding in 2011 (Justin Haas in litt., 2013; Kirk Steffensen, personal communication).

Florida Manatee Recovery Plan

(*Trichechus manatus latirostris*)

Third Revision

U.S. Fish and Wildlife Service
Southeast Region

FLORIDA MANATEE RECOVERY PLAN

(Trichechus manatus latirostris)

THIRD REVISION

Original Approval: April 15, 1980
First revision approved: July 24, 1989
Second revision approved: January 29, 1996

Southeast Region
U.S. Fish and Wildlife Service
Atlanta, Georgia

Approved: Sam D. Hamilton

Sam D. Hamilton, Regional Director, Southeast Region,
U.S. Fish and Wildlife Service

Date: 10/30/01

DISCLAIMER

Recovery plans delineate reasonable actions believed to be required to recover and/or protect listed species. Plans published by the U.S. Fish and Wildlife Service (FWS), are sometimes prepared with the assistance of recovery teams, contractors, state agencies, and other affected and interested parties. Recovery teams serve as independent advisors to FWS. Plans are reviewed by the public and submitted to additional peer review before they are adopted by FWS. Objectives of the plan will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific tasks and may not represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than FWS. They represent the official position of FWS only after they have been signed by the Regional Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

By approving this document, the Regional Director will certify that the data used in its development represent the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in development of the plan are available in the administrative record located at U.S. Fish and Wildlife Service, 6620 Southpoint Drive, South, Suite 310, Jacksonville, Florida 32216. (904) 232-2580.

LITERATURE CITATION SHOULD READ AS FOLLOWS:

U.S. Fish and Wildlife Service. 2001. Florida Manatee Recovery Plan, (*Trichechus manatus latirostris*), Third Revision. U.S. Fish and Wildlife Service. Atlanta, Georgia. 144 pp. + appendices.

ADDITIONAL COPIES MAY BE OBTAINED FROM:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
(301) 492-6403 or 1-800-582-3421

Fees for plans vary depending upon the number of pages.

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***Appointed Recovery Team members have an asterisk by their name.**

EXECUTIVE SUMMARY

CURRENT SPECIES STATUS

Endangered. The near and long term threats from human-related activities are the reasons for which the Florida manatee currently necessitates protection under the Endangered Species Act. The focus of recovery is not on how many manatees exist, but instead the focus is on implementing, monitoring and addressing the effectiveness of conservation measures to reduce or remove threats which will lead to a healthy and self-sustaining population. The Florida manatee could be considered for reclassification from endangered to threatened provided that threats can be reduced or removed, and that the population trend is stable or increasing for a sufficient time period.

HABITAT REQUIREMENTS AND LIMITING FACTORS

The Florida manatee lives in freshwater, brackish and marine habitats. Submerged, emergent, and floating vegetation are their preferred food. During the winter, cold temperatures keep the population concentrated in peninsular Florida and many manatees rely on the warm water from natural springs and power plant outfalls. During the summer they expand their range and on rare occasions are seen as far north as Rhode Island on the Atlantic coast and as far west as Texas on the Gulf coast.

The most significant problem presently faced by manatees in Florida is death or injury from boat strikes. The long-term availability of warm-water refuges for manatees is uncertain if minimum flows and levels are not established for the natural springs on which many manatees depend, and as deregulation of the power industry in Florida occurs. Their survival will depend on maintaining the integrity of ecosystems and habitat sufficient to support a viable manatee population.

RECOVERY GOAL

The goal of this revised recovery plan is to assure the long-term viability of the Florida manatee in the wild, allowing initially for reclassification to threatened status and, ultimately, removal from the List of Endangered and Threatened Wildlife.

RECOVERY CRITERIA

This plan sets forth criteria, which when met, will ensure a healthy, self-sustaining population of manatees in Florida by reducing or removing threats to the species' existence.

The following criteria must be met prior to **reclassification of the Florida manatee from endangered to threatened (downlisting)**:

1. Reduce threats to manatee habitat or range, as well as threats from natural and manmade factors by:
   - identifying minimum spring flows;
   - protecting selected warm-water refuge sites;
   - identifying for protection foraging habitat associated with the warm-water refuge sites;
   - identifying for protection other important manatee areas; and
   - reducing unauthorized human caused “take.”

2. Achieve the following population benchmarks in each of the four regions over the most recent 10 year period of time:
   - statistical confidence that the average annual rate of adult survival is 90% or greater;
   - statistical confidence that the average annual percentage of adult female manatees accompanied by first or second year calves in winter is at least 40%; and
   - statistical confidence that the average annual rate of population growth is equal to or greater than zero.

The following criteria must be met prior to **removal of the Florida manatee from the List of Endangered and Threatened Wildlife (delisting)**:

1. Reduce or remove threats to manatee habitat or range, as well as threats from natural and manmade factors by enacting and implementing federal, state or local regulations that:
   - adopt and maintain minimum spring flows;
   - protect warm-water refuge sites;
   - protect foraging habitat associated with select warm-water refuge sites;
   - protect other important manatee areas; and
   - reduce or remove unauthorized human caused “take.”

2. Achieve the following population benchmarks in each of the four regions for an additional 10 years after reclassification:
   - statistical confidence that the average annual rate of adult survival is 90% or greater;
   - statistical confidence that average annual percentage of adult female manatees accompanied by first or second year calves in winter is at least 40%; and
   - statistical confidence that average annual rate of population growth is equal to or greater than zero.

ACTIONS NEEDED

1. Minimize causes of manatee disturbance, harassment, injury and mortality.
2. Determine and monitor the status of the manatee population.
3. Protect, identify, evaluate, and monitor manatee habitats.
4. Facilitate manatee recovery through public awareness and education.

DATE OF RECOVERY

Currently, in some regions of the state, there are only reliable population data for the past 6 years. Therefore, full recovery may not be possible for at least another 14 years in order to meet the standard of assessing the population over the most recent 10 years of data for reclassification from endangered to threatened status and for an additional 10 years after reclassification for removal from the List of Endangered and Threatened Wildlife. Time is also needed to establish and implement management initiatives to reduce or remove the threats.

TOTAL ESTIMATED COST OF RECOVERY

Based on information provided by our recovery partners, current annual estimated budget expenditures for recovery approach $10,000,000.

TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

The following standard abbreviations for units of measurements and other scientific/technical acronyms and terms are found throughout this document:

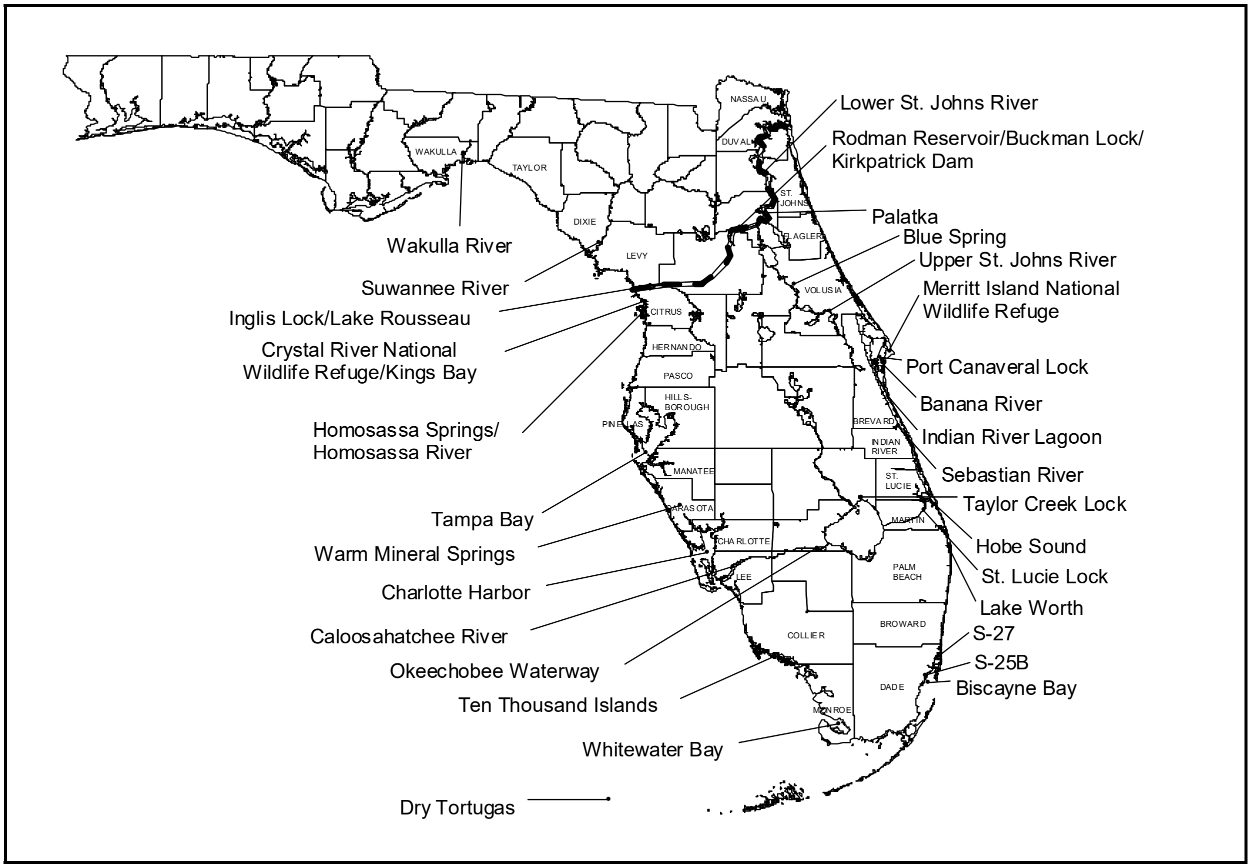
BPSM	Florida Fish and Wildlife Conservation Commission, Bureau of Protected Species Management
CERP	Comprehensive Everglades Restoration Plan
CFR	Code of Federal Regulations
COE	U.S. Army Corps of Engineers
CZS	Chicago Zoological Society
DERM	Miami-Dade Department of Environmental Resources Management
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act of 1973, as amended
FDEP	Florida Department of Environmental Protection
FDNR	Florida Department of Natural Resources
FIND	Florida Inland Navigation District
FMRI	Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute
FPL	Florida Power and Light Company
FR	Federal Register
FWC	Florida Fish and Wildlife Conservation Commission
FWC-DLE	Florida Fish and Wildlife Conservation Commission Division of Law Enforcement
FWS	U.S. Fish and Wildlife Service
GDNR	Georgia Department of Natural Resources
GIS	Geographic Information System
GPS	Global Positioning System
HBOI	Harbor Branch Oceanographic Institute
HWG	Habitat Working Group
IOWG	Interagency Oceanaria Working Group

LOA	Letter of Authorization
LE	Law Enforcement
MIPS	Manatee Individual Photo-Identification System
MML	Mote Marine Laboratory
MMPA	Marine Mammal Protection Act of 1972, as amended
MMPL	Marine Mammal Pathology Lab
MNPL	Maximum net productivity level
MPP	Manatee Protection Plan
MPS	Manatee protection system
MPSWG	Manatee Population Status Working Group
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPS	National Park Service
NSAV	Native submerged aquatic vegetation
NWR	National Wildlife Refuge
OC	The Ocean Conservancy (formerly the Center for Marine Conservation)
OSP	Optimum Sustainable Population
PIT	Passive Integrated Transponder
SAV	Submerged aquatic vegetation
SMC	Save the Manatee Club
USCG	U.S. Coast Guard
USGS-Sirenia	U.S. Geological Survey, Sirenia Project
USN	U.S. Navy
VHF	Very high frequency
WMD's	Water Management Districts

C Fish Industry	Commercial Fishing Industry
Local Gov'ts	Local Governments
M Industry	Marine Industries
Oceanaria	Cincinnati Zoo, Columbus Zoo, Homosassa Springs State Wildlife Park, Living Seas, Lowry Park Zoo, Miami Seaquarium, Mote Marine Laboratory, Sea World Florida and California, South Florida Museum
Photo-ID	Photo-identification
P Industry	Power Industries
R Fish Industry	Recreational Fishing Industry

C	Centigrade
cm	centimeters
ft	feet
hrs	hours
K	carrying capacity
kg	kilograms
km	kilometers
lbs	pounds
m	meters
mi	miles
min	minutes
ppm	parts per million
%	percent
≤	less than or equal to
°	degrees

Florida Coastal Counties and Other Sites Referenced in the Florida Manatee Recovery Plan



PREFACE

This Florida Manatee Recovery Plan revision adds new and refines existing recovery program activities for the next five years. The Recovery Plan is composed of four major sections:

1. Introduction: This section acquaints the reader with the Florida manatee, its status, the threats it faces, and past and ongoing conservation efforts. It also serves as a review of the biological literature for this subspecies.

2. Recovery: This section describes the goal of the plan; outlines an upcoming status review; presents reclassification and delisting criteria based upon the five listing/recovery factors and population benchmarks to assist in evaluating the status; objectives, strategy and actions or tasks needed to achieve recovery. These recovery tasks are presented in step-down outline format for quick reference and in a narrative outline, organized by four major objectives: (1) minimize causes of manatee disturbance, harassment, injury and mortality; (2) determine and monitor the status of the manatee population; (3) protect, identify, evaluate, and monitor manatee habitats; and (4) facilitate manatee recovery through public awareness and education.

3. Implementation Schedule: This section presents the recovery tasks from the step down outline in table format; assigns priorities to the tasks; estimates the time necessary to complete the tasks; identifies parties with authority, responsibility, or expressed interest in implementation of the tasks; and estimates the cost of the tasks and recovery program.

4. Appendices: This section presents additional information utilized by the FWS and Recovery Team to draft this revision.

PART I. INTRODUCTION

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.) (ESA), establishes policies and procedures for identifying, listing and protecting species of wildlife that are endangered or threatened with extinction. The ESA defines an "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." A "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

The West Indian manatee, *Trichechus manatus*, was listed as endangered throughout its range for both the Florida and Antillean subspecies (*T. manatus latirostris* and *T. manatus manatus*) in 1967 (32 FR 4061) and received federal protection with the passage of the ESA in 1973. It should be noted that since the manatee was designated as an endangered species prior to enactment of the ESA, there was no formal listing package identifying threats to the species, as required by Section 4(a)(1) of the ESA. Critical habitat was designated in 1976 for the Florida subspecies, *Trichechus manatus latirostris* (50 CFR Part 17.95(a)). This was one of the first ESA designations of critical habitat for an endangered species and the first for an endangered marine mammal.

The Secretary of the Interior is responsible for administering the ESA's provisions as they apply to this species. Day-to-day management authority for endangered and threatened species under the Department's jurisdiction has been delegated to the U.S. Fish and Wildlife Service (FWS). To help identify and guide species recovery needs, section 4(f) of the ESA directs the Secretary to develop and implement recovery plans for listed species or populations. Such plans are to include: (1) a description of site-specific management actions necessary to conserve the species or population; (2) objective measurable criteria which, when met, will allow the species or populations to be removed from the List; and (3) estimates of the time and funding required to achieve the plan's goals and intermediate steps. Section 4 of the ESA and regulations (50 CFR Part 424) promulgated to implement its listing provisions, also set forth the procedures for reclassifying and delisting species on the federal lists. A species can be delisted if the Secretary of the Interior determines that the species no longer meets the endangered or threatened status based upon these five factors listed in Section 4(a)(1) of the ESA:

(1) the present or threatened destruction, modification, or curtailment of its habitat or range;
(2) overutilization for commercial, recreational, scientific, or educational purposes;
(3) disease or predation;
(4) the inadequacy of existing regulatory mechanisms; and
(5) other natural or manmade factors affecting its continued existence.

Further, a species may be delisted, according to 50 CFR Part 424.11(d), if the best scientific and commercial data available substantiate that the species or population is neither endangered nor threatened for one of the following reasons: (1) extinction; (2) recovery; or (3) original data for classification of the species were in error.

West Indian manatees also are protected under the Marine Mammal Protection Act (MMPA) of 1972, as amended (16 U.S.C. 1461 *et seq*.). The MMPA establishes, as national policy, maintenance of the health and stability of marine ecosystems, and whenever consistent with this primary objective, obtaining and maintaining optimum sustainable populations of marine mammals. It also establishes a moratorium on the taking of marine mammals, which includes harassing, hunting, capturing, killing, or attempting to harass, hunt, capture, or kill any marine mammal. Section 101(a)(5)(A) of the MMPA allows FWS, upon request, to authorize by specific regulation the incidental, unintentional take of marine mammals by persons engaged in identified activities within specific geographic areas, if FWS determines that such taking would have a negligible impact on the species or stock. Since the West Indian manatee, which is comprised of the Florida and Antillean manatee stocks, is currently listed as "endangered" under ESA, they are thus considered "depleted" under the MMPA. Section 115(b) of the MMPA requires that conservation plans be developed for marine mammals considered "depleted." Such plans are to be modeled after recovery plans required under section 4(f) of the ESA, as described above. The purpose of a conservation plan is to identify actions needed to restore species or stocks to optimum sustainable population levels as defined under the MMPA. Thus, in the case of the Florida manatee, this plan addresses conservation planning under MMPA and recovery planning under the ESA.

FWS developed the initial recovery plan for the West Indian manatee in 1980. This initial plan focused primarily on manatees in Florida, but included Antillean manatees in Puerto Rico and the United States Virgin Islands. In 1986, FWS adopted a separate recovery plan for manatees in Puerto Rico. To reflect new information and planning needs for manatees in Florida, FWS revised the original plan in 1989 and focused exclusively on the Florida manatee. This first revision covered a 5-year planning period ending in 1994. FWS revised and updated the plan again in 1996, which again covered a 5-year planning period ending in 2000. In 1999, FWS initiated the process to revise the plan for a third time. A 18-member recovery team (see Acknowledgment Section), consisting of representatives of the public, agencies, and groups that have an interest in manatee recovery and/or could be affected by proposed recovery actions, was established to draft this revision.

In the 20 years since approval of the original recovery plan, a tremendous amount of knowledge of manatee biology and ecology has been obtained, and significant protection programs have been implemented, through the guidance provided by the recovery planning process. This third revision of the Florida Manatee Recovery

Plan reflects many of those accomplishments, addresses current threats and needs, and specifically addresses the planning requirements of both the ESA and MMPA through 2006. This plan was developed with the assistance of the Florida Manatee Recovery Team. Henceforth in this document, unless otherwise specified, the term “manatee” refers to *Trichechus manatus latirostris*, the Florida manatee subspecies of the West Indian manatee.

OVERVIEW

In the southeastern United States, manatees occur primarily in Florida and southeastern Georgia, but individuals can range as far north as Rhode Island on the Atlantic coast (Reid 1996), and probably as far west as Texas on the Gulf coast. This population appears to be divided into at least two somewhat isolated areas, one on the Atlantic coast and the other on the Gulf of Mexico coast of Florida and into two regional groups on each coast: Northwest, Southwest, Atlantic, and Upper St. Johns River (Fig. 1).

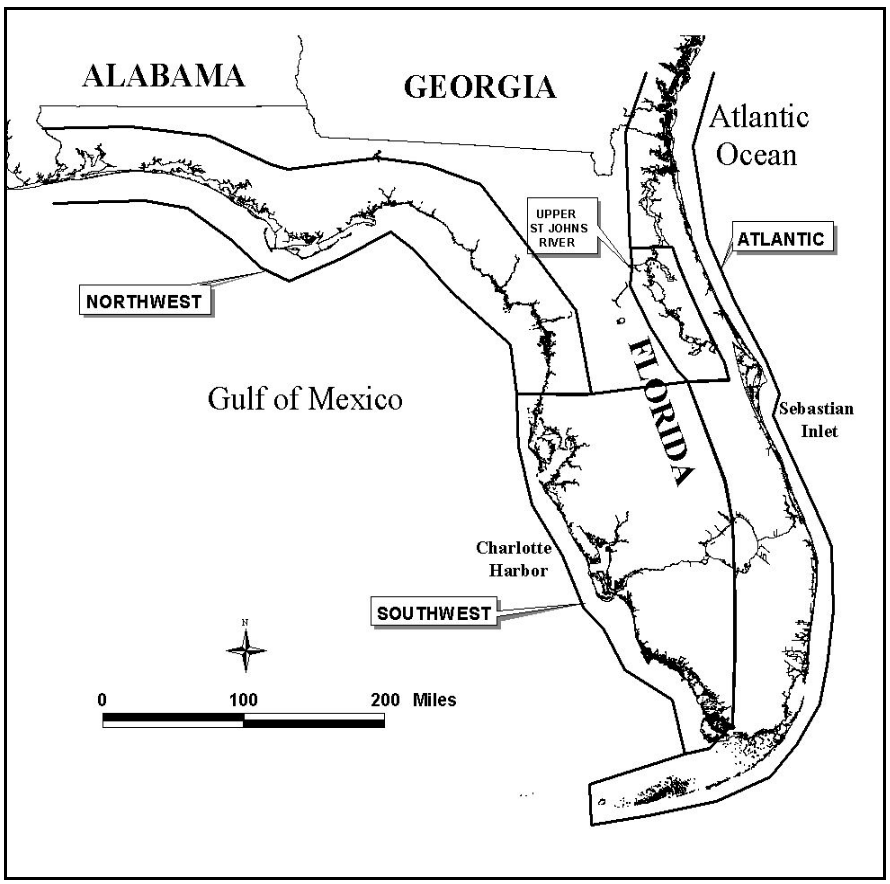


Figure 1. Florida manatee generalized regions: Northwest, Southwest, Upper St. Johns River and Atlantic coast.

Florida manatees have a low level of genetic diversity (Garcia-Rodriguez *et al*. 1998). Historical accounts and archeological evidence of manatees prior to the first half of the 20th century are poor and often contradictory (Domning *et al*. 1982; O'Shea 1988). The record indicates that manatees probably are almost as geographically widespread today as they were historically; however, they appear to be less abundant in many regions (Lefebvre et al. 2001). They were hunted by pre-Columbian societies, but the extent to which they were taken is unclear. After Spanish occupation, Florida's human population increased, and manatees probably were taken in greater numbers. Commercial and subsistence hunting, particularly in the 1800s, probably reduced the population significantly. In 1893, the State of Florida passed legislation prohibiting the killing of manatees.

The major threats faced by manatees today are many fold. Collisions with watercraft account for an average of 24 percent (%) of known manatee deaths in Florida annually (1976-2000), with 30% in 1999 and 29% in 2000. Deaths attributed to water control structures and navigational locks represents 4% of known deaths. The future of the current system of warm-water refuges for manatees is uncertain as deregulation of the power industry in Florida occurs, and if minimum flows and levels are not established and maintained for the natural springs on which many manatees depend. There are also threats to habitat caused by coastal development throughout much of the manatee's Florida range. Florida's human population has grown by 130% since 1970 (6.8 to 15.7 million) and is expected to exceed 18 million by 2010 and 20 million by the year 2015 (Florida Office of Economic and Demographic Research 2000). It is also projected that by 2010, 13.7 million people will reside in the 35 coastal counties (Florida Office of Economic and Demographic Research 2000). There are also threats from natural events such as red tide and cold events. The challenge for managers has increasingly become how to modify human, not manatee, behavior (Reynolds 1999). Yet, since the first Manatee Recovery Plan in 1980, well-coordinated interagency and non-governmental efforts to recover the Florida manatee have been extraordinary, making recovery an achievable goal (Domning 1999).

Based on the highest minimum count of the southeastern United States manatee population (Table 1), Florida manatees constitute the largest known group of West Indian manatees anywhere in the species' range. Outside the United States, manatees occur in the Greater Antilles, on the east coast of Mexico and Central America, along the North and Northeastern coast of South America, and in Trinidad (Lefebvre *et al*. 2001). In most of these areas, remaining populations are believed to be much smaller than the United States population and are subject to poaching for food, incidental take in gillnets, and habitat loss. Manatee protection programs in many countries are not well organized or supported and, in this context, protection of the Florida population takes on international significance.

Table 1. Estimates of manatee life history traits and related statistics. Except as noted, information was obtained from O'Shea *et al*. 1995.

Life-history trait		**Data**
Maximum determined age		59 years
Gestation		11-14 months
Litter size		1
% twins	Blue Spring	1.79%
	Crystal River	1.40%
Sex ratio at birth		1:1
Calf survival	Blue Spring	60%
	Crystal River	67%
Annual adult survival	Atlantic coast	90%
	Blue Spring	96%
	Crystal River	96%
Age of first pregnancy (female)		3-4 years
Mean age at first reproduction (female)		5 years
Age of spermatogenesis (male)		2-3 years
Proportion pregnant	Salvaged carcasses	33%
	Blue Spring (photo-ID)	41%
Proportion nursing - 1st-year calves during winter	Mean	36%
	Blue Spring	30%
	Crystal River	36%
	Atlantic coast	38%
Calf dependency		1.2 years
Interbirth interval		2.5 years
Highest number of births		May-September
Highest frequency in mating herds		February-July
No. verified carcasses in Florida[a]		4,043 (1974-2000)
No. documented in ID catalog		>1,200 (1975-2000)
Highest minimum count (aerial surveys)[a]		3,276 in Jan 5-6, 2001

[a] Data provided by the Florida Marine Research Institute, FWC.

A. TAXONOMY

The West Indian manatee, *Trichechus manatus* Linnaeus, 1758, is one of four living species of the mammalian Order Sirenia. The other three sirenians are the West African manatee (*T. senegalensis*), the Amazonian manatee (*T. inunguis*), and the dugong (*Dugong dugon*). All four species are aquatic herbivores listed as endangered or threatened throughout their ranges by FWS. A fifth species, Steller's sea cow (*Hydrodamalis gigas*), existed in sub-Arctic waters of the Bering Sea. Hunted to extinction within 27 years of its discovery in 1741, Steller's sea cow was a toothless sirenian that fed on kelp and reached lengths of up to 8 m (26 ft) (Reynolds and Odell 1991).

Two subspecies of West Indian manatee are now recognized: the Florida manatee, *T. manatus latirostris*, which occurs in the southeastern United States, and the Antillean manatee, *T. manatus manatus*, found throughout the remainder of the species' range. The Florida manatee was first described by Harlan (1824) as a separate species, *Manatus latirostris*. Later, Hatt (1934) recognized Florida manatees as a subspecies of *T. manatus* Linnaeus. Although subsequent researchers (Moore 1951; Lowery 1974) questioned the validity of the subspecies status, Domning and Hayek (1986) carefully examined morphological characteristics and concluded that the distinction was warranted. The historical ranges of the two subspecies may overlap on the coast of Texas, where the origin of occasional strays (from Florida or Mexico) is uncertain.

B. SPECIES DESCRIPTION

West Indian manatees are massive fusiform-shaped animals with skin that is uniformly dark grey, wrinkled, sparsely haired, and rubber-like. Manatees possess paddle-like forelimbs, no hind limbs, and a spatulate, horizontally flattened tail. Females have two axillary mammae, one at the posterior base of each forelimb (Fig. 2). Their bones are massive and heavy with no marrow cavities in the ribs or long bones of the forearms (Odell 1982). Adults average about 3.0 m (9.8 ft) in length and 1,000 kg (2,200 lbs) in weight, but may reach lengths of up to 4.6 m (15 ft) (Gunter 1941) and weigh as much as 1,620 kg (3,570 lbs) (Rathbun *et al*. 1990). Newborns average 1.2 to 1.4 m (4 to 4.5 ft) in length and about 30 kg (66 lbs) (Odell 1981). The nostrils, located on the upper snout, open and close by means of muscular valves as the animals surface and dive (Husar 1977; Hartman 1979). A muscular flexible upper lip is used with the forelimbs to manipulate food into the mouth (Odell 1982). Bristles are located on the upper and lower lip pads. Molars designed to crush vegetation form continuously at the back of the jaw and move forward as older ones wear down (Domning and Hayek 1986). The eyes are very small, close with sphincter action, and are equipped with inner membranes that can be drawn across the eyeball for protection. Externally, the ears are minute with no pinnae. Internally, the ear structure suggests that they can hear sound within a relatively narrow low frequency range, that their hearing is not acute, and that they have difficulty in localizing sound (Ketten *et al*. 1992). This indirect "structured" evidence is not entirely concordant with actual electro physiological measurements. Gerstein (1995) suggested that manatees may have a greater low-frequency sensitivity than the other marine mammal species that have been tested.

Figure 2. Mother manatee nursing a calf. (*Photograph by G. Rathbun*)

C. POPULATION BIOLOGY

Information on manatee population biology was reviewed during a technical workshop held in February 1992 (O'Shea *et al.* 1992). The objectives of the workshop were to synthesize existing information, evaluate the strengths and weaknesses of current data sets and research methods, and make recommendations for future research, particularly for constructing new population models (O'Shea *et al*. 1995). The population and life history information published in the workshop proceedings suggests that the potential long-term viability of the Florida manatee population is good, provided that strong efforts are continued to curtail mortality, ensure warm-water refuges are protected, maintain and improve habitat quality, and offset potential catastrophes (Lefebvre and O'Shea 1995).

The value of maintaining long-term databases was emphasized in the 1992 workshop. The collection of manatee reproduction, sighting history, life history, carcass salvage, and aerial survey data has continued, and improved techniques for estimating trends in important population characteristics have been developed.

Such measures include estimation of adult manatee survival (probabilities based on photo-identification) (Langtimm *et al*. 1998), determination of population trends from aerial survey data (Craig *et al*. 1997; Eberhardt *et al*. 1999), and development of population models (Eberhardt and O'Shea 1995). Population modeling will be an ongoing process that evolves as databases and modeling tools improve.

POPULATION SIZE Despite considerable effort in the early 1980s, scientists have been unable to develop a useful means of estimating or monitoring trends in the size of the overall manatee population in the southeastern United States (O'Shea 1988; O'Shea *et al*. 1992; Lefebvre *et al.* 1995). Even though many manatees aggregate at warm-water refuges in winter (Fig. 3) and most if not all such refuges are known, direct counting methods (i.e., by aerial and ground surveys) have been unable to account for uncertainty in the number of animals that may be away from these refuges at any given time, the number of animals which are not seen because of turbid water, and other factors. The use of mark-resighting techniques to estimate manatee population size based on known animals in the manatee photo identification database also has been impractical, as the proportion of unmarked manatees cannot be estimated.

Figure 3. Manatee aggregated during a winter cold front at a power plant warm-water outfall in Titusville, Florida. (*Photograph by B. Bonde*)

The only data on population size have been uncalibrated indices based on maximum counts of animals at winter refuges made within one or two days of each other. Based on such information in the late 1980s, the total number of manatees throughout Florida was known to be at least 1,200 animals (Reynolds and Wilcox 1987). Because aerial and ground counts at winter refuges are highly variable depending on the weather, water clarity, manatee behavior, and other factors (Packard *et al.* 1985; Lefebvre *et al*. 1995), interpretation of analyses for temporal trends is difficult (Packard and Mulholland 1983; Garrott *et al*. 1994). Strip-transect aerial surveys are used routinely to estimate dugong population size and trends (Marsh and Sinclair 1989); however, they are difficult to adapt to manatees because of the species' much more linear (coastal and riverine) distribution. This survey method was tested in the Banana River, Brevard County, and recommended for use in that area to monitor manatee population trends (Miller *et al*. 1998). This approach may also have utility in the Ten Thousand Islands-Everglades area.

Beginning in 1991, the former Florida Department of Natural Resources (FDNR) initiated a statewide aerial survey program to count manatees in potential winter habitat during periods of severe cold weather (Ackerman 1995). These surveys are much more comprehensive than those used to estimate a minimum population during the 1980s. The highest two-day minimum count of manatees from these winter synoptic aerial surveys and ground counts is 3,276 manatees in January 2001 (Fig. 4); the highest east coast of Florida count is 1,756 and highest on the west coast is 1,520, both in 2001. It remains unknown what proportions of the total manatee population were counted in these surveys. No statewide surveys were done during the winters of 1992-93 or 1993-94 because of the lack of strong mid-winter cold fronts. These uncorrected counts do not provide a basis for assessing population trends. However, trend analyses of temperature-adjusted aerial survey counts show promise for providing insight to general patterns of population growth in some regions (Garrott *et al*. 1994, 1995; Craig *et al.* 1997; Eberhardt *et al.* 1999).

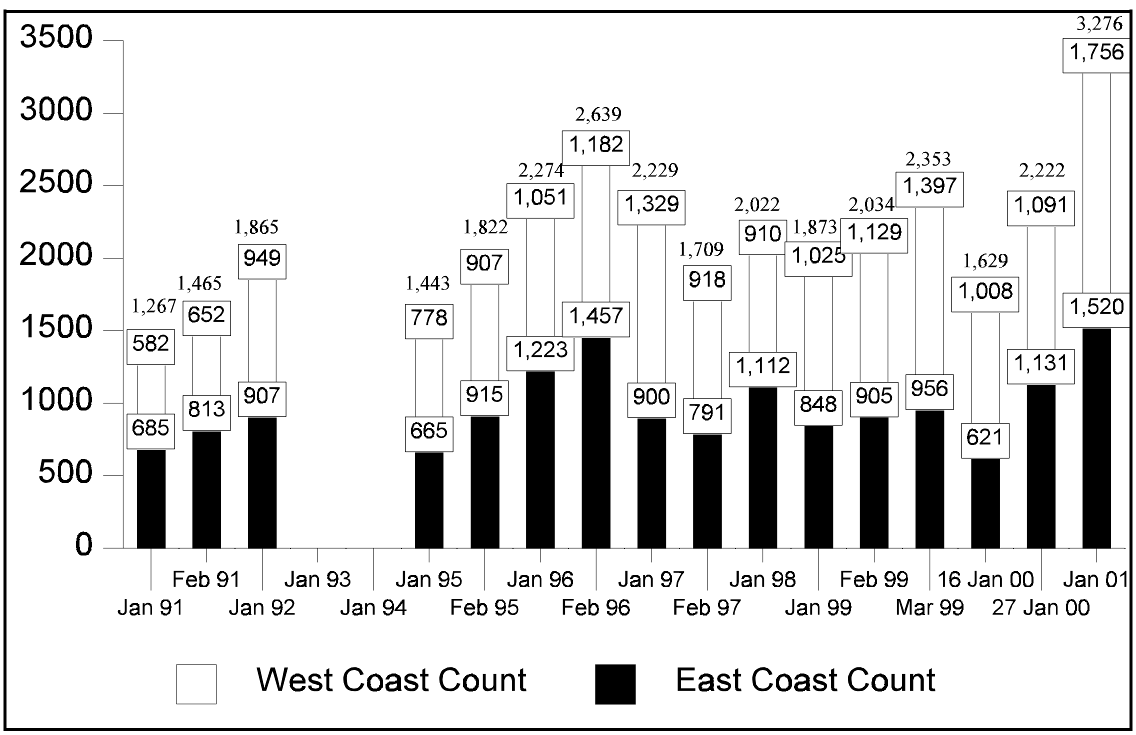


Figure 4. Manatee synoptic survey total, West coast, and East coast counts, 1991-2001 (FWC, unpublished data).

On a more limited basis, it has been possible to monitor the number of manatees using the Blue Spring and Crystal River warm-water refuges. At Blue Spring, with its unique combination of clear water and a confined spring area, it has been possible to count the number of resident animals by identifying individual manatees from scar patterns. The data indicate that this group of animals has increased steadily since the early 1970s when it was first studied. During the 1970s the number of manatees using the spring increased from 11 to 25 (Bengtson 1981). In the mid-1980s about 50 manatees used the spring (Beeler and O'Shea 1988), and in the winter of 1999-2000, the number increased to 147 (Hartley 2001).

On the west coast of Florida, the clear, shallow waters of Kings Bay have made it possible to monitor the number of manatees using the warm-water refuge in Kings Bay at the head of the Crystal River. Large aggregations of manatees apparently did not exist there until recent times (Beeler and O'Shea 1988). The first careful counts were made in the late 1960s. Since then manatee numbers have increased significantly. In 1967 to 1968, Hartman (1979) counted 38 animals in Kings Bay. By 1981 to 1982, the maximum winter count increased to 114 manatees (Powell and Rathbun 1984) and in December 1997, the maximum count was 284 (Buckingham *et al.* 1999). Both births and immigration of animals from other areas have contributed to the increases in manatee numbers at Crystal River and Blue Spring. Three manatee sanctuaries in Kings Bay were established in 1980, an additional three were added in 1994, and a seventh in 1998. The increases in counts at Blue Spring and Crystal River are accompanied by estimates of adult survival and population growth that are higher than those determined for the Atlantic coast (Eberhardt and O'Shea 1995; Langtimm *et al.* 1998; Eberhardt *et al.* 1999).

OPTIMUM SUSTAINABLE POPULATION The MMPA defines the term "optimum sustainable population" (OSP) for any population stock to mean "the number of animals which will result in the maximum productivity of the population or species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element." By regulation (50 CFR 216.3), the OSP is further defined as a range of population sizes between the maximum net productivity level (MNPL) and the carrying capacity (K) of the environment, under conditions of no harvest. The MNPL is defined as the population level producing "the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less losses due to natural mortality."

Pursuant to the MMPA, stocks are to be maintained within their OSP ranges. Just as we are uncertain of the Florida manatee's population size and trend, we are uncertain whether the population is currently below or within its OSP level. Even in the regions where population growth has been documented (Northwest and Upper St. Johns River), we do not know if maximum productivity has yet been achieved.

The MNPL has been estimated only for a few marine mammal species, and is generally treated as a percentage of carrying capacity. Carrying capacity varies over time and space, and is likely to be artificially reduced by a growing human population. Loss of artificial and natural warm-water refuges, for example, could greatly reduce the winter carrying capacity of habitats north of the Sebastian River on the Atlantic coast and the Caloosahatchee River on the Gulf coast. The Recovery Team recognizes the importance of conserving important manatee habitat, and emphasizes the need for sufficient quantity and quality of habitat within each region of the Florida manatee's range to permit sustained manatee population growth from current population levels. Key habitat types include those that are used for the following essential manatee activities: (1) thermoregulation at warm-water refuges; (2) feeding, reproduction and shelter; and (3) travel and migration.

DETERMINATION OF POPULATION STATUS The quality of the long-term database of scarred manatees "captured" by photography (Fig. 5) at winter-aggregation sites, combined with advances in mark-recapture (resighting) statistical models and computer programs, has allowed statistically valid estimates of adult manatee survival rates (Pollock *et al.* 1990; Lebreton *et al.* 1992; Pradel and Lebreton 1993, cited in Langtimm *et al*. 1998; Langtimm *et al.* 1998; White and Burnham 1999). Additional models have been developed that will allow estimation of the proportion of females with calves (Nichols *et al.* 1994). These statistical techniques allow the examination of vital rate variation over time or in association with specific environmental factors. They provide "Goodness-of-Fit" tests of the data to the models to assess bias in the estimates, and provide confidence intervals to assess the precision of the estimates. The application of these techniques to the manatee photo-identification (photo-ID) data provides statistical robustness (Langtimm *et al.* 1998) that has not yet been achieved with trend analyses of aerial survey data (Lefebvre *et al.* 1995; Eberhardt *et al.* 1999) or carcass recovery data (Ackerman *et al.* 1995). Furthermore, population size changes only after there has been a change in survival and/or reproductive rates (or emigration/immigration). Thus, directly monitoring survival and reproduction rates can provide immediate information on probable trends in abundance and gives managers specific information that can help them design realistic plans to achieve species recovery, reclassification, and eventual removal from the List of Endangered and Threatened Wildlife.

The previous recovery plan (FWS 1996) identified the need for a population status working group to assess manatee population size and trends. The first meeting of the Manatee Population Status Working Group (MPSWG), a subcommittee of the Recovery Team, was held in March 1998. The goals of the MPSWG are to: (1) assess the status of the Florida manatee population; (2) advise FWS on population recovery criteria for determining when recovery has been achieved (see Appendix A); (3) provide interpretation of available information on manatee population biology to managers; (4) make recommendations concerning needed research directions and methods; and (5) obtain rigorous external review of manatee population data, conclusions, and research methods by independent researchers with expertise in population biology. The Manatee Population Ecology and Management Workshop, scheduled for April 2002, is a forum that will address these goals and will specifically include a panel of independent experts to review research progress and to make recommendations on how to improve integration of population models with management.

Figure 5. Catalogued female Florida manatee SB 79 was first documented on May 1, 1993 with a large calf (not shown on left). Documented with her third calf (right) on August 15, 1997. These photographs illustrate how injuries/scars appear to change as they heal or as they are altered by new features. This individual uses the Ft. Myers/Charlotte Harbor area during the winter and Sarasota Bay during the warmer months. Estimated to be at least 13 years old, she has given birth to calves in 1992, 1994, 1997, and 2000. (*Photographs by J. Koelsch*)

In order to develop quantitative recovery criteria, the MPSWG reviewed the best available published information on manatee population trends, and determined that analysis of status and trends by region would be appropriate. Based on the highest minimum winter counts for each region between 1996 and 1999 (Fig. 4 and Fig. 6), the number of manatees on the east and west coasts of Florida appears to be approximately equal. Within both the east and west coast segments of the Florida manatee population, documented movements suggest that at least some loosely formed subpopulations exist, which may constitute useful management units. Four subgroups were identified, which tend to return to the same warm-water refuge(s) each winter (Fig. 1) and have similar non-winter distribution patterns. For example, on the east coast, a core group of more than 100 manatees use the Blue Spring warm-water refuge in the upper St. Johns River. Radio-tracking studies (Bengtson 1981) and other information (Beeler and O'Shea 1988; Marine Mammal Commission 1988) suggest that most manatees wintering at Blue Spring tend to remain in the area identified as the **Upper St. Johns River Region** (Fig. 1). The lower St. Johns River, the east coast, and the Florida Keys are considered to represent the **Atlantic Region** (Fig. 1), based on the results of long-term radio tracking and photo-ID studies (Beck and Reid 1995; Reid *et al.* 1995; Deutsch *et al.* 1998).

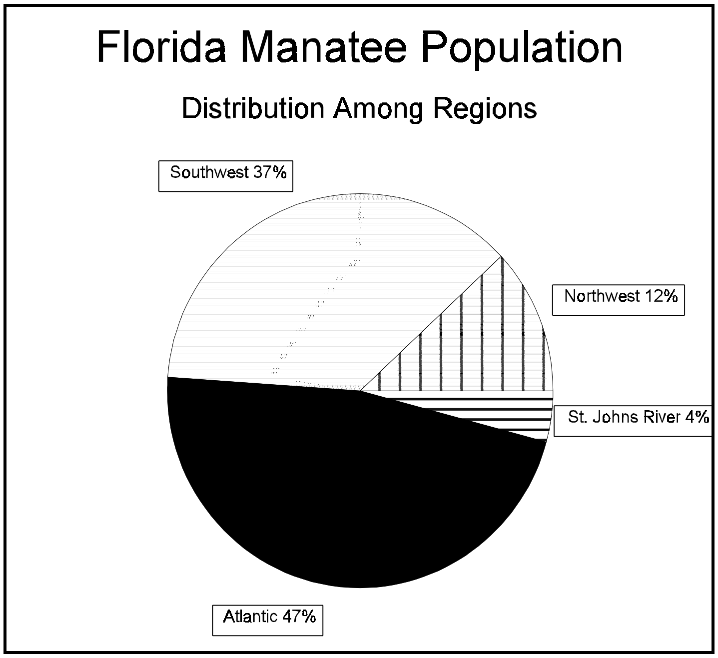


Figure 6. Florida manatee population distribution among regions. Percentage estimates are based upon highest minimum winter counts for each region between 1996 and 2000 (FWC, unpublished data).

On the west coast, Rathbun *et al.* (1995) reported that of 269 recognizable manatees identified at the Kings Bay and Homosassa River warm-water refuges in northwest Florida between 1978 and 1991, 93% of the females and 87% of the males returned to the same refuge each year. Radio-tracking results suggest that many animals wintering at Crystal River disperse north in warm seasons to rivers along the Big Bend coast, particularly the Suwannee River (Rathbun *et al.* 1990). This area is designated as the **Northwest Region** (Fig. 1). The existence of more or less distinct subgroups in the southwestern half of Florida (i.e., from Tampa Bay south) is debatable. It is possible that manatees using warm-water refuges in Tampa Bay, the Caloosahatchee River, and Collier County may be somewhat discrete groups; however, given available data, the Recovery Team chose to identify them as one group, the **Southwest Region** (Fig. 1).

Determination of manatee population status is based upon research described in Objective 2 and Appendix B. Table 2 provides regional status summaries and includes an overview of current status, habitat concerns, carcass recovery and cause of death data, and reproduction, survival, and population growth estimates for each region, if available. Cause of death data are summarized for each region in Appendix C to provide an overview on causes of death for: (1) all age classes; and (2) for adults only. Modeling has shown that manatee population trends are most sensitive to changes in adult survival rates (Eberhardt and O'Shea 1995; Marmontel *et al.* 1997; Langtimm *et al.* 1998).

Table 2. Florida manatee population status summaries by region. Data from the Northwest, Upper St. Johns River and Atlantic Regions were based upon survival rates from Langtimm et al. (1998) and population growth estimates from Eberhardt and O'Shea (1995).

		Northwest Primarily NW peninsular FL	**Southwest** Tampa Bay to Whitewater Bay	**Upper St. Johns** Upstream, South of Palatka	**Atlantic** GA - Miami & lower St. Johns
Photo-identification-based estimates	Adult Survival (% per year)	96.5 (95.1-97.5)	Survival, reproductive and population growth rate estimates based on resightings of known individuals are not currently available.	96.1 (90.0-98.5)	90.7 (88.7-92.6)
	Population Growth Rate (% per year)	7.4		5.7 (3-8)	1.0
	Reproduction: Percent adult females with calf	43% ± 9%		41%	42%
	Percent adult females with 1st year calf	36% ± 6%		30%	39%
	Mean interbirth interval	2.5 ± 0.77		2.6 ± 0.81 winter seasons	2.6 ± 0.64 winter seasons
	Mean calf dependency period	1.2 ± 0.42		1.3 ± 0.48 winter seasons	1.2 ± 0.42 winter seasons
	Mean age females at first reproduction	5.1 ± 1.21 years		5.4 ± 0.98 years	- - -
Causes of death based on carcass recovery	1980 - 1999 Overview	• Total of 153 carcasses • All causes, increasing 5.5% per year • Watercraft-related, increasing 10.8% per year	• Total of 1,358 carcasses • All causes increasing 4.8% per year • Watercraft-related, increasing 7.1% per year	• Total of 79 carcasses • All causes, increasing 2.6% per year • Watercraft-related, increasing 1.6% per year	• Total of 1,659 carcasses • All causes, increasing 6.9% per year • Watercraft-related, increasing 5.5% per year
	1989 - 1999 More recent trends	• Average of 8.9 per year (range = 6-12) • Human related cause of death 30% (adults 40%)	• Average of 85.5 per year (range = 57-134) • 281 in 1996 (including 145 red tide related deaths) • Human related cause of death 30% (adults 48%)	• Average of 4.5 per year (range = 2-7) • Human related cause of death 43% (adults 62%)	• Average of 107 per year (range = 70-135) • 206 in 1990 (46 cold-related) • Human related cause of death 34% (adults 57%)
Habitat Related Concerns		• Spring flow rates • Water quality and SAV • Storm-related salinity fluctuations, resulting in vegetation declines • Storm-related impacts on adult survival • Human disturbance at warm-water springs • Potential conflict between weed control and manatee food supply • Papilloma virus implications unknown	• Manatee dependence on power plants as thermal refuges • Increasing boat traffic • Periodic red tide-related deaths • Moderate level of water control structure deaths • Water quality and SAV • Salinity fluctuations, resulting in vegetation declines • Storm-related impacts on adult survival • Human disturbance	• Spring flow rates • Increasing boat traffic • Water quality and SAV • Low to moderate level of water control structure deaths • Potential conflict between weed control and manatee food supply	• Manatee dependence on power plants as thermal refuges • Increasing boat traffic • ICW shared manatee-human travel corridor • High level of water control structure deaths, especially in SE • Water quality and SAV • Salinity fluctuations, resulting in vegetation declines • Storm-related impacts on adult survival • Human disturbance
Current Status		• Exceeds survival, reproduction, and population growth criteria • Although overall deaths are relatively low, watercraft-related deaths are increasing rapidly	• Estimates of survival and population growth not yet available; reproduction criterion has been exceeded for group that summers in Sarasota Bay • Overall deaths are high, watercraft-related deaths are increasing rapidly	• Meets or exceeds survival, reproduction, and population growth criteria • Overall deaths are moderate, watercraft-related deaths increasing slowly	• Meets reproduction criterion; may meet survival and population growth criteria • Overall deaths are high, watercraft-related deaths increasing moderately

CURRENT STATUS Two goals of the MPSWG are to assess the status of the Florida manatee population and provide interpretation of available information on manatee population biology to managers. The MPSWG developed a status statement (Appendix D) for these purposes, and through Recovery Task 2.1 will update this statement annually.

The **Northwest** and **Upper St. Johns River Regions** have survival and reproduction rates that are adequate to sustain population growth (Eberhardt and O'Shea 1995). The adult survival rates are estimated at 96.5% and 96.1% respectively (Table 2). These two regions represent only 16% of the manatees documented in the last three years (Fig. 6). Collection of comparable life history data for the **Southwest Region** only began in 1995 and was not adequate for these survival estimates. This region represents 37% of the population. The health of the population in the **Atlantic Region**, which represents almost one-half of the entire population, is less certain, and the confidence interval surrounding a 90.7% adult survival rate suggests a cause for concern as it drops below 90.0% (Langtimm *et al*. 1998). These statements about the regions are based on data collected from 1977 to 1993 and thus may not reflect the current status of the population. Additionally, the recent increase in the percentage of watercraft-related deaths as a proportion of the total mortality and the effects this will have on adult survival rates is uncertain. Regional demographic estimates are currently being updated for the Manatee Population Ecology and Management Workshop in April 2002.

The near and long term threats from human-related activities are the reasons for which the Florida manatee currently necessitates protection under the ESA. The focus of recovery is not on how many manatees exist, but instead the focus is on implementing, monitoring and addressing the effectiveness of conservation measures to reduce or remove threats which will lead to a healthy and self-sustaining population. The Florida manatee could be considered for reclassification from endangered to threatened provided that threats can be reduced or removed, and that the population trend is stable or increasing for a sufficient time period.

D. DISTRIBUTION AND HABITAT USE PATTERNS

Based on telemetry, aerial surveys, photo identification sighting records, and other studies over the past 20 years, manatee distribution in the southeastern United States is now well known (Marine Mammal Commission 1984, 1986; Beeler and O'Shea 1988; O'Shea 1988; Lefebvre *et al.* 2001). In general, the data show that manatees exhibit opportunistic, as well as predictable patterns in their distribution and movement. They are able to undertake extensive north-south migrations with seasonal distribution determined by water temperature.

When ambient water temperatures drop below 20° C (68°F) in autumn and winter, manatees aggregate within the confines of natural and artificial warm-water refuges (Fig. 7, Lefebvre *et al.* 2001) or move to the southern tip of Florida (Snow 1991). Most artificial refuges are created by warm-water outfalls from power plants or paper mills. The largest winter aggregations (maximum count of 100 or more animals) are at refuges in Central and Southern Florida (Fig. 7). The northernmost natural warm-water refuge used regularly on the west coast is at Crystal River and at Blue Springs in the St. Johns River on the east coast. Most manatees return to the same warm-water refuges each year; however, some use different refuges in different years and others use two or more refuges in the same winter (Reid and Rathbun 1984, 1986; Rathbun *et al.* 1990; Reid *et al.* 1991; Reid *et al.* 1995). Many lesser known, minor aggregation sites are used as temporary thermal refuges. Most of these refuges are canals or boat basins where warmer water temperatures persist as temperatures in adjacent bays and rivers decline.

During mild winter periods, manatees at thermal refuges move to nearby grassbeds to feed, or even return to a more distant warm season range (Deutsch *et al.* 2000). For example, manatees using the Riviera Power Plant feed in adjacent Lake Worth and in Jupiter and Hobe Sounds, 19 to 24 km (12 to 15 mi) to the north (Packard 1981); animals using the Port Everglades power plant feed in grass beds in Biscayne Bay 24 to 32 km (15 to 20 mi) to the south (Marine Mammal Commission 1988); animals in Kings Bay feed on submerged aquatic vegetation along the mouth of the Crystal River (Rathbun *et al.* 1990); animals at Blue Spring leave the spring run to feed on freshwater aquatic plants along the St. Johns River and associated waters near the spring (Bengtson 1981; Marine Mammal Commission 1986).

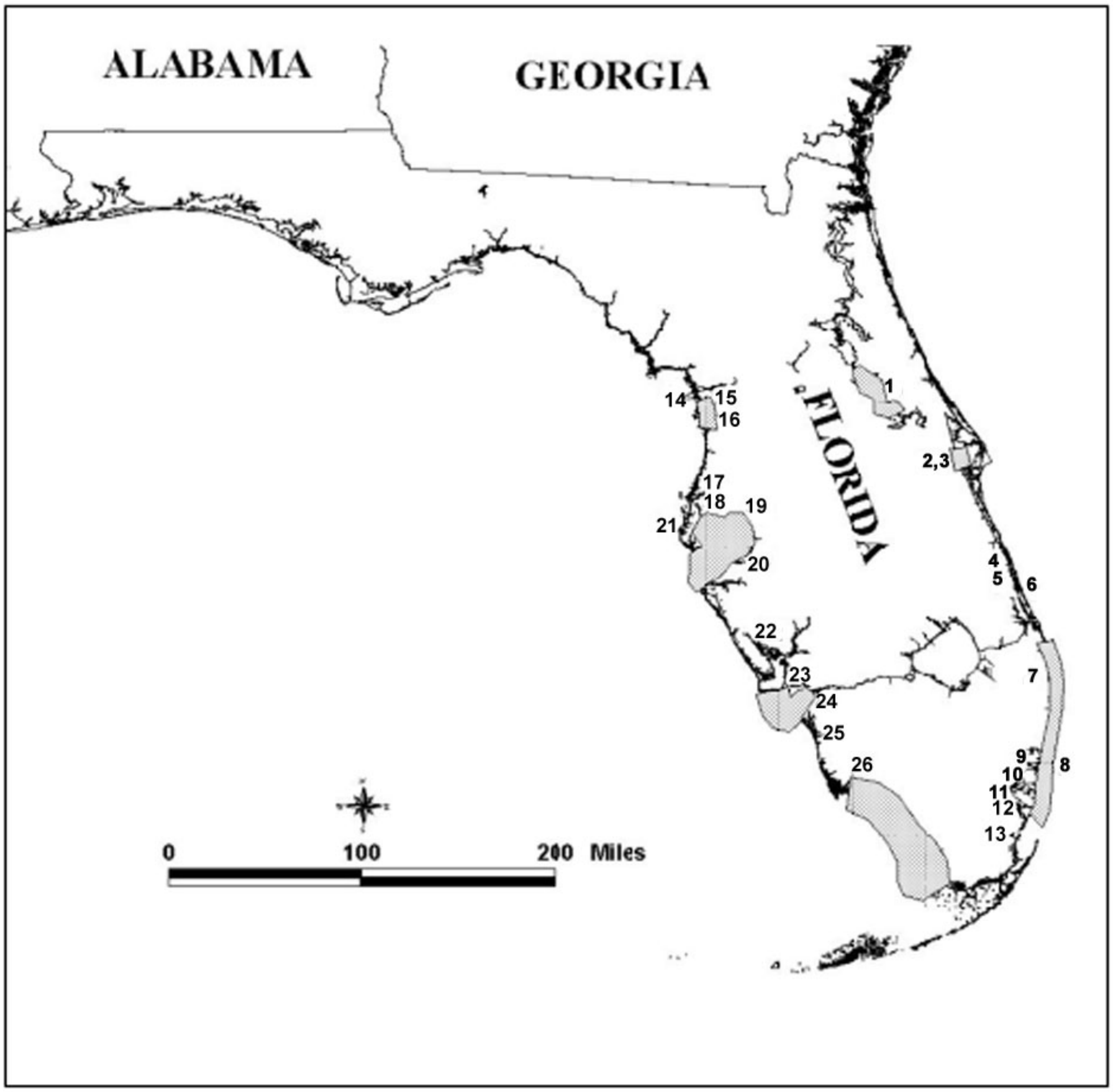


Figure 7. General winter distribution and warm-water manatee aggregation sites in the southeastern United States. Key with name of location and status of refuge is on the following page.

Key to Figure 7. Winter Aggregation Sites (based on Table 1, FWS 1996)

	❶ =	commonly have aggregations of 100 or more manatees
	❷ =	commonly have aggregations of 25 to 100 manatees
	❸ =	aggregations of less than 25 manatees
EAST COAST	(1)	❶Blue Spring (Volusia County, FL)
	(2)	❶Reliant Energy Power Plant (Brevard County, FL)
	(3)	❶FPL Canaveral Power Plant (Brevard County, FL)
	(4)	❷Sebastian River (Brevard County, FL)
	(5)	❷Vero Beach Power Plant (Indian River County, FL)
	(6)	❷Henry D. King Electric Station (St. Lucie County, FL)
	(7)	❶FPL Riviera Beach Power Plant (Palm Beach County, FL)
	(8)	❶FPL Port Everglades Power Plant (Broward County, FL)
	(9)	❶FPL Fort Lauderdale Power Plant (Broward County, FL)
	(10)	❷Little River (Dade County, FL)
	(11)	❷Coral Gables Waterway (Dade County, FL)
	(12)	❷ Palmer Lake (Dade County, FL)
	(13)	❸Black Creek Canal (Dade County, FL)
WEST COAST	(14)	❷FPC Crystal River Power Plant (Citrus County, FL)
	(15)	❶Crystal River (Citrus County, FL)
	(16)	❶Homosassa River (Citrus County, FL)
	(17)	❸Weeki Watchee/Mud/Jenkins Creek Springs (Hernando County, FL)
	(18)	❸FPC Anclote Plant (Pasco County, FL)
	(19)	❷TECO Port Sutton Plant (Hillsborough County, FL)
	(20)	❶TECO Big Bend Power Plant (Hillsborough County, FL)
	(21)	❷FPC Bartow Power Plant (Pinellas County, FL)
	(22)	❷Warm Mineral Springs (Sarasota County, FL)
	(23)	❷Matlacha Isles (Lee County, FL)
	(24)	❶FPL Fort Myers Power Plant (Lee County, FL)
	(25)	❷Ten Mile Canal Borrow Pit (Lee County, FL)
	(26)	❶Port of the Islands (Collier County, FL)
Abbreviations:	FPC	Florida Power Corporation
	FPL	Florida Power & Light Company
	TECO	Tampa Electric Company

As water temperatures rise manatees disperse from winter aggregation areas. While some remain near their winter refuges, others undertake extensive travels along the coast and far up rivers and canals. On the east coast, summer sightings drop off rapidly north of Georgia (Lefebvre *et al.* 2001) and are rare north of Cape Hatteras (Rathbun *et al.* 1982; Schwartz 1995); the northernmost sighting is from Rhode Island (Reid 1996). On the west coast, sightings drop off sharply west of the Suwannee River in Florida (Marine Mammal Commission 1986), although a small number of animals, about 12 to 15 manatees, are seen each summer in the Wakulla River at the base of the Florida Panhandle. Rare sightings also have been made in the Dry Tortugas (Reynolds and Ferguson 1984) and the Bahamas (Lefebvre *et al*. 2001; Odell *et al.* 1978).

In recent years, the most important spring habitat along the east coast of Florida has been the northern Banana River and Indian River Lagoon and their associated waters in Brevard County; more than 300 to 500 manatees have been counted in this area shortly before dispersing in late spring (Provancha and Provancha 1988; FWC, unpublished data). A comparable spring aggregation area does not appear to exist on the west coast, although Charlotte Harbor was visited in the spring by almost half of the 35 manatees radio-tagged at the Fort Myers power plant in Lee County (Lefebvre and Frohlich 1986). During summer, manatees may be commonly found almost anywhere in Florida where water depths and access channels are greater than 1 to 2 m (3.3 to 6.6 ft) (O'Shea 1988). Manatees can be found in very shallow water. Hartman (1979) observed manatees utilizing waters as shallow as 0.4 m with their backs out of the water. In warm seasons they usually occur alone or in pairs, although interacting groups of five to ten animals are not unusual.

Shallow grass beds with ready access to deep channels are preferred feeding areas in coastal and riverine habitats. Manatees often use secluded canals, creeks, embayments, and lagoons, particularly near the mouths of coastal rivers and sloughs, for feeding, resting, cavorting, mating, and calving (Marine Mammal Commission 1986, 1988). In estuarine and brackish areas, natural and artificial fresh water sources are sought by manatees. As in winter, manatees often use the same summer habitats year after year (Reid *et al.* 1991; Koelsch 1997).

E. BEHAVIOR AND PHYSIOLOGY

The first comprehensive study of manatee behavior was conducted in the late 1960s at Crystal River by Hartman (1979). This study attempted, among other things, to develop an ethogram for the species, and despite a number of additional studies that have been done since, Hartman's work stands today as the best source of information on certain aspects of manatee behavior, such as locomotion, breathing, resting, and socializing.

Other aspects of manatee behavioral ecology have been clarified during the last 20 years of manatee research. Migration corridors and responses by individual animals have been elaborated by long-term telemetry studies initiated by scientists at U.S. Geological Survey, Sirenia Lab (USGS-Sirenia) and the Florida Fish and Wildlife Conservation Commission (FWC) Florida Marine Research Institute (FMRI). Scientists have demonstrated site-fidelity in manatees, but have also noted that individual animals adjust their behaviors to take advantage of protected areas or changes in availability of resources. For example, Buckingham *et al.* (1999) confirmed increased manatee use of selected sanctuary areas during times when surrounding disturbance by boats was high. Reynolds and Wilcox (1994) continued to document the extent that manatees seek warm water at power plant discharges in winter (Fig. 8), taking advantage of the tendency by the manatees to aggregate around warm-water refuges in winter. Packard (1981, 1984), Lefebvre and Powell (1990), Rathbun *et al.* (1990) and Zoodsma (1991) described feeding and feeding ecology of manatees aggregated at natural or artificial warm-water refuges in winter, and additional studies further elaborated aspects of feeding behavior and ecological consequences thereof. Studies of foraging ecology were complemented by analyses of gut contents (e.g., Ledder 1986) and assessments of the functional morphology of the gastrointestinal tract (Reynolds and Rommel 1996).

Figure 8. Manatee aggregation at power plant warm-water outfall in Titusville, Florida. (*Photograph by T. O'Shea*)

Descriptions of behaviors have been followed or paralleled by studies that address how and why questions. Perhaps the most obvious questions center around why manatees need to seek warm-water refuges in winter. Gallivan and Best (1980) and Irvine (1983) documented the surprisingly low metabolism of manatees, and scientists suggested that water temperatures below 19° C triggered manatee behavioral changes, such as movements to warm-water sources. Recent research suggests that the temperature eliciting metabolic and behavioral changes in manatees is closer to 17° C, but upper and lower critical temperatures for manatees (the points at which they become metabolically stressed) remain unclear (Worthy *et al.* 1999). It is also unclear, but vital to understand, how manatees would react physiologically and behaviorally to reductions, cessations, or other changes in availability of warm water in winter.

Scientists have noted that manatees seek freshwater sources to drink. Hill and Reynolds (1989) suggested that the structure of the manatee kidney should permit the animals to survive well without regular access to freshwater. In other words, fresh water may be an attractant, without being required for survival, by manatees. Although manatees can tolerate a wide range of salinities (Ortiz *et al.* 1998), they prefer habitats where osmotic stress is minimal or where fresh water is periodically available (O'Shea and Kochman 1990). Ortiz *et al*. (1998) report that "manatees may be susceptible to dehydration after an extended period if freshwater is not available."

A number of research projects have considered manatee sensory capabilities, in part to attempt to comprehend how manatees perceive their environment, including aspects of the environment that are harmful to manatees, such as high-speed watercraft. Behavioral observation studies (e.g., Hartman 1979; Wells *et al*. 1999), and anatomical studies (e.g., Ketten *et al*. 1992) and psychoacoustic research that produced an audiogram for the manatee (Gerstein *et al.* 1999) have all addressed manatee hearing capabilities and the watercraft/manatee issue. These studies have not produced a complete understanding of manatee acoustics.

Other studies that have assessed other sensory capabilities, neuroanatomy, or fine motor coordination include: (1) Cohen *et al.* 1982 (photo receptors and retinal function); (2) Griebel and Schmid 1996 (color vision); (3) Griebel and Schmid 1997 (brightness discrimination); (4) Marshall *et al.*1998a (use of perioral bristles in feeding); (5) Marshall *et al.* 1998b (presence of a muscular hydrostat to facilitate bristle use); (6) Marshall and Reep 1995 (structure of the cerebral cortex); (7) Mass *et al.* 1997 (ganglion layer topography and retinal resolution); (8) O'Shea and Reep 1990 (extent of encephalization); (9) Reep *et al.* 1998 (distribution and innervation of facial bristles and hairs)and (10) Bowles *et al.* 2001(studies of response to novelty). Questions still remain regarding chemosensory ability of manatees, and clarification is needed regarding acoustics and the functional morphology of non-cerebral cortex regions of the brain.

The outcome of research into behavior, general physiology and sensory biology is that these aspects of manatee biology are better understood than is the case for most marine mammals. Due to long-term and diverse research efforts, scientists understand a great deal and continue to learn more about manatee habitat utilization, general behavior patterns, and life history attributes. Science and management would benefit from a carefully structured approach to answering, or providing higher resolution answers to questions associated with thermoregulation and thermal requirements of manatees and aspects of psychoacoustics and perceptual psychology (e.g., what they hear and how they respond to high levels of anthropogenic noise).

A comprehensive description of manatee behavior appears in Wells *et al.* (1999). This chapter provides synopses of the following topics: diving behavior, predation, foraging, thermoregulation and thermally-induced movements, resource aggregations, mating, rearing patterns, communication, and social organization. Sensory and general physiology of manatees are reviewed by Wartzok and Ketten (1999) and Elsner (1999), respectively. Reynolds and Powell (in press) provide a brief overview of manatee biology and conservation, including synopses of behavioral and physiological attributes.

F. FEEDING ECOLOGY

Manatees are herbivores that feed opportunistically on a wide variety of submerged, floating, and emergent vegetation. Because of their broad distribution and migratory patterns, Florida manatees utilize a wider diversity of food items and are possibly less specialized in their feeding strategies than manatees in tropical regions (Lefebvre *et al.* 2000).

Feeding rates and food preferences depend, in part, on the season and available plant species. Bengtson (1981, 1983) reported that the time manatees spent feeding in the upper St. Johns River was greatest (6 to 7 hrs/day) before winter (August to November), least (3 to 4 hrs/day) in spring and summer (April to July), and intermediate (about 5 hrs/day) in winter (January to March). He estimated annual mean consumption rates at 33.2 kg/day/manatee or about 4 to 9% of their body weight per day depending on season (Bengtson 1983). At Crystal River, Etheridge *et al.* (1985) reported cumulative daily winter feeding times from 0 to 6 hrs. 10 min. based on observations of three radio-tagged animals over seven 24-hour periods. The estimated daily consumption rates by adults, juveniles, and calves eating hydrilla (*Hydrilla verticillata*) were 7.1, 9.6, and 15.7% of body weight per day, respectively.

Seagrasses appear to be a staple of the manatee diet in coastal areas (Ledder 1986; Provancha and Hall 1991; Kadel and Patton 1992; Koelsch 1997; Lefebvre *et al.* 2000). Packard (1984) noted two feeding methods in coastal seagrass beds: (1) rooting, where virtually the entire plant is consumed; and (2) grazing, where exposed grass blades are eaten without disturbing the roots or sediment. Manatees may return to specific seagrass beds to graze on new growth (Koelsch 1997; Lefebvre *et al.* 2000).

In the upper Banana River, Provancha and Hall (1991) found spring concentrations of manatees grazing in beds dominated by manatee grass (*Syringodium filiforme*). They also reported an apparent preference for manatee grass and shoalgrass (*Halodule wrightii*) over the macroalga *Caulerpa* spp. Along the Florida-Georgia border, manatees feed in salt marshes on smooth cordgrass (*Spartina alterniflora*) by timing feeding periods with high tide (Baugh *et al*. 1989; Zoodsma 1991).

G. REPRODUCTION

Breeding takes place when one or more males (ranging from 5 to 22) are attracted to an estrous female to form an ephemeral mating herd (Rathbun *et al*. 1995). Mating herds can last up to 4 weeks, with different males joining and leaving the herd daily (Hartman 1979; Bengtson 1981; Rathbun *et al*. 1995. Cited in Rathbun 1999). Permanent bonds between males and females do not form. During peak activity, the males in mating herds compete intensely for access to the female (Fig. 9; Hartman 1979). Successive copulations involving different males have been reported. Some observations suggest that larger, presumably older, males dominate access to females early in the formation of mating herds and are responsible for most pregnancies (Rathbun *et al.* 1995), but males as young as three years old are spermatogenic (Hernandez *et al.* 1995). Although breeding has been reported in all seasons, Hernandez *et al.* (1995) reported that histological studies of reproductive organs from carcasses of males found evidence of sperm production in 94% of adult males recovered from March through November. Only 20% of adult males recovered from December through February showed similar production.

Figure 9. Mating herd in Plummers Cove, St. Johns River, Jacksonville, Florida. (*Photograph by B. Brooks*)

Females appear to reach sexual maturity by about age five but have given birth as early as four (Marmontel 1995; Odell *et al.* 1995; O'Shea and Hartley 1995; Rathbun *et al.* 1995), and males may reach sexual maturity at 3 to 4 years of age (Hernandez *et al.* 1995). Manatees may live in excess of 50 years (Marmontel 1995), and evidence for reproductive senescence is unclear (Marmontel 1995; Rathbun *et al.* 1995). Catalogued Florida manatee CR 28, a wild manatee that overwinters in Crystal River, was last documented with a calf in 1998, at which time she was estimated to be at least 34 years of age (USGS-Sirenia, unpublished data). A captive animal, MSTm-5801, gave birth to a calf in 1990, at which time she was estimated to be 43 to 48 years of age (FWS, unpublished data). The length of the gestation period is uncertain but is thought to be between 11 and 14 months (Odell *et al.* 1995; Rathbun *et al.* 1995; Reid *et al.* 1995). The normal litter size is one, with twins reported rarely (Marmontel 1995; Odell *et al.* 1995; O'Shea and Hartley 1995; Rathbun *et al.* 1995).

Calf dependency usually lasts one to two years after birth (Hartman 1979; O'Shea and Hartley 1995; Rathbun *et al.* 1995; Reid *et al.* 1995). Calving intervals vary greatly among individuals. They are probably often less than 2 to 2.5 years, but may be considerably longer depending on age and perhaps other factors (Marmontel 1995; Odell *et al.* 1995; Rathbun *et al.* 1995; Reid *et al.* 1995). Females that abort or lose a calf due to perinatal death may become pregnant again within a few months (Odell *et al.* 1995), or even weeks (Hartman 1979).

H. THREATS TO THE SPECIES

The most significant problem presently faced by manatees in Florida is death or serious injury from boat strikes. The availability of warm-water refuges for manatees is uncertain if minimum flows and levels are not established for the natural springs on which many manatees depend, and as deregulation of the power industry in Florida occurs. Consequences of an increasing human population and intensive coastal development are long-term threats to the Florida manatee. Their survival will depend on maintaining the integrity of ecosystems and habitat sufficient to support a viable manatee population.

CAUSES OF DEATH (A summary of Cause of Death by region can be found in Appendix C). Data on manatee deaths in the southeastern United States have been collected since 1974 (O'Shea *et al.* 1985; Ackerman *et al.* 1995; FWC, unpublished data). Data since 1976 were used in the following summary (Table 3), as carcass collection efforts were more consistent following that year. They indicate a clear increase in manatee deaths over the last 25 years (Fig. 10, 6.0 % per year exponential regression between 1976 and 2000; Ackerman *et al.* 1995; FWC, unpublished data). Most of the increase can be attributed to increases in watercraft-related and perinatal deaths (Marine Mammal Commission 1993). However, it is unclear whether this represents a proportional increase relative to the overall population of manatees.

Natural causes of death include disease, parasitism, reproductive complications, and other non-human-related injuries, as well as occasional exposure to cold and red tide (O'Shea *et al.* 1985; Ackerman *et al.* 1995). These natural causes of death accounted for 17% of all deaths between 1976 and 2000 (FWC, unpublished data). Perinatal deaths accounted for 21% of all deaths in the same period. Human-related causes of death include watercraft collisions, manatees crushed in water control structures and navigational locks, and a variety of less-common causes. Human-related causes of death accounted for at least 31% of deaths between 1976 and 2000. Cause of death of some carcasses could not be determined, because they were too decomposed, the cause was medically difficult to determine, or the carcass was verified but not recovered. The cause of death for these carcasses was classified as undetermined (30% of deaths between 1976 and 2000).

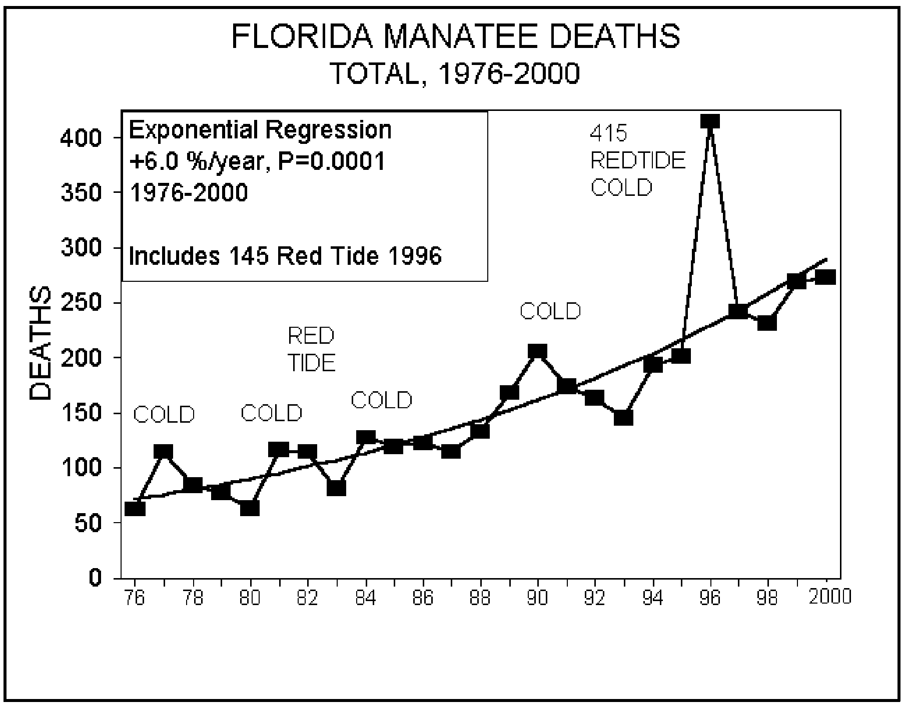


Figure 10. Florida manatee deaths from 1976 to 2000 with an exponential regression of +6.0% per year (FWC, unpublished data).

A prominent natural cause of death in some years is exposure to cold. Following a severe winter cold spell at the end of 1989, at least 46 manatee carcasses were recovered in 1990; cause of death for each was attributed to cold stress. Exposure to cold is believed to have caused many deaths in the winters of 1977, 1981, 1984, 1990, 1996, 2001 and have been documented as early as the 19th century (Ackerman *et al*. 1995; O'Shea *et al.* 1985; FWC, unpublished data).

In 1982, a large number of manatees also died coincidentally with a red tide dinoflagellate (*Gymnodinium breve*) outbreak between February and March in Lee County, Florida (O'Shea *et al.* 1991). At least 37 manatees died, perhaps in part due to incidental ingestion of filter-feeding tunicates that had accumulated the neurotoxin-producing dinoflagellates responsible for causing the red tide. In 1996, from March to May, at least 145 manatees died in a red tide epizootic over a larger area of southwest Florida (Fig. 11; Bossart *et al.* 1998; Landsberg and Steidinger 1998). Although the exact mechanism of manatee exposure to the red tide brevetoxin is unknown in the 1982 and 1996 outbreaks, ingestion, inhalation, or both are suspected (Bossart *et al.* 1998). The critical circumstances contributing to high red tide-related deaths are concentration and distribution of the red tide, timing and scale of manatee aggregations, salinity, and timing and persistence of the bloom (Landsberg and Steidinger 1998). It is difficult to manage for these rare but catastrophic causes of mortality.

Figure 11. Several of the 145 manatees that died during the red tide mortality event, Southwest Florida, 1996. (*Photographs by T. Pitchford*)

Perinatal deaths are carcasses of very small manatees (≤150 cm in length, O'Shea *et al.* 1995). Some are aborted fetuses; others are stillborn or die of natural causes within a few days of birth. Some may die from disease, reproductive complications, and/or congenital abnormalities. The cause of many perinatal deaths is difficult to determine, because these carcasses are generally in an advanced state of decomposition at the time they are retrieved. Most perinatal deaths appear to be due to natural causes; however, watercraft-related injuries or disturbance, or other human-related factors affecting pregnant and nursing mothers also may be responsible for a significant number of perinatal deaths. It has also been suggested that some may die from harassment by adult males (O'Shea and Hartley 1995). Between 1976 and 1999, perinatal deaths increased at an average of 8.8 % per year, increasing from 14% of all deaths between 1976 and 1980 to 22% between 1992 and 2000 (Ackerman *et al.* 1995; FWC, unpublished data).

The largest known cause of manatee deaths is collisions with the hulls and/or propellers of boats and ships. Between 1976 and 2000, watercraft-related deaths accounted for 24% of the total mortality and increased at an average of 7.2% per year: increasing from 21% of all deaths between 1976 and 1980; to 29% between 1986 and 1991; and 24% between 1992 and 2000 (Ackerman *et al.* 1995; FWC, unpublished data). Watercraft-related deaths were much lower in 1992 and 1993, but increased thereafter. From 1996 to 2000, the watercraft-related deaths have been the highest on record.

The next largest human-related cause of manatee deaths is entrapment or crushing in water control structures and navigational locks and accounts for 4% of the total mortality between 1976 and 2000 (Ackerman *et al.* 1995; FWC, unpublished data). These deaths were first recognized in the 1970s (Odell and Reynolds 1979), and steps have been taken to eliminate this source of death. Beginning in the early 1980s gate-opening procedures were modified; annual numbers of deaths initially decreased after this modification. However, the number of deaths subsequently increased, and in 1994, a record 16 deaths were documented. An ad hoc interagency task force was established in the early 1990s and now includes representatives from the South Florida Water Management District (WMD), U.S. Army Corps of Engineers (COE), FWS, Miami-Dade Department of Environmental Research Management (DERM), FWC and Florida Department of Environmental Protection (FDEP). This group meets several times a year to discuss recent manatee deaths and develop measures to protect manatees at water control structures and navigational locks. The overall goal is to eliminate completely structure-related deaths.

Other known causes of human-related manatee deaths include poaching and vandalism, entanglement in shrimp nets, monofilament line (and other fishing gear), entrapment in culverts and pipes, and ingestion of debris. These account for 3% of the total mortality from 1976 to 2000. Together, deaths attributable to these causes have remained constant and have accounted for a low percentage of total known deaths, i.e., about 4% between 1976 and 1980, 3% between 1981 and 1985, 2% between 1986 and 1991, and 2% between 1992 and 2000 (Ackerman *et al*. 1995; FWC, unpublished data). Entrapment in shrimp nets has been the largest component of this catch-all category. Eleven deaths were probably related to shrimping activities from 1976 to 1998 (7 in Florida, 4 in other states; Nill 1998). These deaths have become less common since regulations on inshore shrimping, the 1995 Florida Net Ban regulations, and education efforts about protecting manatees were implemented.

These data on causes of manatee deaths, and particularly the increasing number of watercraft-related deaths, should be viewed in the context of Florida's growing human population, which increased by 130% since 1970, 6.8 to 15.7 million (Florida Office of Economic and Demographic Research, 2001). The rise in manatee deaths during this period is attributable, in part, to the increasing number of people and boats sharing the same waterways. It should be noted that the increasing number of deaths could, in part, also be due to increasing numbers of manatees.

Table 3. Known manatee mortality in the southeastern United States reported through the manatee salvage and necropsy program, 1976 to 2000 (FWC, unpublished data).

Age Class	Adult/Subadult					Perinatal (≤150 cm)				Total
Cause / Year	Water-craft	Lock Gate	Other Human	Natural	Undeter-mined	Water-craft	Lock Gate	Other Human	Natural/ Undeter-mined	
1976	10	3	0	1	32	0	1	0	15	62
1977	13	6	5	1	79	0	0	1	10	115
1978	21	9	1	3	40	0	0	0	10	84
1979	22	8	8	4	24	2	0	1	9	78
1980	15	8	2	6	19	1	0	0	14	65
1981	23	2	4	9	65	1	0	0	13	117
1982	19	3	2	40	37	1	0	0	15	117
1983	15	7	5	6	30	0	0	0	18	81
1984	33	3	1	24	41	1	0	0	27	130
1985	35	3	3	20	39	0	0	0	23	123
1986	31	3	1	13	47	2	0	0	28	125
1987	37	5	3	15	23	2	0	1	31	117
1988	43	7	3	22	25	0	0	1	33	134
1989	50	3	4	32	45	1	0	1	40	176
1990	49	3	4	71	41	0	0	0	46	214
1991	52	9	6	15	39	1	0	0	53	175
1992	38	5	6	21	49	0	0	0	48	167
1993	35	5	7	24	36	1	0	0	39	147
1994	50	16	5	37	40	0	0	0	46	194
1995	43	8	5	35	55	0	0	0	57	203
1996	59	10	1	118	164	1	0	0	63	416
1997	52	8	8	46	67	3	0	1	61	246
1998	66	9	6	23	85	1	0	0	53	243
1999	83	15	7	43	69	0	0	1	56	274
2000	79	8	8	51	75	0	0	0	58	279
Total	973	166	105	680	1,266	18	1	7	866	4,082

THREATS TO HABITAT

WARM WATER One of the greatest threats to the continued existence of the Florida manatee is the stability and longevity of warm-water refuges. Historically, the sub-tropical manatee relied on the warm temperate waters of south Florida and on natural warm-water springs scattered throughout their range as buffers to the lethal effects of cold winter temperatures. With the advent of industrial plants and their associated warm-water discharges, manatees have expanded their winter range to include these sites as refuges from the cold. In the absence of these sources of warm water, manatees are vulnerable to cold temperatures and can die from both hypothermia and prolonged exposure to cold. Based upon recent synoptic survey data, just under two-thirds of the population of Florida manatees rely on industrial sites, which are now made up almost entirely of power plants (FWC unpublished data).

Overall, industrial warm-water refuges have been a benefit to manatees inasmuch as they have: (1) reduced the frequency of cold-related deaths by providing reliable sources of warm water during the winter; (2) reduced the incidence of juvenile, cold-weather related mortality in south Florida; and (3) provided additional winter refuges and foraging sites which supplant heavily-stressed wintering sites in south Florida. While these sites have clearly benefitted the species, they also pose a significant risk. During periods of extreme cold, some plants are unable to provide water warm enough to meet the manatees' physiological needs. Plants are also vulnerable to winter shutdowns due to equipment failures and needed maintenance and, in the long-term, have a limited life span. Older plants are less cost-effective to operate, and market economics will increasingly play a more significant role in the plants' operating schedules (FWS 2000).

In addition, natural wintering sites also have been affected by human activities (FWS 2000). Winter habitat in south Florida has been altered (e.g., shoreline areas have been rip-rapped and bulkheaded, sources of warm water have been diverted and/or capped, foraging and resting sites have been eliminated, etc.). Important springs in the northern area of the species' range have also been altered; demands for water for residential, industrial, and agricultural purposes from the aquifer have diminished spring flows, as have paving and water diversion projects in spring recharge areas. Nutrient loading (e.g., nitrates) from residential and agricultural sources has promoted the growth of alga and clouded water columns, thus reducing available winter forage in these refuges.

Alterations to both natural and industrial warm-water refuges will significantly affect the manatee's ability to tolerate and withstand the cold. In the absence of stable, long term sources of warm water and winter habitat, large numbers of manatees may succumb to the cold. Given the magnitude of the problem, the outright loss of these numbers of animals could significantly affect recovery efforts. The power industry and wildlife managers and researchers are currently working together to secure the manatee's winter habitat.

Other Habitat As discussed earlier in this document, Florida manatees are found in fresh, brackish, and marine environments in the southeastern United States. These areas include many habitat types (including vegetated freshwater bottoms, salt marshes, sea grass meadows, and many others) where manatees ably exploit the many resources found in these areas. As herbivores, manatees feed on the wide range of forage that these habitats provide. In addition, manatees utilize many other resources found in these areas, including: (1) springs and deep water areas for warmth; (2) springs and freshwater runoff sites for drinking water; (3) quiet, secluded tributaries and feeder creeks for resting, calving, and nurturing their young, (4) open waterways and channels as travel corridors, etc.

These habitats are affected by human activities. Dredge and fill activities, polluted runoff, propeller scarring, and other actions have resulted in the loss of vegetated areas and springs. Quiet backwaters have been made more accessible to human activities, and increasing levels of vessel traffic have made manatees increasingly vulnerable to boat collisions in travel corridors. Manatees seem to have adapted to some of these changes. For example, industrial warm-water discharges and deep-dredged areas are now used as wintering sites, stormwater pipes and freshwater discharges in marinas provide manatees with drinking water, and the imported exotic plant, hydrilla (which has replaced native aquatic species), has become an important food source at wintering sites.

While manatees may adapt to some changes, some activities clearly can have an adverse effect on the species. The loss of industrial warm-water discharges can result in the deaths of individuals using these sites. Dozens of manatees die each year due to collisions with watercraft. Other activities may also affect manatees, albeit on a much more subtle level. Harassment by boats and swimmers may drive animals away from preferred sites; the loss of vegetation in certain areas (e.g., as seen in winter foraging areas) requires manatees to travel greater distances to feed. Adequate feeding habitat associated with warm-water refuge sites is important to the overall recovery of the Florida manatee, however, it does not appear that warm season foraging habitat is limiting.

Efforts are in place and are being made to protect, enhance, and restore the manatee's aquatic environment. There are many existing federal, state, and local government regulations in place to minimize the effect of human activities on manatees and their habitat (e.g., Clean Water Act, Rivers and Harbors Act, ESA, Fish and Wildlife Coordination Act, Coastal Zone Management Act, etc.), and significant efforts are being made to improve this environment and to maintain those resources that are vital to the manatee. Also refer to the discussion in section I, **Habitat Protection**.

Contaminants and Pollution Effects The reliance of manatees on inshore habitats and their attraction to industrial and municipal outfalls have the potential to expose them to relatively high levels of contaminants. Despite this relationship, there have been few studies of contaminant levels and their effects on manatees. Available information suggests that direct effects are not significant at a population level. O'Shea *et al.* (1984) investigated levels of pesticides, polychlorinated biphenyls, mercury, lead, cadmium, copper, iron, and selenium in manatee tissues collected in the late 1970s and early 1980s. Of these, only copper levels in the liver were found to be notably high. The highest copper levels (1,200 ppm dry weight) were found in animals from areas of high herbicidal copper usage and exceeded all previously reported concentrations in livers of wild mammals. Despite these findings, there were no field reports of copper poisoning and no evidence of deleterious effects to individual animals. Ames and Van Vleet (1996) analyzed a small number of tissue samples for chlorinated hydrocarbons and petroleum hydrocarbons. None of the latter were found; however, pesticides (o,p-DDT, o,p-DDD, hexachlorobenzene, and lindane) were found in some of the liver, kidney, and blubber samples, but at very low concentrations and at a lower frequency of occurrence than in earlier studies. Contaminants, siltation and modified deliveries of fresh water to the estuary can indirectly impact manatees by causing a decline in submerged aquatic vegetation on which manatees depend.

Manatees ingest various debris incidental to feeding. Beck and Barros (1991) found monofilament fishing line, plastic bags, string, rope, fish hooks, wire, rubber bands, and other debris in the stomachs of 14.4% of 439 manatees recovered between 1978 and 1986. Monofilament line was the most common item found. In most cases, ingested items do not appear to affect animals. However, ingested monofilament line has resulted in death due to blockage of the digestive system (Forrester *et al.* 1975; Buergelt *et al.* 1984). A few deaths were caused by ingesting wire, which perforated the stomach lining, and plastic sheeting, which blocked the digestive tract (Laist 1987). Discarded monofilament line and rope were found wrapped around flippers, sometimes leading to serious injury or death (Beck and Barros 1991). Records of scarred or mutilated flippers on free-ranging manatees known from the photo-ID catalog and rescue events suggest that female manatees are more vulnerable than males to entanglement in fishing gear (Beck and Lefebvre 1995).

I. PAST AND ONGOING CONSERVATION EFFORTS

Under the guidance of previous manatee recovery plans, federal agencies, state agencies, local agencies and private organizations have initiated cooperative actions to address the important conservation needs, which this plan builds upon. Some of the major initiatives are reviewed below.

EFFORTS TO REDUCE WATERCRAFT-RELATED INJURIES AND DEATHS The largest identified cause of manatee death is collisions with watercraft. Many living manatees also bear scars or wounds from vessel strikes. An analysis of injuries to 406 manatees killed by watercraft and recovered between 1979 and 1991 found that 55% were killed by impact, 39% were killed by propeller cuts, 4% had both types of injuries, either of which could have been fatal, and 2% with unidentified specifics (Wright *et al.* 1995). Between 1976 and 2000, the total number of carcasses (i.e., deaths due to all causes) collected has increased at a rate of 6.0 percent per year, while deaths caused by watercraft strikes increased by 7.2 percent per year (Fig. 12). Because watercraft operators cannot reliably detect and avoid hitting manatees, federal and state managers have sought to limit watercraft speed in areas where manatees are most likely to occur to afford both manatees and boaters time to avoid collisions.

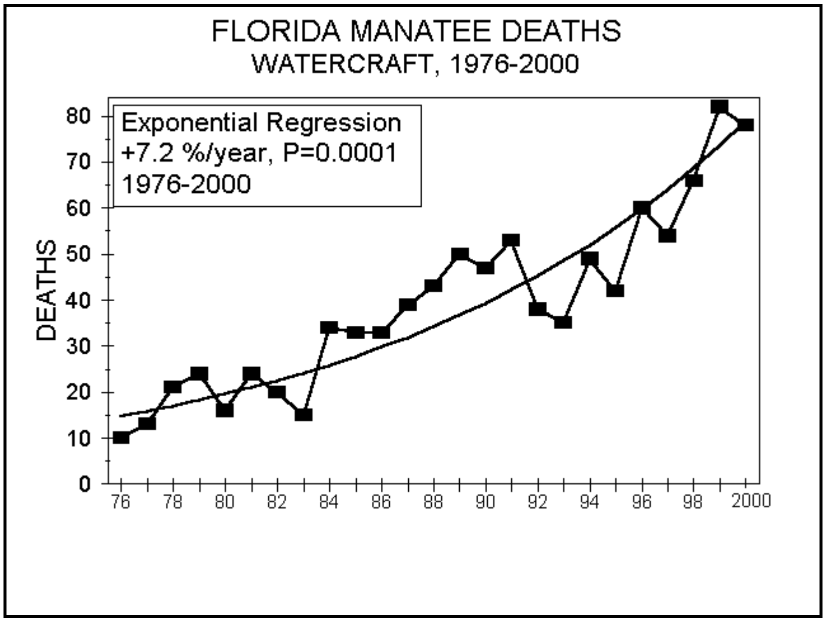


Figure 12. Florida manatee watercraft deaths from 1976 to 2000 with an exponential regression increase of 7.2% per year (FWC, unpublished data).

In 1989, the Florida Governor and Cabinet approved a series of recommendations by the former FDNR to improve protection of manatees in 13 key counties. For the next ten years, state and local governments cooperated in the creation and implementation of four county Manatee Protection Plans and 12 county-wide manatee protection speed zone rules. In 1999, Florida's manatee research and management programs were transferred to the newly created FWC. FWC approved comprehensive manatee protection rules in Lee County, completing the speed zone component of the initiative started in 1989. As the State of Florida's initiative to establish manatee protection zones in the 13 key counties is completed, attention is now focused on the development and approval of key county manatee protection plans.

Two types of manatee protection areas also have been developed by FWS: (1) manatee sanctuaries; and (2) manatee refuges. Manatee sanctuaries are areas in which all waterborne activities are prohibited, and manatee refuges are areas where certain waterborne activities are restricted or prohibited (designation of refuges or sanctuaries, however, will not eliminate waterway property owner access rights). To date, FWS has established seven winter sanctuaries to protect manatees in association with the Crystal River National Wildlife Refuge (NWR). The most recent was a one-quarter-acre sanctuary established in 1997 at Three Sisters Spring run (Fig. 13).

Figure 13. Three Sisters Spring Manatee Sanctuary, Crystal River, Florida. Manatees within the sanctuary and tour boats (left) and snorklers (right) along the outer sanctuary boundary edge. (*Photographs by J. Kleen and C. Shaw*)

FWS and FWC continue to evaluate needs for additional protection areas that may be necessary to achieve recovery. The goal is to consider the needs of the manatee at an ecosystem level and to establish regulations to ensure that adequate protected areas are available throughout Florida to satisfy habitat requirements of the Florida manatee population with a view toward recovery. In addition, through the NWR System Administration Act, access rules for boats have been established by FWS to protect manatees within Merritt Island NWR.

In recent years, both the FWS and FWC have been using targeted enforcement strategies in an attempt to increase boater compliance with speed zones and ultimately reduce manatee injuries and death. FWS strategy has been to allocate significant enforcement manpower to specific areas on designated weekends. These enforcement teams travel to various locations around the state, with particular emphasis given to those zones within counties where there is a history of high watercraft-caused manatee deaths. FWC has increased its emphasis on enforcement and compliance with manatee speed zones by adding new officers, conducting law enforcement task force initiatives, increasing overtime, and increasing the proportion of law enforcement time devoted to manatee conservation.

In addition to manatee protection plans, manatee protection areas, and other efforts, managers, researchers, and the boating industry have investigated the use of various devices to aid in the reduction of watercraft-related manatee deaths. For example, the State of Florida funded an evaluation of propeller guards (Milligan and Tennant 1998). The state's evaluation concluded that these devices would reduce cutting damage associated with propellers when boats were operating at low speeds. However, when boats (including boats equipped with propeller guards) operate at high speeds, guards would be of little benefit because animals would continue to be killed by blunt trauma associated with impacts from boat hulls, lower units, and other gear. The U.S. Coast Guard (USCG) identified additional concerns, stating that propeller guards on small recreational vessels "may create more problems than they solve" and does not support their use on recreational vessels at this time (Carmichael 2001). There are propeller guard applications, however, that appear to work for certain large, commercial vessels; for example, the use of guards on C-tractor tugs has eliminated this specific source of manatee mortality at the Kings Bay Naval Submarine Base in St. Marys, Georgia. To prevent injuries to manatees, propeller guards are used on some rental and sight-seeing boats at Blue Spring and Crystal River.

Researchers have also begun to investigate the manatees' acoustic environment to better evaluate the animal's response to vessel traffic. This line of research needs to be thoroughly assessed for its potential as another management tool to minimize collisions between manatees and boats. Results from Gerstein (1999) indicate that manatees hear in the range from 500 Hz to 38 kHz and that inadequate hearing sensitivity at low frequencies may be a contributing factor to the manatees' ability to effectively detect boat noise to avoid collisions. One technology often discussed is an acoustic deterrence device mounted on a boat. Conceptually, this technological approach may sound like an answer to the manatee/watercraft issue. A number of problems have been defined with the use of acoustic deterrents. No alarm/warning device has yet been demonstrated to adequately protect wildlife or marine mammals. Additionally, concern has also been stated regarding the increase in background noise that these deterrents would add to an already noisy marine environment. It has not been determined what negative impacts this device would have on marine life and what effects it would have on animals that use acoustic cues for a variety of purposes. For these reasons, this technology needs to be thoroughly researched and assessed and managers need to evaluate the MMPA and ESA "take" issues related to implementing such technology.

Current research into the sensory capabilities of manatees is being supported at both the state and federal levels. The FWC contracted Mote Marine Laboratory to further test manatee sensory capabilities. One contract assessed the effects of boat noise in a more controlled environment. This study recorded the physical and acoustic reaction of a manatee to a pre-determined acoustical level. This study design will allow the development of a relationship between acoustic dosage and behavioral responses (vocal and visual displays; movements). Another contract study looked at acoustical propagation over various types of marine topography. In cooperation with Mote Marine Laboratory and the Woods Hole Oceanographic Institution, the FWC is also examining manatee behavioral response to watercraft using new technology, the DTAG, a digital acoustic tag which records acoustic attributes of the environment and detailed manatee movement simultaneously. A FWS contracted study to assess manatee behaviors in the presence of fishing gear and their response to novelty and the potential for reducing gear interactions has an acoustic component. The FWC also received funding to support the development and implementation of technological solutions for reducing the risks that watercraft pose to manatees. They recently issued a Request for Proposals (RFP) to specifically address manatee avoidance technology.

Currently, priority actions in manatee conservation and protection include boater education, enforcement, maintenance of signs and buoys, compliance assessment, and periodic re-evaluation of the effectiveness of the rules. Such work requires close cooperation between FWC Bureau of Protected Species Management (BPSM), FWC's Division of Law Enforcement (DLE), county officials, the Inland Navigation Districts, FWS, USCG, and, of course, boaters.

EFFORTS TO REDUCE FLOOD GATE AND NAVIGATION LOCK DEATHS Entrapment in water-control structures and navigational locks is the second largest cause of human-related manatee deaths. In some cases, manatees appear to have been crushed in closing gates; in others, they may have been drowned after being pinned against narrow gate openings by water currents rushing through openings. Water-control structures implicated in manatee deaths in Dade and Broward counties are operated by the South Florida WMD. From 1976 through 2000, 166 manatees have been killed in water control structures in Dade County alone, accounting for 33% of all manatee deaths in this county.

The COE operates five water-control structures in conjunction with navigational locks along the Okeechobee Waterway and also operates the Port Canaveral Lock, located in Brevard County. FDEP operates locks and water-control structures associated with the Cross Florida Greenway.

In the early 1980s, steps were taken to modify gate-opening procedures to ensure openings were wide enough to allow a manatee to pass through unharmed. Steps were also initiated to fence off openings and cavities in gate structures where manatees might become trapped. Manatee deaths subsequently declined and remained low for much of the 1980s (Table 2). Since the 1996 Recovery Plan, much progress has been made toward identifying, testing, and installing manatee protection devices at water control structures. The COE Section 1135 Study, "Project Modification on Manatee Protection at Select Navigation and Water Control Structures, Part I," has been completed and the technology developed and successfully tested. Consequently, since 1996, pressure sensor devices have been installed at the five water control structures. Three recent deaths at two of the modified South Florida Water Management District water control structures suggests that these type of protective measures will continue to need on-going maintenance, review and refinement. The COE has also installed removable barriers on the upstream side of the Ortona and St. Lucie Lock spillway structures. The large difference in the up and downstream water levels at these structures compromises the effectiveness and use of pressure sensor devices. Such barriers will be considered for other structures where appropriate. A task force, established in 1991, comprised of representatives from the South Florida WMD, COE, FWC, FDEP, DERM, and FWS, continues to monitor, examine and make recommendations to protect manatees at water control structures and navigational locks.

The COE completed the "Section 1135 Project Modification Report on Manatee Protection at Select Navigation and Water Control Structures, Part II," which investigated several alternatives to protect manatees at locks. The COE contracted with the Harbor Branch Oceanographic Institute (HBOI) to develop and install a prototype acoustic array for manatee protection at lock gates. HBOI completed system design, and during 1999 the St. Lucie Lock was equipped with this manatee protection system (Fig. 14). This system consists of a device that is installed on the lock gates and detects the presence of manatees through acoustic signals. When a manatee is detected near the gate during the last 52 inches of closure, an alarm sounds; the gate stops closing and is then re-opened back to 52 inches. An upgraded version of this same type of system also has been installed at Port Canaveral Lock. Future plans are to install protective systems at the following locks: Moore Haven, Ortona, and Port Mayaca.


Figure 14. Water control structure retrofitted with pressure sensitive technology (left). Retrofitting of St. Lucie Lock with acoustic sensors (right) to protect manatees from being crushed as the gates close. (*Photographs by FWS and B. Brooks*)

FDEP currently is designing and preparing to install barriers at the Kirkpatrick Dam (Putnam County), and on the tainter valve culvert pipes at Buckman Lock (Putnam County) and downstream side of Inglis Lock (Levy County); work is anticipated to be completed during 2001. FDEP also has contracted with HBOI to install an acoustic array system at Buckman Lock, similar to arrays installed at the COE's Port Canaveral and St. Lucie Locks. Upon completion of the manatee protection systems at the Rodman Reservoir (Putnam County), FDEP plans to reopen Buckman Lock for operation. Currently the FDEP's Inglis Lock at Lake Rouseau/Withlacoochee River is not operating; long-term plans are to replace Inglis Lock with a smaller one with a manatee protection system installed.

HABITAT PROTECTION Intensive coastal development throughout Florida poses a long-term threat to the Florida manatee. There are three major approaches to address this problem. First, FWS, FWC, Georgia Department of Natural Resources (GDNR), and other recovery partners review and comment on applications for federal and state permits for construction projects in manatee habitat areas and to minimize their impacts. Under section 7 of the ESA, FWS annually reviews hundreds of permit applications to the COE for construction projects in waters and wetlands that include or are adjacent to important manatee habitat. FWC and GDNR provide similar reviews to their respective state's environmental permitting programs.

A second approach is the development of county manatee protection plans. The provisions of these plans are anticipated to be implemented through amendments to local growth management plans under the Florida's Local Government Comprehensive Planning and Land Development Regulation Act of 1985. In addition to boat speed rules, manatee protection plans are to include boat facility siting policies and other measures to protect manatees and their habitat. To date, five counties (Citrus, Collier, Dade, Duval, and Indian River counties) have completed manatee protection plans, which the State of Florida has approved, and other counties' plans are in varying stages of development. Of the five completed plans, FWS has approved only two, those of Citrus and Dade.

A third approach to habitat protection is land acquisition. Both FWS and the State of Florida have taken steps to acquire and add new areas containing important manatee habitat to federal and state protected area systems. The State of Florida has acquired important areas through several programs, most notably the Florida Forever Program (formerly the Conservation and Recreational Lands Program). In Florida, the Governor and Cabinet have included special consideration for purchase of lands that can be of benefit to manatees and their habitat. Over $500 million has been spent to acquire 250,000 acres, whose importance included, but was by no means limited to, protection of manatee habitat. Particularly important purchases have been made along and near the Crystal River, at Rookery Bay, the Sebastian River, and near Blue Spring. FWS has also acquired and now manages thousands of acres of land important to manatees and many other species in the NWR System. In addition to these efforts, FWS's initiative to propose new manatee refuges and sanctuaries factors into habitat protection. Both the State of Florida and FWS are continuing cooperative efforts with a view towards establishing a network of important manatee habitats throughout Florida.

MANATEE RESCUE, REHABILITATION AND RELEASE Thousands of reports of distressed manatees purportedly in need of assistance have been made to the state wildlife enforcement offices and other resource protection agencies by a concerned public. While most of the manatees do not require assistance, dozens of manatees are rescued and treated each year. A network of state and local agencies and private organizations (Fig. 15), coordinated by FWS, has been rescuing and treating these animals for well over twenty years.

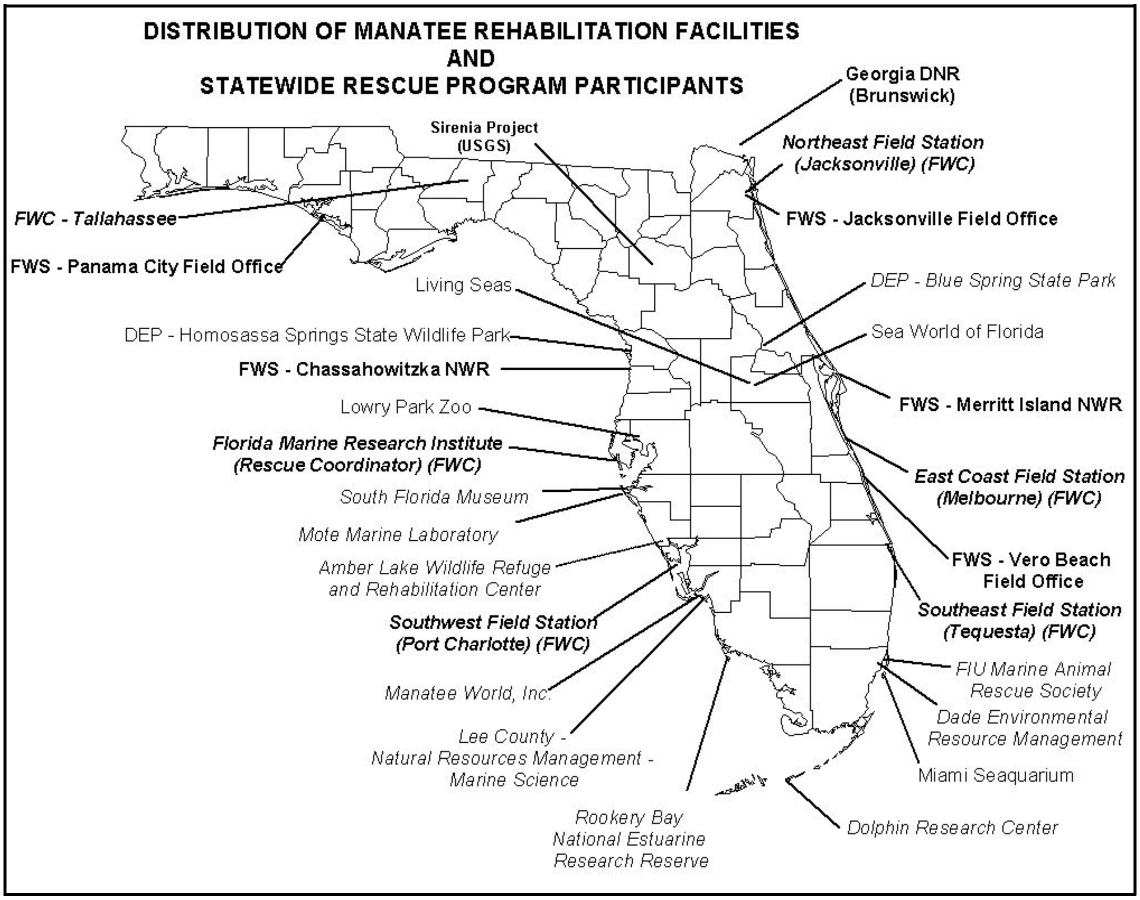


Figure 15. Locations of participants in the manatee rescue, rehabilitation, and release program.

Manatees are brought into captivity when stressed by cold weather, when struck and injured by watercraft, when injured because of entanglements in crab traps and monofilament fishing line, when orphaned, and when compromised by other natural and man-made factors. Program veterinarians and staff have developed treatments and protocols for these animals and have been remarkably successful in their efforts to rehabilitate compromised individuals (Fig. 16). Since 1973, over 180 manatees have been treated and returned to the wild (FWS unpublished data).

Treatments and protocols developed for these distressed animals have provided notable insights into the physiology and behavior of manatees. In certain settings, captive manatees are used in research; captive studies have provided a wealth of information on sensory capacities, digestion, reproduction, etc. Information obtained through treatments and research, in addition to the number of animals released back into the wild each year, contributes significantly to efforts to reduce mortality and further the recovery of the species.

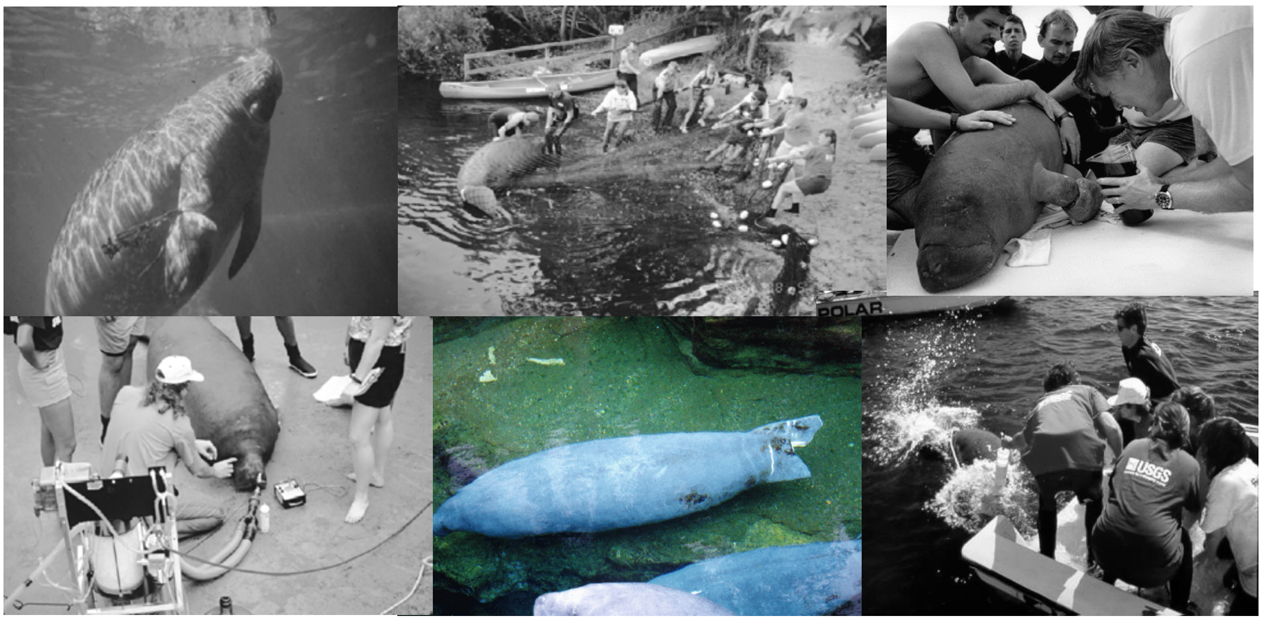


Figure 16. Manatee rescue, rehabilitation, and release program. (*Photographs by G. Rathbun, C. Shaw, J. Reid, Miami Seaquarium, J. Pennington, and J. Reid*)

Media coverage of manatee rescues, treatments, and releases helps to educate millions of people about manatees, the life-threatening problems that they face, and actions that can be taken to minimize the effect of anthropogenic activities on this species. In addition, more than eighteen million visitors a year see manatees at rehabilitation facilities and participate in manatee education programs sponsored by several parks. The publicity and outreach inherent in this program provide significant support to efforts to recover the manatee.

PUBLIC EDUCATION, AWARENESS, AND SUPPORT Government agencies, industries, oceanaria and environmental groups have all contributed to manatee public awareness and education efforts that were initiated in the 1970s. These efforts have expanded in scope and increased in quantity since that time. Some key counties in Florida also have started the education component of their manatee protection plans.

These public awareness and education efforts encourage informed public participation in regulatory and other management decision-making processes and provide constructive avenues for private funding of state manatee recovery programs, research, and land acquisition efforts through programs such as the specialty automobile license tag for manatees. This particular funding source has resulted in substantial savings in federal and state tax revenues and has permitted important work to proceed which likely would not have been possible in their absence.

The public has been made aware of new information on the biology and status of manatees, urgent conservation issues, and the regulations and measures required to assure their protection through the production of brochures, posters, films and videos, press releases, public service announcements and advertisements, and other media-oriented materials. Outdoor signs have been produced that provide general manatee information and highlight the problems associated with feeding manatees.

Manatee viewing opportunities have also been made available to the public. In addition, volunteers from several organizations annually give presentations to schools and other groups and distribute educational materials at festivals and events. Such efforts are essential for obtaining public compliance with conservation measures to protect manatees and their habitats.

Many public awareness materials have been developed specifically focusing on boater education. Public awareness waterway signs are produced and distributed alerting boaters to the presence of manatees. Brochures, boat decals, boater's guides, and other materials with manatee protection tips and boating safety information have been produced and are distributed by law enforcement groups, through marinas, and boating safety classes. Educational kiosks have been designed and installed at marinas, boat ramps, and other waterfront locations. Fishing line collection sites and cleanup efforts are being established. In addition, the Manatee Awareness Coalition of Tampa Bay and Crystal River NWR have initiated programs for on-water manatee public awareness.

Several agencies and organizations provide educator's guides, posters, and coloring and activity books to teachers in Florida and across the United States. In addition, Save The Manatee Club (SMC) and FWC Advisory Council on Environmental Education have produced a video for distribution to schools throughout Florida and the United States. SMC and FWC also provide free manatee education packets to students and staff interviews for students. Agencies and organizations help to educate law enforcement personnel about manatees and inform them about available outreach materials that can be distributed to user groups.

Public interest in manatee conservation also has grown internationally. Manatee education and public awareness materials are distributed in Central and South America and the wider Caribbean, as well as to numerous other countries around the world.

PART II. RECOVERY

The goal of this revised recovery plan is to assure the long-term viability of the Florida manatee in the wild, allowing initially for reclassification from endangered to threatened status (downlisting) and ultimately removal from the List of Endangered and Threatened Wildlife (delisting).

This section of the Recovery Plan presents: (A) details on an upcoming status review; (B) objective and measurable recovery criteria; (C and D) site-specific management actions to monitor and reduce or remove threats to the Florida manatee; and (E) Literature Cited. The steps for reclassification and removal from the list are consistent with provisions specified under sections 4(a)(1), 4(b), 4(c)(2)(B), and 4(f)(1) of the ESA. The FWS must, to the maximum extent practicable, incorporate into each recovery plan objective, measurable recovery criteria which, when met, would result in a determination that the species be removed from the List of Endangered and Threatened Wildlife. In designing these criteria, the FWS has addressed the five statutory listing/recovery factors (section 4(a)(1) of the ESA, (see page 1) to the current extent practicable.

A. STATUS REVIEW

The 1967 Federal Register Notice (32FR406) designating the West Indian manatee and several other species as "endangered" did not provide a detailed explanation for the listing. Since the manatee was designated as an endangered species prior to enactment of the ESA (1973), there was no formal listing package identifying threats to the species, as required by Section 4(a)(1). Under section 4(c)(2) of the ESA, the FWS is charged with periodically reviewing the the status of species included in the List of Endangered and Threatened Wildlife to determine whether any species should change in status from a threatened species to an endangered species, change in status from an endangered species to a threatened species, or be removed from the List.

During the 20 years since approval of the first manatee recovery plan, a tremendous amount of knowledge has been gained about manatee biology and ecology and significant protection programs have been implemented. The knowledge and the results of these protection programs are reflected in this recovery plan. The Manatee Population Ecology and Management Workshop scheduled for April 2002 will update and review the science and population ecology of manatees, including an assessment of the recovery criteria presented in this plan. The FWS has determined that the year following this workshop is an appropriate time to conduct a thorough status review of the Florida manatee and anticipates this review to take place in 2003.

The review will include:

(1) a detailed evaluation of the population status using the most up to date demographic data and other biological indices available (The FWS anticipates that much of this data will come from the April 2002 Manatee Population Ecology and Management Workshop);
(2) an evaluation of the status of manatee habitat as it relates to recovery;
(3) an evaluation of the existing threats to the species and the effectiveness of existing mechanisms to reduce or remove those threats (e.g., adequate protection areas, signage, enforcement, education and compliance have resulted in a reduction or minimization of watercraft deaths) as prescribed in this recovery plan;
(4) recommendations, if any, regarding reclassification of the Florida manatee; and
(5) if necessary, recommendations to update or modify recovery criteria.

B. RECOVERY CRITERIA

RECLASSIFICATION FROM ENDANGERED TO THREATENED (DOWNLISTING)

The near and long term threats from human-related activities are the reasons for which the Florida manatee currently necessitates protection under the ESA. The focus of recovery is not on how many manatees exist, but instead the focus is on implementing, monitoring and addressing the effectiveness of conservation measures to reduce or remove threats which will lead to a healthy and self-sustaining population. The Florida manatee could be considered for reclassification from endangered to threatened status if the following listing/recovery and demographic criteria are met:

LISTING/RECOVERY FACTOR CRITERIA: Tasks listed with each criterion are examples of actions that may reduce or remove the identified threats and were developed from recovery team discussions.

Listing/Recovery Factor A: The Present or Threatened Destruction, Modification, or Curtailment of a Species Habitat or Range (Habitat Working Group and Warm-water Task Force identified in other portions of this plan are tasked to further refine and improve these criteria.) In order to ensure the long-term recovery needs of the manatee and provide adequate assurance of population stability (i.e., achieving the demographic criteria), threats to the manatee's habitat or range must be reduced or removed. This can be accomplished through federal, state or local regulations (identified in Factor D below) to establish minimum spring flows and protect the following areas of important manatee habitat:

a. Minimum flow levels to support manatees at the Crystal River Spring Complex, Homosassa Springs, Blue Springs, Warm Mineral Spring, and other spring systems as appropriate, in terms of quality (including thermal) and quantity have been identified by the WMDs or other organizations.(Task 3.2.4.3)
b. A network of the level 1 and 2 warm-water refuge sites identified in Figure 7 are protected as either manatee sanctuaries, refuges or safe havens. (Task 1.2.3, 1.3, 3.2.2, 3.2.3, 3.2.4, 3.3.1)
c. Feeding habitat sites (extent, quantity and quality) associated with the network of warm-water refuge sites above in (b) have been identified by the HWG for protection. (Task 3.1(3), 3.3.8).
d. A network of migratory corridors, feeding areas, calving and nursing areas are identified by the HWG to be protected as manatee sanctuaries, refuges and/or safe havens in the following Florida counties: Duval (including portions of Clay and St. Johns in the St. Johns River), Volusia, Brevard, Indian River, Martin, Palm Beach, Broward, Dade and Monroe on the Florida Atlantic Coast; Citrus, Pinellas, Hillsborough, Manatee, Sarasota, Charlotte, Lee and Collier on the Florida Gulf Coast; and Glades County on the Okeechobee Waterway. (Task 1.3, 3.3.1)

Listing/Recovery Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes "Take" in the form of harassment, is currently occurring at some of the winter refuge sites and other locations. This "take" is presently not authorized under the MMPA or ESA. However, there are no data at this time to indicate that this issue is limiting the recovery of the Florida manatee. The actions in this plan that address harassment are recommended in order to achieve compliance with the MMPA and ESA and as a conservation benefit to the species. Statutory mechanisms outlined in Factor D to protect and enact protection regulations for important manatee habitats identified in Factor A and enact regulations to address unauthorized "take" identified in Factor E, will also assist to reduce or remove these threats.

Recovery actions and their subtasks specifically addressing this issue are 1.1, 1.11, 4.4 and those tasks identified in Factors A, D and E.

Listing/Recovery Factor C: Disease or Predation At this time, there are no data indicating that this is a limiting factor, thus no reclassification (downlisting) criteria are necessary.

Listing/Recovery Factor D: The Inadequacy of Existing Regulatory Mechanisms The current legal framework outlined below allows federal and state government agencies to take both broad scale and highly protective action for the conservation of the manatee and its habitat. The FWS believes these regulatory mechanisms are adequate for recovery. However, additional specific actions under these laws such as those listed pursuant to Factor A and E must be accomplished (as well as meeting the demographic criteria) before the FWS will consider this species for reclassification.

Factor A (a) Establish Minimum Flows (Task 3.2.4.3)

STATE Florida Water Resources Act of 1972, Chapter 373, F.S. (specifically Minimum Flows and Levels, Sect. 370.42, F.S. and Establishment and Implementation of Minimum Flows and Levels, Sect. 370.421, F.S.)

Factor A (b)(c) and (d) Protect Important Manatee Habitats (Task 1.2, 1.3.1, 1.3.2, 1.4, 3.2.2, 3.2.3, 3.2.4, 3.3.1, 3.3.8)

FEDERAL Endangered Species Act; Marine Mammal Protection Act; Clean Water Act, Sect. 401, 402 and 404; Rivers and Harbors Act, Sect. 10; National Environmental Policy Act; and Coastal Zone Management Act;

STATE Florida Manatee Sanctuary Act, Sect. 370.12(2), F.S.; Florida Water Resources Act of 1972, Chapter 373, F.S.; Florida Air and Water Pollution Control Act, Chapter 403, F.S.; State Lands, Chapter 253, F.S.; and State Parks and Preserves, Chapter 258, F.S.; and

LOCAL Florida Manatee Sanctuary Act, Sect. 370.12(o), F.S. which allows local governments to regulate by ordinance, motorboat speed and operations to protect manatees.

Factor E (a)(b)(c) Reduce or Remove Unauthorized "take" (Task 1.1, 1.2, 1.3.1, 1.3.2, 1.4, 1.6, 1.7, 3.3.1)

FEDERAL Marine Mammal Protection Act; and Endangered Species Act; and

STATE Florida Manatee Sanctuary Act, 370.12(2), F.S.

Listing/Recovery Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence The most predictable and controllable threat to manatee recovery remains human-related mortality. In order to ensure the long-term recovery needs of the manatee and provide adequate assurance of population stability (i.e., achieving the demographic criteria), natural and manmade threats to manatees need to be reduced or removed. This can be accomplished through establishing the following federal, state or local regulations, tasks and guidelines to reduce or remove human caused "take" of manatees:

a. State safe havens and/or federal manatee refuges have been established by regulation and are being adequately enforced to reduce unauthorized watercraft-related "take" in the following Florida counties: Duval (including portions of Clay and St. Johns in the St. Johns River), Volusia, Brevard, Indian River, Martin, Palm Beach, Broward, Dade and Monroe on the Florida Atlantic Coast; Citrus, Pinellas, Hillsborough, Manatee, Sarasota, Charlotte, Lee and Collier on the Florida Gulf Coast; and Glades County on the Okeechobee Waterway. (Task 1.3, 1.4, 1.5, 3.3.1)
b. One half of the water control structures and navigational locks listed as needing devices to prevent mortality have been retrofitted. (Task 1.6)
c. Guidelines have been drafted to reduce or remove threats of injury or mortality from fishery entanglements and entrapment in storm water pipes and structures. (Task 1.7, 1.6.3)

DEMOGRAPHIC CRITERIA: The annual synoptic surveys have too many weaknesses to reliably guage the health of the population (see discussion of Population Size in the Introduction and in Appendix D). Therefore, the FWS has established population related benchmarks for certain aspects of manatee demographics (based upon mark/recapture studies and population modeling) that it will use to help determine the success of manatee conservation efforts. These are derived from the MPSWG's Recommendation for Population Benchmarks To Help Measure Recovery (Appendix A). While these benchmarks are dependent on the amount and statistical reliability of the data available, we believe these "vital signs" are currently the best scientific indicators of the overall health of the manatee population. If future scientific studies indicate that other survival, reproduction, or population growth rates or other population indices are more appropriate for demographic recovery criteria, the FWS will modify these benchmarks.

The current benchmarks are as follows:

a. statistical confidence that the average annual rate of adult manatee survival is 90 % or greater;
b. statistical confidence that the average annual percentage of adult female manatees accompanied by first or second year calves in winter is 40% or greater; and
c. statistical confidence that the average annual rate of population growth is equal to or greater than zero.

These population benchmarks should be achieved with a 95% level of statistical confidence. When they are achieved in each of the four regions for the most recent ten year period of time (approximately one manatee generation), we may conclude that the manatee is not in danger of extinction throughout all or significant portion of its range and reclassify to threatened, provided the listing/recovery factor criteria (outlined above) are also met.

REMOVAL FROM THE LIST OF ENDANGERED AND THREATENED WILDLIFE (DELISTING)
The Florida manatee could be considered for removal from the List of Endangered and Threatened Wildlife if the following listing/recovery and demographic criteria are met:

LISTING/RECOVERY FACTOR CRITERIA: Tasks listed with each criterion are examples of actions that may reduce or remove the identified threats.

Listing/Recovery Factor A: The Present or Threatened Destruction, Modification, or Curtailment of a Species Habitat or Range (The Warm-water Task Force and Habitat Working Group identified in other portions of this plan are tasked to further refine and improve these criteria.) In order to ensure the long-term recovery needs of the manatee and provide adequate assurance of population stability (i.e., achieving the demographic criteria), threats to the manatee's habitat or range must be reduced or removed. This can be accomplished through federal, state or local regulations to establish and maintain minimum spring flows and protect the following areas of important manatee habitat:

a. Minimum flow levels to support manatees at the Crystal River Spring Complex, Homosassa Springs, Blue Springs, Warm Mineral Spring, and other spring systems as appropriate, in terms of quality (including thermal) and quantity have been adopted by regulation and are being maintained.(Task 3.2.4.3)
b. A network of level 1, 2 and 3 warm-water refuge sites identified in Figure 7 have been protected as either manatee sanctuaries, refuges or safe havens. (Task 1.2.3, 1.3, 3.2.2, 3.2.3, 3.2.4, 3.3.1)
c. Adequate feeding habitat sites (extent, quantity and quality) associated with the network warm-water refuge sites identified by the HWG and are protected. (Task 3.1(3), 3.3.8).
d. The network of migratory corridors, feeding areas, calving and nursing areas identified by the HWG are protected as manatee sanctuaries, refuges or safe havens. (Task 1.3, 3.3.1)

Listing/Recovery Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes "Take" in the form of harassment, is currently occurring at some of the winter refuge sites and other locations. This "take" is presently not authorized under the MMPA or ESA. However, there are no data at this time to indicate that this issue is limiting the recovery of the Florida manatee. The actions in this plan that address harassment are recommended in order to achieve compliance with the MMPA and ESA and as a conservation benefit to the species. Statutory mechanisms outlined in Factor D to protect and enact protection regulations for important manatee habitats identified in Factor A and enact regulations to address unauthorized "take" identified in Factor E, will also assist to reduce or remove these threats.

Recovery actions and their subtasks specifically addressing this issue are 1.1, 1.11, 4.4 and those tasks identified in Factors A, D and E.

Listing/Recovery Factor C: Disease or Predation At this time, there are no data indicating that this is a limiting factor, thus no delisting criteria are necessary.

Listing/Recovery Factor D: The Inadequacy of Existing Regulatory Mechanisms The current legal framework outlined below allows federal and state government agencies to take both broad scale and highly protective action for the conservation of the manatee and its habitat. The FWS believes these regulatory mechanisms are adequate for recovery. However, additional specific actions under these laws such as those listed pursuant to Factor A and E must be accomplished (as well as meeting the demographic criteria) before the FWS will consider this species for removal from the List of Endangered and Threatened Wildlife.

Factor A (a) Establish Minimum Flows (Task 3.2.4.3)

STATE Florida Water Resources Act of 1972, Chapter 373, F.S. (specifically Minimum Flows and Levels, Sect. 370.42, F.S. and Establishment and Implementation of Minimum Flows and Levels, Sect. 370.421, F.S.)

Factor A (b)(c) and (d) Protect Important Manatee Habitats (Task 1.2, 1.3.1, 1.3.2, 1.4, 3.2.2, 3.2.3, 3.2.4, 3.3.1, 3.3.8)

FEDERAL Marine Mammal Protection Act; Clean Water Act, Sect. 401, 402 and 404; Rivers and Harbors Act, Sect. 10; National Environmental Policy Act; and Coastal Zone Management Act;

STATE Florida Manatee Sanctuary Act, Sect. 370.12(2), F.S.; Florida Water Resources Act of 1972, Chapter 373, F.S.; Florida Air and Water Pollution Control Act, Chapter 403, F.S.; State Lands, Chapter 253, F.S.; and State Parks and Preserves, Chapter 258, F.S.; and

LOCAL Florida Manatee Sanctuary Act, Sect. 370.12(o), F.S. which allows local governments to regulate by ordinance, motorboat speed and operations to protect manatees.

Factor E (a)(b)(c) Reduce or Remove Unauthorized “take” (Task 1.1, 1.2, 1.3.1, 1.3.2, 1.4, 1.6, 1.7, 3.3.1)

FEDERAL Marine Mammal Protection Act; and

STATE Florida Manatee Sanctuary Act, 370.12(2), F.S.

Listing/Recovery Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence The most predictable and controllable threat to manatee recovery remains human-related mortality. In order to ensure the long-term recovery needs of the manatee and provide adequate assurance of population stability (i.e., achieving the demographic criteria), natural and manmade threats to manatees need to be removed or removed. This can be accomplished through establishing the following federal, state or local regulations, tasks and guidelines to reduce or remove human caused "take" of manatees:

a. State, federal and local government manatee conservation measures (such as, but not limited to speed zones, refuges, sanctuaries, safe havens, enforcement, education programs, county MPPs etc.) have been adopted and implemented to reduce or remove unauthorized watercraft-related "take" in the following Florida counties: Duval (including portions of Clay and St. Johns in the St. Johns River), Volusia, Brevard, Indian River, Martin, Palm Beach, Broward, Dade and Monroe on the Florida Atlantic Coast; Citrus, Pinellas, Hillsborough, Manatee, Sarasota, Charlotte, Lee and Collier on the Florida Gulf Coast; and Glades County on the Okeechobee Waterway. These measures are not only necessary to achieve recovery, but may ultimately help to comply with the MMPA. (Task 1.3, 1.4, 1.5, 3.3.1).

   Stable or positive population benchmarks as outlined in the demographic criteria provide measurable population parameters that will assist in measuring the stabilization, reduction, or minimization of watercraft related "take." Two other indices (weight of evidence) will assist in measuring success include: (1) watercraft-related deaths as a proportion of the total known mortality; and (2) watercraft-related deaths as a proportion of a corrected estimated population. These and other indices should be monitored.

b. All water control structures and navigational locks listed as needing devices to prevent mortality have been retrofitted. (Task 1.6)
c. Guidelines have been established and are being implemented to reduce or remove threats of injury or mortality from fishery entanglements and entrapment in storm water pipes and structures. (Task 1.7, 1.6.3)

DEMOGRAPHIC CRITERIA: The ESA requires that the FWS, to the maximum extent practicable, incorporate into each recovery plan objective, measurable recovery criteria which, when met, would result in a determination that the species be removed from the List of Endangered and Threatened Wildlife. The MPSWG thus far has not proposed delisting criteria to the FWS "as specific, quantitative habitat criteria have yet to be developed" (Appendix A). In lieu of criteria from the MPSWG, the FWS will use the population benchmarks for reclassification (downlisting) to help determine the long-term success of manatee conservation efforts and recovery. While these benchmarks are dependent on the amount and statistical reliability of the data available, we believe these "vital signs" are currently the best scientific indicators of the overall health of the manatee population. If future scientific studies indicate that other survival, reproduction, or population growth rates or other population indices are more appropriate for demographic recovery criteria, the FWS will modify these benchmarks.

Those benchmarks are as follows:

a. statistical confidence that the average annual rate of adult manatee survival is 90 % or greater;
b. statistical confidence that the average annual percentage of adult female manatees accompanied by first or second year calves in winter is 40% or greater; and
c. statistical confidence that the average annual rate of population growth is equal to or greater than zero.

These benchmarks should be achieved with a 95% level of statistical confidence. When they are achieved in each of the four regions for an additional 10 years after reclassification (an additional manatee generation), we may conclude that the population is healthy and will sustain itself such that the Florida manatee could be removed from the List of Endangered and Threatened Wildlife provided the listing/recovery factor criteria (outlined above) are also met.

C. OUTLINE OF RECOVERY ACTIONS ADDRESSING THREATS

D. NARRATIVE OUTLINE OF RECOVERY ACTIONS

OBJECTIVE 1: Minimize causes of manatee disturbance, harassment, injury, and mortality. Manatees are killed and injured as a result of interactions with boats, water control structures, navigational locks, stormwater pipes, marine debris, and fishing gear. In rare cases, manatees are killed by vandals and poachers. Additional mortalities from natural causes, such as severe cold weather or red tide, may also significantly affect the status of the manatee population. To permit maintenance and/or growth of the manatee population to attain recovery, such causes of mortality, injury, harassment and disturbance must be minimized. This section of the recovery plan identifies activities needed to minimize sources of disturbance, harassment, injury, and mortality.

1.1 Promulgate special regulations for incidental take under the MMPA for specific activities. FWS will evaluate its programs related to watercraft operation and watercraft access facilities and promulgate incidental take regulations under the MMPA for FWS activities (e.g., operation of vessels, managing surface waters and recreation on NWRs, and funding of boat ramps through Federal Aid). The process will lead to appropriate modification to FWS activities to ensure that such activities are minimized to the maximum extent practicable and ensure that these activities will have no more than a negligible impact on the manatee. FWS believes that programs of other federal and state agencies would benefit from a similar review and rule promulgation process.

1.2 Continue state and federal review of permitted activities to minimize impacts to manatees and their habitat. There are three separate processes where state and federal agencies provide biological review in order to minimize impacts to manatees and their habitat. These are: (1) review of permits for development activities (such as marinas, boat ramps, and other boat-related facilities) and dredge and fill activities; (2) review of permits for marine events (boat races and regattas); and (3) review of permits for power plants and other industrial outfalls (authorization to discharge warm water through the NPDES permit). FWS , FWC and GDNR should continue to participate in all of these review processes.

1.2.1 Continue to review coastal construction permits to minimize impacts. Dredge and fill activities and coastal construction of facilities such as marinas or large docks require permits from the COE, environmental resource permits from FDEP or the WMDs, and, in some cases, submerged land leases from Florida’s Board of Trustees, and in Georgia from the GDNR Coastal Resources Division. There are several aspects of these development projects that must be considered. First, the construction process itself should be conducted in a way to minimize the direct risk to manatees. Second, the permanent effect of the facility once it is built must be considered. For example, facilities should be designed to minimize shading of submerged aquatic plants. Third, the intended use or indirect effects of the project must also be considered. Marinas, boat ramps, and docking facilities can alter boat traffic patterns and increase boat traffic in specific areas, thus potentially increasing the possibility that manatees will be injured or killed. The effects of that traffic should be considered in the permit evaluation. Finally, the cumulative effect of multiple projects must be taken into account. While the impacts of a small single project may be negligible, multiple small projects may have a cumulative effect as great or greater than single large projects.

FWC will continue to provide assessments and recommendations on permit and submerged land lease applications to FDEP or appropriate WMD. GDNR Wildlife Resources Division will continue to provide assessments and recommendations on permit applications to the Coastal Resources Division. These permitting agencies have specific state statutory obligations to protect listed species and should use the recommendations provided by FWC and GDNR in meeting those obligations. In addition, FWC and GDNR will actively coordinate on an annual basis with the permitting agencies to ensure that the best data are available, that communication remains unimpeded, and that the review process is efficient and effective. FWS will continue to provide consultations, pursuant to section 7 of the ESA and other federal laws to the COE, USCG, and other federal agencies on permit applications where it has been determined that the activity may affect manatees or any other listed species and/or their habitat. This formal review process is a fundamental part of the manatee recovery program and must be continued. (Also refer to Task 3.3.5 regarding regulatory recommendations supporting habitat conservation.)

1.2.2 **Minimize the effect of organized marine events on manatees.** Marine sport events may also affect manatees, and many of these events require permits from the USCG. Under section 7 of the ESA and other federal laws, the FWS reviews and comments on permit applications where it has been determined that the activity may affect manatees or any other listed species. In order to provide guidance to the USCG regarding the types of events and the locations where manatee conditions are needed, standard draft guidelines were prepared. These are also intended to assist event planners involved in the planning process for boat races, fishing tournaments, water ski events, boat parades, and other organized boating events. The guidelines and standard conditions pertaining to when, where, and under what conditions such events could be held consistent with manatee protection objectives, should be updated and agreed upon by FWS and FWC. These guidelines should be distributed to the USCG groups in Florida. The USCG, in following those guidelines, should consult with FWS on appropriate events. FWC should provide technical expertise and data where needed to assist FWS in the review.

1.2.3 Continue to review NPDES permits to minimize impacts. The NPDES has been approved by the Environmental Protection Agency (EPA) to be implemented by FDEP and GDNR. Power plants and other industries that discharge into state waters are required to obtain a NPDES permit. In Florida, power plants that have the potential to affect manatees because of the attraction of a warm-water discharge are required to have a power plant manatee protection plan (MPP) as part of the permit. FWC works directly with the utilities in the development of the plan. FWC provides a recommendation to FDEP whether to accept, modify, or reject the MPP. FWS also reviews the plan and provides an assessment. This program ensures that issuance of the NPDES permit for discharge of warm water into ambient waters of the State of Florida by powerplants includes FWS- and FWC-approved plans. GDNR Nongame and Endangered Wildlife Program provides an assessment and recommendations to the GDNR Environmental Protection Division on NPDES permits in Georgia. This permit review process should be continued. (Task 3.2.2 provides further discussion of NPDES permits.)

1.2.4 Pursue regulatory changes, if necessary, to address activities that are "exempt," generally authorized, or not covered by state or federal regulations. FWS should look at non-regulated coastal construction projects or projects authorized under general permits to assess their cumulative impact on manatees. FWS should propose changes to existing regulatory programs as appropriate to minimize such impacts.

1.3 Minimize collisions between manatees and watercraft. Significant work is needed to monitor, review, assess needs to update existing protection zones (Task 2.7.2), develop new zones warranted in other areas, and make vessel operators aware of those zones. FWC has the responsibility for developing and amending state waterway speed and access rules to protect manatees. These rules aim to reduce the risk of collisions between manatees and watercraft by considering both manatee use patterns and the needs of the boating public. Further, under the authority of the ESA and MMPA and their implementing regulations at 50 CFR 17, FWS may designate certain waters as manatee protection areas, within which certain waterborne activities will be restricted or prohibited for the purpose of preventing the taking of manatees. Actions to address these needs are discussed below. In addition to these methods, alternative strategies minimizing collisions between manatees and watercraft should be investigated (Tasks 1.5.1, 1.5.2, 2.8.12, and 2.8.16).

1.3.1 **Develop and refine state waterway speed and access rules.** FWC is responsible for developing and amending state waterway speed and access rules to protect manatees under the State of Florida Manatee Sanctuary Act. FWC will monitor and review the effectiveness of existing zones and make appropriate modifications as needed. FWC will establish additional zones, as needed, to protect manatees throughout the state and implement where appropriate.

1.3.2 **Develop and refine federal waterway speed and access rules.** As necessary and appropriate, federal rules should be promulgated and existing rules should be modified in cooperation with the State of Florida and other concerned parties to protect the manatee. Particularly, waterways in or adjacent to NWRs, National Parks, and other federally-managed areas within manatee habitat should be protected as warranted. Under the authority of the ESA and MMPA and their implementing regulations at 50 CFR 17, FWS may establish boating speed and access rules in conjunction with efforts to designate certain waters as manatee sanctuaries (areas where all waterborne activities are prohibited), no entry areas or manatee refuges (areas where certain waterborne activities such as boat speeds may be regulated) (Task 3.3.1).

1.3.3 **Post and maintain regulatory signs.** The effective use of regulatory and informational signs is essential in providing the public with on-site information on manatee protection measures. Sign messages, to the greatest extent possible, should be uniform, understandable, and concise. Sign design and placement should provide for uniformity, rapid identification as a regulatory sign, and should be located at a site where it is readily observable to the target audience. Regulated areas should be posted by the appropriate agency. Of critical need is the continued effort to inspect and repair/replace signs as needed in an expedient manner. A task force, which includes the USCG, FWC, FWS, the navigation districts, and those counties with sign-posting responsibilities needs to be established. This task force should focus on improving the sign-posting and maintenance process and will explore innovative sign designs that would contribute to better compliance and enforcement.

1.4 **Enforce manatee protection regulations.** Enforcement is one the highest priorities for manatee recovery. Compliance with manatee protection regulations will reduce human-caused manatee mortality, particularly that caused by watercraft collisions. Effective enforcement of these regulations is needed to maximize protection efforts and to minimize manatee injuries and deaths.

(Also refer to Task 1.11 and its related tasks regarding enforcement of regulations prohibiting harassment).

1.4.1 Coordinate law enforcement efforts. Enforcement of manatee protection rules is provided by officers of FWS and FWC-DLE, USCG, and local law enforcement agencies, as well as the courts. To ensure compliance with the waterway speed and access rules and with manatee harassment provisions, enforcement capabilities must be expanded and coordinated. Although efforts have increased significantly during the past two years, manatee enforcement operations still must be expanded in both geographic scope and frequency. To meet these needs, federal and state enforcement agencies should take all possible steps to increase funding and heighten agency priority for manatee-related law enforcement activities. Those activities should be maintained at levels commensurate with those of vessel traffic, watercraft-related manatee deaths, and added enforcement responsibilities. To carry out enforcement activities as efficiently and cost-effectively as possible, involved agencies are encouraged to coordinate enforcement efforts. In addition, enforcement agencies should review and assist as possible with the development of new manatee protection statutes and regulations, the posting of manatee regulatory signs, enforcement training seminars, studies to monitor regulatory compliance, and actions by the judiciary to prosecute violations.

1.4.2 Provide law enforcement officer training. Law enforcement officers responsible for enforcing manatee regulations need to receive training in order to acquire knowledge and skills to enhance their abilities. Officers should be given training on manatee regulations during appropriate agency training courses. Refresher training should be conducted annually at appropriate opportunities.

1.4.3 Ensure judicial coordination. Designated personnel will meet periodically with members of the judiciary to ensure their knowledge of present manatee protection regulations or changes thereto, as well as to provide a forum for information exchange.

1.4.4 Evaluate compliance with manatee protection regulations. Compliance with manatee protection regulations is paramount to their subsequent success. FWS, FWC, and local governments should evaluate compliance with manatee protection regulations through research, surveys and other methods to ensure effectiveness and to identify needed improvements (Task 2.7.2.2.).

1.4.5 **Educate boaters about manatees and boater responsibility.** State-wide speed limits, boat operator licenses, and mandatory boater education will enhance efforts to reduce watercraft-related manatee deaths by offering opportunities to educate boaters about rules to protect manatees and to reduce boat speeds in other areas where manatees may occur. New proposals to establish state-wide boating safety measures should be encouraged. Particular efforts should be made to integrate manatee protection concerns into any new boater education programs (Tasks 4.1 through 4.3.). A website should be developed to allow the public and boating community easy access to manatee protection zone information (Task 4.2.2).

1.4.6 **Evaluate effectiveness of enforcement initiatives.** In recent years, both federal and state agencies have been using targeted enforcement strategies in an attempt to increase boater compliance with speed zones and ultimately reduce manatee injuries and death. FWS strategy has been to allocate significant enforcement manpower to specific areas on designated weekends. These enforcement teams travel to various locations around the state, with particular emphasis given to those zones within counties where there is a history of high watercraft-caused manatee deaths. FWC has increased its emphasis on enforcement and compliance with manatee speed zones by adding new officers, conducting law enforcement task force initiatives, increasing overtime, and increasing the proportion of law enforcement time devoted to manatee conservation. FWS and FWC should evaluate the effectiveness of these and other enforcement efforts and make adjustments, as appropriate. The research should evaluate if there are significant changes in boater compliance as a result of additional enforcement, and determine the residual effect of the enforcement efforts, if any.

1.4.7 **Provide updates of enforcement activities to managers.** It is important for managers to have a good understanding of enforcement activities and special initiatives in order to determine if the desired outcomes (reduction of manatee injury/death and enhanced public awareness and compliance) are achieved. In addition, up-to-date information on enforcement activities is needed for outreach and media contacts. As part of a new manatee enforcement initiative, FWC provides updates of manatee-related enforcement every other week to FWC managers. Such data summary and distribution should continue. Other law enforcement agencies also should provide similar updates of their special enforcement details. Information provided in the updates should be standardized across agencies so that a law enforcement database can be developed to provide information on effort, number of citations and/or other contacts, vessel registration, size, type, disposition of the case, and other pertinent information.

1.5 **Assess and minimize mortality caused by large vessels.** Large vessels (e.g., tugs and cargo vessels) and large displacement hull vessels are known to kill manatees. Some animals appear to be pulled into propeller blades by the sheer power of generated water currents, while others are crushed between the bottom and the hull of deep draft ships. When moored, large vessels also can crush manatees between their hulls and adjacent wharves or ships.

1.5.1 **Determine means to minimize large vessel-related manatee deaths.** Studies should be undertaken to: (1) further review mortality data for evidence of deaths attributable to large vessels; (2) examine barge, tug, and other large vessel traffic patterns relative to manatee distribution; (3) assess the feasibility and cost of installing propeller guards or shrouds on large displacement hull vessels or tugs routinely plying waterways used by manatees; (4) evaluate ways to educate harbor pilots about threats large vessels pose to manatees; and (5) identify other possible mitigation measures to minimize these threats. Actions to implement appropriate measures should be taken based on study findings.

1.5.2 **Provide guidance to minimize large vessel-related manatee deaths.** FWS and FWC will promote use of devices such as fenders to maintain minimum stand-off distances of four feet at maximum compression between moored vessels and between vessels and wharves to minimize manatee deaths. If studies support actions to address the threat of large vessel propeller-related incidences to manatees, it is recommended that propellers of large displacement hull vessels, particularly tugs that tend to remain in harbors or rivers, be retrofitted with a propeller guard or shroud to reduce these types of mortalities.

1.6 **Eliminate manatee deaths in water control structures, navigational locks, and drainage structures.** The second largest source of human-related manatee death is due to entrapment in water control structures and navigational locks. These structures are owned and operated by the WMDs, COE, and FDEP and are primarily located in South Florida. They have been responsible for an average of 10 manatee deaths per year since 1995 and a total of 167 deaths since 1976. An ad hoc interagency task force was established in 1991 (current members include South Florida WMD, COE, FWS, DERM, FWC, and FDEP) to examine steps to prevent such deaths. This group meets at least twice a year to discuss recent manatee deaths and measures to protect manatees from structure-related mortality. The overall goal is to eliminate completely structure-related deaths.

In addition to causing crushing deaths, manatees may become trapped in the extensive canal systems of south Florida. Manatees passing through open structures become trapped once the structures close, due to changing water conditions. Manatees trapped in the shallow canal systems are vulnerable to cold stress during the winter. An evaluation and mapping of manatee-accessible canals is needed, and actions should be taken to prevent manatee entry into these areas.

FWS also should assess the need for manatee protection technology and help to update standard operating procedures at the lock systems at Lake Moultrie, South Carolina and Lake Seminole, Florida/Georgia.

Entrapment in drainage structures such as pipes, culverts and ditches also lead to injury and death of manatees. Installation of barriers or guards on such structures can prevent future entrapments.

1.6.1 Install and maintain protection technology at water control structures where manatees are at risk and monitor success. Pressure sensor devices have been installed at the five water control structures in south Florida through a South Florida WMD/COE cooperative project. Although the success of these devices generally has been encouraging, two structures equipped with the device have failed to eliminate all manatee deaths at them. An investigation at S-25B, after two deaths in December 1999, revealed that modifications to the sensitivity were required to provide the needed protection for manatees; after a manatee death at S-27 in January 2000, the South Florida WMD moved the manatee sensor strips in an attempt to get them closer to the actual gate. Thus, while it has been demonstrated that manatees can be successfully protected through the installation of pressure devices at water control structures, it is possible that as more devices are installed and operated, occasional failures will occur until all site-specific maintenance and installation needs are identified and resolved.

Twenty identified water control structures should be equipped with a manatee protection system (MPS) (pressure devices or removable barriers) by the year 2004. Removable barriers should be installed at structures where the pressure sensor devices are not feasible or appropriate. Standard operating procedures to protect manatees also have been developed for periods when the barriers are removed for high flow or cleaning the debris off the barriers. MPSs will be installed at additional water control structures in the Central and South Florida Project on a case-by-case basis as part of the Comprehensive Everglades Restoration Plan (CERP), and standard operating procedures and the need for a MPS should be assessed and installed as needed for other structures in manatee habitat.

The FDEP is designing and preparing to install barriers at the Kirkpatrick Dam, the tainter valve culvert pipes at Buckman Lock, and the downstream side of Inglis Lock. FDEP anticipates to complete this work during the summer of 2001.

1.6.2 **Install and maintain protection technology at navigational locks where manatees are at risk and monitor success.** Manatee protection devices have been installed at the St. Lucie, Port Canaveral, and Taylor Creek Locks. The long-term plan is to continue installing these protective devices on the remaining locks in order of their potential to harm manatees until all such structures are equipped with manatee protection devices. The COE should continue to partner with local sponsors to accomplish this retrofitting as quickly as possible. The COE should prepare an annual report assessing the performance of the manatee protection devices and evaluating the needs for modification and improvement.

FDEP has contracted with HBOI to install an acoustic array system at Buckman Lock similar to arrays installed at the COE's Canaveral and St. Lucie Locks. FDEP plans to reopen Buckman Lock for operation once the manatee protection systems are installed on both the Buckman Lock and Kirkpatrick Dam. It is anticipated that these projects will be completed during the summer of 2001 (the State of Florida has also budgeted $800,000 to begin restoring the Oklawaha River). Currently FDEP's Inglis Lock at Lake Rouseau/Withlacoochee River is not operating; long-term plans are to replace the existing lock with a smaller one which includes manatee protection equipment.

1.6.3 **Minimize injuries and deaths attributable to entrapment in drainage structures.** Sites where manatees have been rescued or died due to entrapment in drainage structures should be identified and, as warranted, steps taken to install barriers or guards which prevent such entrapment at these culverts or drainage structures. Additionally, stormwater outfalls or similar drainage structures in aggregation areas should be retrofitted with appropriate barriers to prevent manatee entrapment. Federal, state, and local permits should require that new drainage structures (greater than 18 but less than 84 inches in diameter) in manatee habitat be grated or otherwise made inaccessible to manatees.

1.6.4 **Assess risk at existing and future water control structures and canals in South Florida.** Using existing data bases and/or field inspections, categorize all structures as to whether manatees could pass through the structure, and what level of risk the structure poses. Similarly, characterize all canals (including minor irrigation ditches and storm water connector canals) as to whether manatees have access. Based on interagency recommendations, some canals may be designated as off-limits to manatees. The South Florida WMD should establish manatee-safe barriers to prevent access to designated areas. The CERP will dramatically alter the water delivery system in south Florida. New canals and water retention areas will be created, and existing canals will be modified or eliminated. It is critical that the COE and South Florida WMD coordinate closely with FWS and FWC and consider impacts to manatees from this long-range restoration project. Only manatee-safe structures should be installed, and manatee access to newly-created areas should be evaluated by the interagency task force.

1.7 Minimize manatee injuries and deaths caused by fisheries and entanglement. Due to the dynamic nature of commercial and recreational fishing and gear, information on interactions with fishing techniques and gear should be kept under review by FWS, GDNR, and FWC, and measures to reduce or avoid such interactions should be taken. This review should also assess the impacts of the mariculture industry and develop recommendations to minimize impacts to manatees and habitat. To minimize adverse entanglement interactions, the following steps are needed. A working group, which was established in 1999 to address fishery and marine debris and to make recommendations to minimize impacts, should continue to meet regularly.

1.7.1 Minimize injuries and deaths attributed to crab pot fishery. With the recent increasing trend of manatee rescues from crab trap buoy lines, information on interactions with buoy lines should be kept under review by FWC and FWS, and steps should be taken to improve reporting and documentation of such incidents. Steps to identify and implement measures which would reduce or avoid such interactions should be taken, including research regarding gear interactions and ways to avoid them, outreach, and promulgation of regulations (e.g., gear modification) if necessary.

1.7.2 Minimize injuries and deaths attributed to commercial and recreational fisheries, gear, and marine debris. Sites where interactions with recreational and/or commercial fishing gear occur should be identified and, as warranted, steps should be taken to assess and implement actions to prevent potentially threatening interactions with fishing gear. Strategies to reduce monofilament entanglements also need to focus on educating the fishing community on properly discarding monofilament and provide an avenue for recycling it. Strategies also should encourage underwater and drift line debris clean-up of monofilament and other debris in popular fishing areas used by manatees (Task 2.7.4).

1.8 **Investigate and prosecute all incidents of malicious vandalism and poaching.** Poaching, shooting, butchering, and other malicious vandalism against manatees are rare occurrences. All reports and evidence regarding such incidents should be turned over to FWS law enforcement agents for investigation and prosecution to the fullest extent of the law.

1.9 **Update and implement catastrophic plan.** FWS and FWC Contingency Plans for Catastrophic Rescue and Mortality Events for the Florida Manatee should be reviewed annually and updated as needed by those who would be involved in the response. Additionally, guidance and notification procedures between FWC and FWS should be developed and updated as needed for events that do not reach unusual or catastrophic levels in order for such events to be documented.

1.10 **Rescue and rehabilitate distressed manatees and release back into the wild.** Thousands of reports have been provided by the public regarding sick, injured, orphaned, entrapped, and wayward manatees that appear to be in need of assistance. While many clearly do not require intervention, 30 to 40 manatees are rescued every year. Some are assisted and immediately released, while others are taken to one of three critical-care facilities for supportive treatment. Animals successfully treated are released, and to the extent possible, their progress is monitored through tagging and tracking studies. Publicity surrounding distressed manatees, their rescues, treatment, and outcome help to educate millions of people every year about manatees and the problems that they face. The number of manatees successfully treated and released back into the wild provides an important safeguard to the wild population of manatees.

1.10.1 **Maintain rescue network.** FWS is responsible for the rescue and rehabilitation network and coordinates this program through an endangered species/marine mammal enhancement permit. Participants are authorized to participate in the program through Letters of Authorization (LOAs) under the permit held by FWS Jacksonville Field Office. Letter holders: (1) verify the status of manatees reportedly in distress; (2) rescue and/or transport rescued manatees; and (3) treat and maintain distressed manatees. The terms and conditions of the LOA describe the letter holders' level of participation and responsibilities in the program, based on their level of experience and resources. FWS must retain a current permit to authorize these activities and must maintain, update, and modify participant LOAs. As needs and circumstances dictate, letter holders may be added or removed from the program.

To ensure prompt, effective responses to distressed manatees, a rescue coordinator is needed to coordinate and mobilize rescue network teams. FWC 's FMRI maintains a network of field stations to conduct manatee research throughout the state. Field station activities are coordinated through the FMRI's Marine Mammal Pathobiology Laboratory's manager, who acts as the rescue coordinator. FMRI's existing network of staff, resources, and contacts with local law enforcement officials (and others likely to receive reports of distressed manatees) provides the necessary infrastructure for the program. Reports of distressed animals are directed to the rescue coordinator and his/her staff, who in turn contact authorized participants to respond. FWS is notified of ongoing rescues and unusual or significant events, as appropriate. GDNR maintains similar capabilities through its Nongame and Endangered Wildlife Program in their Brunswick, Georgia office.

1.10.2 Maintain rehabilitation capabilities. Adequate facilities are needed to place and treat injured animals. Every year, there are approximately 50 manatees in captivity at any given time, including manatees receiving critical and long-term care treatment. In 2000, there were three critical-care and six long-term care facilities treating manatees, including three out-of-state facilities. In order to maintain our ability to treat distressed manatees, critical care space must be available for these animals. While every effort is made to release treated manatees in a timely manner, some animals are not immediately releasable. Manatees that cannot be released quickly may be transferred to long-term care facilities to make room for critical-care cases. When necessary, existing facilities may expand their holding areas, or additional facilities may be authorized to create room for long-term care cases. Critical-care facilities provide the resources needed to conduct these activities; some costs are statutorily defrayed throughout the State of Florida.

1.10.3 Release captive manatees. As manatees complete the rehabilitation process, their medical status is reviewed by respective facility veterinarians in anticipation of their release. Following this review of physical and behavioral parameters, facility veterinarians recommend that the animal is either ready for release or should be retained for further supportive care. If an animal is deemed healthy, FWS (with input from the Interagency Oceanaria Working Group (IOWG)) evaluates the status of the animal in the context of captive release guidelines and determines whether or not the animal should be released. When an animal is deemed releasable, a release site and release date are identified, and appropriate follow-up monitoring plans are selected. The animals are then transported to the selected site and released. Follow-ups are then conducted, relying on either active monitoring (in which the animals are tagged with satellite, very high frequency (VHF), and/or sonic tags and tracked via satellite and in the field) or passive monitoring (which relies on marking the animals with PIT tags and freeze-brands or by their unique, distinctive markings). These animals are then monitored opportunistically in the field during field studies and/or through the carcass salvage program. Methods identified during a 1998 captive release workshop should be implemented to improve survival rates for released captives. Behavioral parameters need to be evaluated to assess their value in the captive release process.

1.10.4 Coordinate program activities. In addition to authorizing network participants, FWS coordinates many of the day-to-day needs of the program. All transfers and releases, research proposals, and follow-up monitoring plans, program concerns, etc., are evaluated and acted upon by FWS. Many of these are discussed and resolved through the IOWG, which meets twice a year to coordinate rescue, rehabilitation, and release activities and to manage captive program activities to meet manatee recovery objectives. Inherent in this are reviews on the status of rescue and rehabilitation activities, record keeping, development and review of rescue, transport, rehabilitation, maintenance, and release methods, informational exchanges, etc. A product of these meetings will include the development of an annual work plan describing projected releases and monitoring activities.

1.10.5 Provide assistance to international sirenian rehabilitators. Manatee rescue and rehabilitation activities in the United States and Puerto Rico are characterized by more than 30 years of experience and expertise. Rescue and transport techniques, medical practices, and release protocols have been successfully developed and are models for similar efforts. These experiences and expertise should be shared with other countries developing manatee and dugong rescue and rehabilitation programs.

1.10.6 Provide rescue report. An annual report summarizing each year's rescue and rehabilitation activities will be prepared consistent with the requirements of FWS's endangered species/marine mammal enhancement permit. In the interim, monthly updates will be made available to program participants through FWS's internet website.

1.11 Implement strategies to eliminate or minimize harassment due to other human activities. In some cases, human activities (e.g., fishing, swimming, snorkeling, scuba diving, manatee observation, and provisioning) may also disturb, alter behavior or harass manatees. Such disturbance could be life-threatening to manatees, for example, if it occurs in warm-water refuges and animals subsequently move into colder waters. Areas of such conflict should be identified and management actions implemented in order to reduce negative impacts on manatees. Harassment of manatees is considered a form of take as defined in both the ESA and MMPA. Any activity that results in a change of natural behavior which could create harm to the animal is considered take. Most waterborne activities, as well as some upland activities, have the potential to disturb and harass manatees. The following efforts are needed to minimize the impact of these activities.

1.11.1 Enforce regulations prohibiting harassment. Where clear and convincing evidence of harassment is occurring, enforcement of regulations controlling such activities is needed.

1.11.2 Improve the definition of "harassment" within the regulations promulgated under the ESA and MMPA. The current definition of harassment is very vague, making it difficult to enforce. Regulatory definitions need to be amended to specify, to the greatest extent practicable, what actions and activities constitute manatee harassment.

OBJECTIVE 2: Determine and monitor the status of manatee populations. The success of efforts to develop and implement measures to minimize manatee injury and mortality depends upon the accuracy and completeness of data on manatee life history and population status. Population data are needed to identify and define problems, make informed judgments on appropriate management alternatives, provide a sound basis for establishing and updating recovery criteria and management plans, and to determine whether or not actions taken are achieving management objectives. The tasks outlined below are essential to a complete understanding of manatee population status and trends. For all tasks, publication of peer-reviewed results is the preferred method of information dissemination. A detailed research plan is presented in Appendix D and includes informative background information and more detail than is presented here in the narratives.

2.1 Continue the MPSWG. The interagency MPSWG was established in March 1998 as a subcommittee of the recovery team. The group's primary tasks are to: (1) assess manatee population trends; (2) advise FWS on population criteria to determine when species recovery has been achieved; and (3) provide managers with interpretation of available information on manatee population biology. The group also has formulated strategies to seek peer review of their activities. The MPSWG should continue to hold regular meetings, refine recovery criteria, annually update regional and statewide manatee status statements, convene a population biology workshop early in 2002, analogous to the one held in 1992, and publish the results of the workshop.

2.2 Conduct status review. After the Population Status Workshop referenced in Task 2.1 is held, FWS will conduct a status review of the Florida manatee. The review will include: (1) a detailed evaluation of the population status using the benchmark data obtained from the 2002 Population Biology Workshop; (2) an evaluation of the status of manatee habitat as it relates to recovery-based information obtained from the HWG; (3) an evaluation of existing threats to the species and the effectiveness of existing mechanisms to control those threats; (4) recommendations, if any, regarding reclassification of the Florida manatee from endangered to threatened; and (5) objective, measurable criteria for delisting.

2.3 Determine life history parameters, population structure, distribution patterns, and population trends. Population research and data are needed to determine the status of the Florida manatee population. Data collection should be focused so that information on manatee sightings, movement patterns, site use and fidelity, and reproductive histories all can be utilized for further analyses of manatee survival and reproductive rates. Tools which should be continued as a means of gathering these data include: (1) the Manatee Individual Photo-identification System (MIPS); (2) the carcass salvage program; (3) PIT-tagging; (4) telemetry studies; and (5) aerial survey. It is particularly important to utilize these tools at important wintering sites, areas of high use, and poorly-studied regions.

2.3.1 Continue and increase efforts to collect and analyze mark/recapture data to determine survivorship, population structure, reproduction, and distribution patterns. Photographs using standardized protocols for data collection and coding should be collected annually and documented in the field, especially at the winter aggregation sites; these efforts should be expanded, particularly in Southwest Florida. In addition, PIT tags should be inserted under the skin of all manatees that are captured during the course of ongoing research or rescue/rehabilitation. All manatees captured, recaptured, rescued, or salvaged should be checked for PIT tags and other identifying information, because these data provide an additional source of life history information (changes in manatee size, reproductive status, and general condition between time of tagging and recovery). Methods for reliably checking for PIT tags on free-swimming manatees should be developed and tested, and plans should be developed for re-examining the utility of PIT-tagging manatees of certain age classes (juveniles and subadults) or in specific areas where photo-ID is not a feasible way to re-identify individuals.

Analyses using mark-recapture modeling procedures to estimate annual survival rates should be updated annually, utilizing data in MIPS and comparing results to analyses of PIT tag data. To enhance the accuracy and precision of survival estimates, dead manatees previously identified by photographic documentation must be noted in the MIPS database before mark-recapture analyses are undertaken. This research should include estimates of sample sizes required to determine population traits, such as survival and reproductive rates.

Additionally, emphasis should be placed on estimating variance and 95% confidence intervals.

Concurrently with data collection and monitoring, it is important to conduct long-term studies of reproductive traits and life histories of individual females. Such studies would provide information on: (1) age at first reproduction; (2) age-specific birth rates; (3) calving interval; (4) litter size; and (5) success in calf-rearing. The relative success of severely- and lightly-scarred females in bearing and rearing calves also should be determined.

2.3.2 **Continue collection and analysis of genetic samples to determine population structure and pedigree.** Collection of tissue samples from salvage specimens and from living manatees at winter aggregation sites, captured during research, or rescued for rehabilitation should continue. Continued genetic analysis through collaborations with state and federal genetics laboratories may reveal greater population structure than has been demonstrated thus far (i.e., a significant difference between east and west coasts, but not within coasts). Such research will improve our ability to define regional populations and management units. Stock and individual identity for forensic purposes ultimately will be possible. Analytical techniques recently developed for identifying the structure of other marine stocks should be investigated.

Paternity cannot be established in wild manatees without the ability to determine family pedigrees. This information is needed to determine if successful reproduction is limited to a small proportion of adult males, which has important implications for the genetic diversity of the Florida manatee population. By continuing the development of nuclear DNA markers, pedigree analysis can be applied to the growing collection of manatee tissue samples. Pedigree analysis also would improve greatly our knowledge of matrilineal relationships and female reproductive success. Identification of factors associated with successful breeding by males is important in assessing reproductive potential in the wild and in captivity.

2.3.3 **Continue carcass salvage data analysis to determine reproductive status and population structure.** Information and tissue samples collected from all carcasses recovered in the salvage program to determine reproductive status should be continued. Resulting estimates of reproductive parameters complement information obtained from long-term data on living manatees and will help to determine trends and possible regional differences in reproductive rates. The salvage program yields important information on the manatee population sex ratio and proportion of age classes (adult, subadult, juvenile, and perinatal) within each cause-of-death category. Annual changes in these proportions may indicate increases or decreases in certain types of mortality, and thus should be considered as part of the weight of evidence that supports (or rejects) a reclassification decision. Ear bone growth-layer-group analysis should be continued to determine more precise ages of dead manatees, particularly those that have a known history through the MIPS database, telemetry studies, or PIT tag data. Although the age structure of the carcass sample is biased toward younger animals, opportunities may occur to document better the natural age structure within specific regions because of age-independent mortality events.

2.3.4 **Continue and improve aerial surveys and analyze data to evaluate fecundity data and to determine distribution patterns, population trends, and population size.** Aerial surveys provide limited information on the proportion of calves to adults, which may provide insights on reproductive trends when a long time-series of surveys have been conducted by one or relatively few individuals in the same geographic regions. Calf counts from such surveys should be continued and should be compared to those obtained by photo-ID methods.

As appropriate and possible, local and regional aerial surveys should be undertaken or continued to improve information on habitat use patterns and changes in distribution. Documentation of changes in distribution at power plants will be particularly important when changes in warm water availability occur.

Methods to correct for various types of visibility bias in surveys should be developed. Standard procedures for survey teams involved in annual statewide surveys need to be developed and implemented. Where appropriate, strip transect aerial surveys should be used, as it is possible to use this type of survey data to detect regional population trends. Specifically, strip transect surveys should be continued on an annual basis in the Banana River, and their feasibility should be investigated in remote coastal areas of Southwest Florida. To the extent possible, all aerial surveys should be designed to estimate accurately a minimum population number.

2.3.5 **Continue collection and analysis of telemetry data to determine movements, distribution, habitat use patterns, and population structure.** Multi-year telemetry studies have been completed for the Atlantic coast and Southwest Florida from Tampa Bay through Lee County, and research findings have been summarized in manuscripts currently undergoing peer review. Radio-tracking has provided substantial documentation of seasonal migrations, other long-distance movements, and local movements that reveal patterns of site fidelity and habitat use. Such information is needed from each region, particularly Southwestern Florida and the Everglades and areas where anticipated changes are likely to impact manatees, in order to develop management strategies for all significant subgroups within the regional population, however transitory they may be.

Steps should be undertaken to incorporate geographic positioning system (GPS) technology into telemetry studies to improve the accuracy of manatee location data. Such improvements will be helpful in studying precise habitat-use patterns (e.g., the extent to which manatees use marked boat channels verses waterway margins for travel) and the location of preferred foraging sites, especially around warm-water refuge sites.

2.3.6 Continue to develop, evaluate, and improve population modeling efforts and parameter estimates and variances to determine population trend and link to habitat models and carrying capacity. Uncorrected aerial survey data do not permit statistically valid population estimation or trend analysis. Models to correct for the inherent bias and uncertainty have been developed, and these efforts need to be continued.

It also is important to utilize models such as that developed by Eberhart and O'Shea (1995). The underlying assumptions of a population model, the importance of parameters used in the model, the accuracy and uncertainty of the parameter estimates, the relationships of the parameters, and the appropriateness of the mathematics implemented in the model need to be critically evaluated and updated. Also, comparisons need to be made between predicted outcomes of a model and estimates or indices of population trend from other modeling efforts or other data sets. Steps should be taken to improve and to develop more complex models incorporating additional life history information and which better reflect our understanding of the processes involved in population dynamics.

Where estimates of model parameters need to be developed or improved, other relevant tasks should be modified or strengthened. Because parameters can vary over space and time and such variation affects population growth rates, emphasis should be placed on estimating variance and 95% confidence intervals along with developing best estimates of particular population parameters.

It is important for those developing manatee population models to coordinate their activities and to interact directly with research biologists who have collected manatee life history data or who are very familiar with manatee ecology. Interaction with management also is needed to help focus the questions addressed by present and future modeling efforts. Estimates of the number of manatee deaths that can be sustained per region, while still allowing population stability or growth to be achieved are needed. Coordination is needed to develop better models that meet the needs of manatee biologists, policy makers, and managers. The MPSWG is best positioned to track research developments, link important players, and provide one level of peer review and evaluation. Additional peer review from other internal and external sources also is essential.

As manatee habitat requirements are documented and recovery criteria are identified (based on habitat needs) (Task 3.1.1), it will become possible to link regional population and habitat models and estimate optimum sustainable populations for regions. Integration of population and habitat information is essential to understand the implications of habitat change before negative impacts on manatee population trends can occur. The MPSWG and Geographic Information System (GIS) Working Group should meet jointly on an annual basis to coordinate their activities and progress. Summary reports of these meetings should be distributed to all agencies and interested parties involved in manatee recovery efforts.

2.3.7 **Conduct a PVA to help assess population parameters as related to the ESA and MMPA.** The FWS should conduct a PVA and/or other modeling exercises to: determine minimum viable population(s); model effects of various scenarios of stochastic events; determine consequences of losses of industrial warm-water refuge sites; further test and refine demographic recovery criteria; and assist in determination of negligible impacts under the MMPA.

2.4 **Evaluate and monitor causes of mortality and injury.** The manatee salvage/necropsy program is fundamental to identifying causes of manatee mortality and injury and should be continued. The program is responsible for collecting and examining virtually all manatee carcasses reported in the Southeastern United States, determining the causes of death, monitoring mortality trends, and disseminating mortality information. Program data are used to identify, direct, and support essential management actions (e.g., promulgating watercraft speed rules, establishing sanctuaries, and reviewing permits for construction in manatee habitat).

The current manatee salvage and necropsy program components are: (1) receiving manatee carcass reports from the field; (2) coordinating the retrieval and transport of manatee carcasses and conducting gross and histological examinations to determine cause of death; (3) maintaining accurate mortality records; and (4) carrying out special studies to improve understanding of mortality causes, rates, and trends. The carcass salvage program should continue to: (1) describe functional morphology of manatees; (2) assess certain life history parameters of the population; and (3) collect data on survival of known individuals.

To improve the program, FWC should continue to hold manatee mortality workshops to review critically its salvage and necropsy procedures and methods. These workshops: (1) establish and improve “state-of-the-art” forensic techniques, specimen/data collection, and analyses; (2) identify and create projects focusing on death categories that are unresolved; (3) prepare for and assist with epizootics; (4) generate reference data on manatee health; and (5) generate suggestions for attainment of a “healthy” manatee population.

To implement the salvage and rescue program in Florida, FWC maintains a central necropsy facility called the Marine Mammal Pathobiology Laboratory (MMPL) which is located in St. Petersburg. FWC also has three field stations on the east coast situated in Jacksonville, Melbourne, and Tequesta, and one field station on the west coast at Port Charlotte. The GDNR, South Carolina Department of Natural Resources, Louisiana Department of Wildlife and Fisheries, Texas Marine Mammal Stranding Network, University of North Carolina at Wilmington, and others help to coordinate carcass salvages and rescues in other Atlantic and Gulf coast states. FWS and FWC should provide assistance to these manatee salvage and rescue programs through workshops, providing equipment and assistance when possible. The MMPL will maintain and curate the Southeast U.S. Manatee Mortality Database to facilitate management and enhance communication among state agencies and reinforce timely reporting.

2.4.1 Maintain and improve carcass detection, retrieval, and analysis. To the extent possible, the historic mortality database should be reviewed and updated to reflect the cause of death categories currently in used. To estimate the number of unreported manatee carcasses, studies should be done on carcass detection and reporting rates. Studies focusing on carcass drift, rate of decomposition, and how decomposition affects necropsy results should be conducted. Periodic peer reviews should be conducted of necropsy methods, data recording and analysis, and documentation of tissues collected. Selected representative samples should be archived with appropriate national tissue banks. Workshops such as FWC Manatee Mortality Workshop should continue to be conducted to strengthen collaborative research and information sharing. Partnerships with other agencies and process analysis of carcass retrieval protocols should be ongoing to improve efficiency.

2.4.2 Improve evaluation and understanding of injuries and deaths caused by watercraft. Longitudinal studies should be established to examine the effect of boats and boating activity on population growth and reproductive success. Investigations of the characteristics of lethal compared to non-lethal injuries and causes should be developed using data from carcasses and photo-ID records. Another important data set would be that characterizing healing in rescued injured animals; under-reporting of watercraft mortality may occur as individuals die from complications resulting from injuries sustained by boats. Lethal and non-lethal injuries should be investigated to characterize size of vessels, relative direction of movement of vessel, and propeller vs. blunt trauma statistics. Research on mechanical characteristics of skin and bones should be developed to obtain a better understanding of the effects of watercraft-related impacts. Regional studies are needed to characterize boating intensity, types of boats, boating behavior, and boating hot spots in relation to manatee watercraft-related mortality.

2.4.3 Improve the evaluation and understanding of injuries and deaths caused by other anthropogenic causes. Research is needed to continue to assess manatee behavior leading to vulnerability around the water control structures and navigational locks, as well as operational or structural changes that can prevent serious injury or death of manatees. MMPL should continue to associate forensic observations obtained at necropsy with specific characteristics of the particular structure that caused the death.

Commercial fishing is not a major culprit involved in manatee mortality, unlike the case with most other marine mammals. However, manatees have been killed by shrimp trawls and hoop nets, and in recent years injuries and death from monofilament entanglement, hook and line ingestion, and crab pot/rope entanglement have been more prevalent. There is a need to improve the evaluation and understanding of injuries and deaths of manatees caused by commercial and recreational fisheries. To reduce the increasing numbers of fishing gear entanglements, a multi-agency Manatee Entanglement Task Force has been established and should continue to focus on creating changes in data collection protocols, potential technique/gear modifications, innovative tag designs, entanglement research, gear recovery/clean-up, and education/outreach efforts. Research on rates of entanglement, types of gear, and geographical and temporal changes in rates and types of entanglements should be developed. Studies on behavioral characteristics of manatees contributing to entanglement should be pursued. Research on the amount of marine debris in inshore waters should be conducted, particularly where there are high levels of manatee entanglement. Programs to remove marine debris and recycle monofilament line also should be encouraged and continued (Task 1.7.2).

Although no known death or pathology has been associated with toxicants, some concentrations of contaminants have caused concern. Over time, concentrations of chemicals found in manatees from early studies have changed, possibly as a result of the regulation of chemical use. Such changes highlight the need to monitor tissues for chemical residue and also can provide insight into the presence of different or new compounds in the environment. While a broad range of tests have been conducted, there needs to be a greater focus on endocrine disruptor compounds. These compounds can alter reproductive success and have a dramatic effect on population growth.

2.4.4 Improve the evaluation and understanding of naturally-caused mortality and unusual mortality events. By definition, natural causes of mortality are not directly anthropogenic and thus not easily targeted by management strategies. However, some aspects of natural mortality may be influenced by human activities. These activities include but are not limited to: (1) sources of artificial warm water; (2) nutrient loading; and (3) habitat modification.

Cold stress can be a cause or contributing factor to manatee deaths during the winter. Acute cold-related mortality is related to hypothermia and metabolic changes which occur as a consequence to exposure to cold. Research should continue to focus on critical cold air and water temperatures affecting manatee physiology (particularly as it pertains to acute cold- and cold stress-related mortality). To provide important clues as to how manatees deal with cold temperature, future research should study behavioral adjustments to cold (e.g., directed movement to warm-water refuges, time budget during cold periods, and surface resting intervals during warm spells). Research identifying the manatee's anatomical and physiological mechanisms for heat exchange are an important step to understanding the biological limitation of the species. Ancillary research should include identification of natural warm-water sites, because a growing population of manatees may be seasonally-limited by overcrowding at the larger well-known warm-water refuges.

Research is needed to improve our ability to detect brevetoxin in manatee tissues, stomach contents, urine, and blood. At the same time, environmental detection of red tides, their strengths, and the development of retardants are necessary. More advanced immunological research utilizing manatee cell cultures may result in the development of better treatment of manatees exposed to brevetoxin.

Improved methods are needed to subdivide the perinatal category into categories of: (1) clearly fetal; (2) at or near the time of birth; and (3) clearly born. Once these categories are well-defined, analysis can ascertain the life stage subject to the greatest impact, thus allowing for the future development of appropriate management policies. Field research focusing on factors affecting calf survival should be conducted (e.g., age of mother at reproduction, behavior, characteristics of calving areas, and human disturbance).

The FWS and FWC have created complementary manatee die-off contingency plans (Geraci and Lounsbury 1997; FWS 1998) that have been merged into one comprehensive document (FDEP *et al.* 1998). The document contains information and guidance from the two plans together with advice and provisions outlined in the executive summary from Wilkinson (1996). Research and investigations should follow the protocols and recommendations found in the Contingency Plans. In addition, there should be ongoing collection and storage of tissues and samples from healthy and non-mortality event manatees to establish a baseline and to aid interpretation of test results obtained during a catastrophic event and for retrospective studies. Investigators should contact and work closely with other research projects monitoring and evaluating harmful algal blooms. FWC mortality workshops should continue and help to facilitate and develop cooperative arrangements among investigators and institutions.

2.5 **Define factors that affect health, well-being, physiology, and ecology.** Relatively little attention has been paid to the health and well-being of individual manatees, although factors affecting individuals ultimately influence the overall status of the population. There is a need to determine the relatively constant internal state in which factors such as temperature and chemical conditions remain stable and therefore within a range of values that permit the body to function well, despite changing environmental conditions. Stress is part of existence, and not all stress is bad for an individual. However, a stressor can affect homeostasis and health, and thereby precipitate a chain of events that can compromise the survival of an individual. There also is a need to understand the factors that underlie large-scale trends. For example, individual manatees compromised by severe injury or disease may not be able to reproduce successfully. Similarly, sublethal effects of toxicants and even the effects of nutritional, noise-related, and disturbance-related stresses can impair immune function and potentially reduce the ability of individuals to reproduce. Study plans and protocols should be developed, collaborators identified, and results published.

2.5.1 Develop a better understanding of manatee anatomy, physiology, and health factors. Efforts should be made to develop and publish a synthesis of: (1) current knowledge of manatee serology; (2) ranges of values associated with manatees in various demographic groups; (3) anomalies identified in manatees via serum analyses; and (4) any remaining unanswered questions. Major organs and organ systems have been examined by a variety of scientists over the years. Those systems or organs which have been ignored are important to assessing manatee health and should be studied; these include: (1) the lymphatic system; (2) most parts of the endocrine system; and (3) non-cerebral parts of the brain. In addition, potential changes in reproductive tracts routinely should be assessed as part of ongoing life history assessments. Manatee histology (microscopic anatomy) has been relatively unstudied, compared to gross anatomy. It is of no less importance in understanding normal organ or tissue functions, as well as abnormalities thereof; therefore, responsible agencies should respond to this important deficiency.

Anatomical and experimental studies have indicated that manatees osmoregulate well in either fresh or salt water; however, it is unclear whether or not manatees physiologically require fresh water to drink, and it is unknown what stresses may be created when fresh water is not available. Research should be continued, and managers attempting to protect resources sought by, if not required by, manatees should bear in mind that fresh water is a desirable and possibly necessary resource for healthy manatees.

Body indices research at FMRI has initiated certain measurements documenting the body condition of manatees. Maintenance of this work, and refinements/extensions thereof, should be continued to gain a better understanding of physiology and health of individuals and the population.

Continuous long-term monitoring of individual manatees allows for documentation of an animal's health. Information should be gathered on: (1) the acquisition and severity of new wounds to facilitate research on the length of time required for injuries to heal; and (2) any effects of injuries on behavior or reproduction. Natural factors affecting the health of the population also should be monitored during the course of photo-ID studies on wild individuals (e.g., cold-related skin damage, scars caused by fungal infections, and papilloma lesions).

As discussed earlier, brevetoxin has been implicated or suspected in major and minor mortality events for manatees for decades. Tests now exist to allow pathologists to assess, even retrospectively, manatee tissues for signs of brevetoxicosis. The important questions include: (1) how many manatee deaths can be truly attributed to exposure to brevetoxin over the years; (2) if red tides are a natural occurrence, how can effects of red tides on manatees be reduced or mitigated; (3) would changes in human activities (i.e., creation of warm-water refuges which lead to aggregations of manatees) appreciably change vulnerability of the animals; and (4) have human activities contributed to increased prevalence and virulence of red tides.

Inasmuch as a single epizootic event can cause 2 to 3 times as many manatee deaths as watercraft causes annually, gaining a better understanding of the issue is vital and urgent. Development of cell lines and testing of manatee tissues would represent an extremely useful approach. In particular, preliminary results indicate that exposure to brevetoxin reduces manatee immune system function. Further study of the immune system will define levels of concern and will help to identify when rehabilitated manatees are ready for release into the wild. Other natural toxins have affected marine mammals (e.g., saxitoxin) and may represent another potential problem for manatees. Exposure of cultured cells of manatees to saxitoxin and assessment of the responses of those cells, would be useful.

Toxicant studies demonstrate that a few metals occur in high concentrations in manatee tissues. Testing for toxicants can be extremely expensive, thus a carefully-constructed study plan should be developed first to address the most critical uncertainties and to make the assessments as cost-effective as possible. Sediment chemistry/toxicity testing could be used as an indicator to direct toxicant studies in important habitats known to contain sediments that are contaminated.

A disease involves an illness, sickness, an interruption, cessation, or disorder of body functions, systems, and organs. As noted at the outset of this section, scientists need to learn the boundaries of normal structure and function before they can diagnose what is normal or diseased. This process has occurred to some degree through the necropsy program, but it needs considerable refinement. Over the years, cause of death for about 1/3 of all manatee carcasses has been undetermined; this percentage would doubtless drop considerably with better information about and diagnosis of manatee disease states. Planned workshops by the FMRI will attempt to bring scientists conducting necropsies on manatees together with pathologists and forensic scientists working with humans and other species. This effort should be very useful as a first step in an ongoing process of refinement.

Nutritional characteristics of manatee food plants and the importance of different food sources for different manatee age and sex classes in various regions are needed to help assure that adequate food resources are protected in different areas of the population's range. Ongoing studies should be completed to identify manatee food habits and the nutritional value of different aquatic plants important to manatees. In addition, seasonal patterns of food availability in areas of high manatee use need to be documented. Research should also address manatee foraging behavior, emphasizing ways that manatees are able to locate and utilize optimal food resources.

Since degrees of parasitic infestation may be associated with the changes in the health of manatees, assessments of changes in prevalence of parasites over time should be undertaken. Inasmuch as parasite loads are assessed, at least qualitatively, during necropsies, this should be easy to accomplish, relatively speaking.

2.5.2 Develop a better understanding of thermoregulation. Although work has been ongoing to assess effects of environmental temperatures on metabolism of manatees, the relationship among temperature change, metabolic stress, onset of chronic or acute disease symptoms, and even mortality of manatees is not perfectly understood. As noted above, the relationships among manatee reproductive status, body condition, thermal stress levels, and metabolic responses to such stress remain unclear. Answers are needed as the specter of decreased availability of both natural and artificial warm-water sources looms. The research should focus not only on lower critical temperatures (the cold temperatures where metabolic stress occurs), but also on the upper critical temperature.

2.5.3 Develop a better understanding of sensory systems. Vision in manatees has been well studied and tactile ability and acoustics also have been assessed. Conclusions reached as a result of acoustic studies are somewhat inconsistent and controversial, especially in terms of the extent that manatees may hear approaching watercraft. Since the auditory sense of manatees appears to be vital to their ability to communicate and to avoid injury, further studies are warranted. In addition, although chemoreception has been suggested as a mechanism by which male manatees locate estrous females, chemosensory ability of manatees is virtually unknown and should be studied.

2.5.4 Develop a better understanding of orientation and navigation. It is clear from various lines of evidence that manatees show site fidelity, especially in terms of their seasonal use of warm-water refuges, but also in their use of summer habitat. To some extent, calves learn locations of resources from their mothers. However, the way that manatees perceive their environment, cues they use to navigate, and the hierarchy of factors they use to select a particular spot or travel corridor are all unknown. As humans continue to modify coastal environments (physically, acoustically, visually, and chemically), it would be useful to understand better how such changes may interfere with the manatee's ability to orient and to locate or select optimal habitat.

2.5.5 **Develop a better understanding of foraging behavior during winter.** Research should address manatee winter foraging behavior, emphasizing ways that manatees are able to locate and utilize optimal food resources. Research should address food availability near winter aggregation areas and determine if they are a limiting resource. Therefore, food resources near winter aggregation sites in each region need to be assessed to ensure that food resources are adequate and protected.

2.5.6 **Develop baseline behavior information.** Both field studies and controlled experiments at captive facilities are needed to document basic behaviors. This documentation will allow detection and understanding of changes in behavior that occur through changes in allocation of essential resources, such as vegetation and warm water. Telemetry, photo-ID, and aerial videography have been useful tools for behavioral research. New innovative approaches are needed, particularly in habitats where visibility is poor.

2.5.7 **Develop a better understanding of disturbance.** Stress caused by disturbance will be difficult to document, but if manatees move away from critically important resources (e.g., warm water in winter) to avoid being disturbed, this movement could place the animals in immediate and acute jeopardy. Sources and level of activities eliciting disturbance responses need to be characterized further.

2.5.7.1 **Continue to investigate how a vessel's sound affects manatees.** In order to understand the nature of watercraft/manatee interactions, the primary reasons for collisions must be identified. Manatees, particularly mothers and calves, communicate vocally. Often, while vessels are still outside of visual range, manatees initiate movements as boats approach, suggesting that they respond on the basis of hearing the boats. Noise from boats or other sources may interfere with communications or provide a source of stress. Hearing capabilities have been examined through studies involving two individuals in captivity (Gerstein 1995, 1999).

There is a need for further research on hearing capabilities and the effects of noise on manatees potentially to provide another management tool to minimize collisions between manatees and boats. In particular, it is important to determine: (1) the sensitivity of manatee hearing to the different kinds of vessels to which they are exposed; (2) the range of frequencies of importance to manatee communication; (3) the abilities of manatees to localize sound sources; and (4) the role that habitat features may play in altering sound characteristics. The levels and characteristics of vessel sounds leading to behavioral changes, including potentially vacating an area, need to be determined. Development of manatee avoidance technology needs to be thoroughly researched and assessed and managers need to evaluate the MMPA and ESA "take" issues related to implementing such technology.

2.5.7.2 **Investigate, determine, monitor, and evaluate how vessel presence, activity, and traffic patterns affect manatee behavior and distribution.** More effective diagnosis of watercraft-related injuries and mortalities is important for describing the extent and nature of the threat posed by watercraft. Mortality workshops are intended to improve our ability to diagnose watercraft-related mortalities more effectively on both fresh and decomposed carcasses. Prevention of such injuries and mortalities is the goal. Research is needed to address the causes of watercraft mortality and the effectiveness of management actions. Importantly, such research also should investigate the effects of sublethal injuries and stress occurring as a result of boating activity. Injuries and stress may: (1) lead to reductions in animal condition and reproductive success; (2) cause animals to abandon habitat important for foraging, reproduction, or thermal regulation; or (3) impair immune system function thereby increasing the vulnerability of animals to disease, pollutants, or toxins. Thus, indirect or secondary effects of boating activity also may impede population recovery in ways that have not yet been assessed.

MML, FWC, and others are investigating reactions of manatees to boats. Preliminary information indicates that manatees perceive boats, but may, under certain circumstances, react in ways that place the animals in the path of, rather than away from, the boats. Additional studies of manatee responses to boats and vessel acoustics are needed (Task 2.5.7.1). Indirect deleterious effects of shallow-draft or jet boats that can disturb manatees and cause them to move to boating channels or interrupt normal behaviors need to be studied. An evaluation of spatial and temporal factors associated with risk to manatees (i.e., proportion of time manatees are exposed to vessels relative to depth, habitat, and manatee activity) should be conducted. Additional factors to be investigated include: (1) types and frequency of approaches; (2) numbers of boats; (3) distance of nearest approach; (4) individual variations in manatee responses to boats; (5) influences on diurnal activity patterns and habitat use; and (6) effects on mothers and young.

2.5.7.3 **Assess boating activity and boater compliance.** Studies that characterize the intensity and types of boating activities should be conducted at selected locations around the state, with emphasis on areas where boat-related mortality of manatees is highest. Studies are underway and should be expanded to additional areas to identify and evaluate adherence to manatee speed zone restrictions through statewide boater compliance studies. The following studies should be continued and assessed: (1) the frequency of boater compliance with posted manatee speed zone restrictions; (2) the degree of boater compliance with posted manatee speed zone restrictions; (3) the levels of compliance among boat classes, seasonally, and temporally; (4) changes in compliance resulting from different enforcement regimes; and (5) changes in compliance resulting from different signage. Underlying sociological factors affecting compliance also should be investigated (Task 1.4.4). New methods for monitoring compliance, such as remote video systems, should be assessed.

2.5.7.4 **Evaluate the impacts of human swimmers and the effectiveness of sanctuaries.** Specific circumstances or characteristics of human swimming, snorkeling, or SCUBA diving that may result in changes in manatee behavior, including vacating an area, remain to be determined. Factors to be investigated include: (1) types and frequency of approaches; (2) numbers of swimmers; (3) distance of nearest acceptable approach; (4) occurrence of contact; (5) individual variations in manatee responses to humans; (6) influences on diurnal activity patterns and habitat use; and (7) effects on mothers and young.

2.5.7.5 **Evaluate the impacts of viewing by the public.** The relative benefits of burgeoning human attention as compared to potential adverse impacts on the animals have not been evaluated properly to determine the desirability of increasing or decreasing control over manatee viewing activities. Studies relating marketing and overall levels of human viewing activities to changes in manatee behavior, including vacating an area, need to be conducted. Conversely, benefits accrued to the manatees from increased viewing by the public also should be evaluated for comparison.

2.5.7.6 Evaluate the impacts of provisioning. In many parts of the species' range, people provide food or water to manatees, in spite of regulations prohibiting such activities. A systematic evaluation should be conducted to determine if these activities potentially adversely affect manatees in terms of changing their behavior, placing them at greater risk from other human activities, or encouraging them to use inappropriate habitat.

OBJECTIVE 3: Protect, identify, evaluate, and monitor manatee habitats. Manatee population recovery and growth depend on maintaining the availability of habitat suitable to support a larger manatee population. Manatee habitat needs include: (1) ample food sources (including submerged, floating, and emergent vegetation); (2) warm-water refuges during cold winter periods; (3) quiet, secluded areas for calving and nursing; (4) mating and resting areas; (5) safe travel corridors connecting such areas; and (6) possibly fresh drinking water. These resources are affected by development in coastal and riverine areas and by human activities in waterways used by manatees. Managers must protect the quality and quantity of essential manatee habitats and provide for human needs.

Many important manatee areas in Florida are protected through the state's Florida Manatee Sanctuary Act, which protects manatees and their habitat through designated manatee protection zones and sanctuaries; manatee areas also are protected under the ESA and MMPA manatee sanctuaries and refuges provisions. These Acts provide a means to minimize the direct and indirect effects of coastal development on manatees. Existing protection areas should be evaluated and properly-managed, and other important unprotected areas should be identified and afforded necessary protection. Resource agencies, through these authorities, are able to address and minimize the effects of development through comments to state and federal permitting agencies. County MPPs are important guidance documents for agencies and developers. Plans should be developed for those counties lacking state- and federally-approved plans. All plans should be reviewed periodically.

In order to protect adequate quantities of essential habitat in the quality necessary to recover the manatee, information is needed to identify habitats, assess their condition, and understand the factors affecting them.

Methods and means should be improved/developed to understand better and monitor the interactions that take place between manatees, manatee habitat, and humans. A HWG should be convened to assess needs and to identify the tools needed to identify, monitor, and evaluate manatee habitats and better define manatee ecology.

3.1 **Convene a Habitat Working Group.** A HWG (established as a subcommittee of the recovery team), that includes resource managers, manatee biologists, and experts familiar with the many features of the manatees' aquatic environment will meet on a regular basis. This group will: (1) assist managers responsible for protecting habitat; (2) help identify information needs; (3) ensure the implementation of tasks needed to identify, monitor, and evaluate habitat; and (4) refine and improve the recovery criteria that address threats to manatee habitat by October 2002.

3.2 **Protect, identify, evaluate, and monitor existing natural and industrial warm-water refuges and investigate alternatives.** One of the greatest threats to the continued existence of the Florida manatee is the stability and longevity of warm-water habitat. Manatees have learned to rely on natural and industrial warm-water refuges during periods of cold weather. This reliance has made it extremely important for managers and researchers to understand the role played by warm-water refuges in overall manatee survival. Protection, enhancement and/or replacement, identification, and characterization of these sites are essential to the continued recovery of the manatee population.

3.2.1 **Continue the Warm-Water Task Force**. A task force consisting of governmental agencies, power industry representatives, and non-government organizations has been convened to develop and implement strategies to ensure safe and dependable warm-water refuges for manatees. In developing these strategies, the task force should: (1) develop a conceptual plan for a long-term network of warm-water refuges; (2) determine the optimal northern extent of industrial warm-water refuges; (3) develop a plan to reduce the potential loss of manatees in the event that a power plant goes off-line, either permanently or for an extended period of time; (4) explore whether new sources of artificial warm water are an avenue that should be considered and, if so, identify potential new sources that could be exploited to produce consistent, dependable, and inexpensive warm water. The task force also should examine the potential effects of deregulation of the Florida power industry.

3.2.2 **Develop and implement an industrial warm-water strategy.** Short- and long-term strategies should be developed for industrial warm-water refuges. Efforts to address short-term concerns currently are accomplished through the state-adopted NPDES permitting program, which includes power plant-specific MPPs. These plans ensure a safe, consistent, and dependable network of warm-water refuges. A long-term plan, addressing concerns identified in Task 3.2.1, should be developed with the creation of an effective network of warm-water refuges as its goal. The development of this plan will require that all industrial sites used by wintering manatees be identified, described, and monitored. These assessments should contain the location and physical description of each plant, expected life span of each plant, and history of manatee use at each plant. Habitat attributes associated with each plant also should be addressed. These attributes should include: (1) availability and location of forage and freshwater; and (2) an assessment of human disturbance levels over the next 5, 10, and 20 years. As more information regarding each plant is collected, BPSM and FWS should recommend modifications to existing power plant-specific MPPs to insure protection of manatees at these facilities.

3.2.2.1 Obtain information necessary to manage industrial warm-water refuges. Research efforts should focus on collating and analyzing existing data related to manatees and industrial warm-water refuges. New research initiatives should focus on filling in data gaps concerning manatees, warm water requirements, and associated behaviors. These research efforts should include: (1) determining the tolerance of manatees to low ambient air and water temperatures; and (2) investigating manatee use of warm-water refuges and nearby habitats in relation to water temperature. Existing research efforts such as aerial monitoring of manatee use at power plants and identifying trends in the abundance of manatees at each plant should be continued. Carrying capacity and factors influencing the number of manatees which can and/or should be using each individual plant should be assessed for each facility. Building partnerships with the industry is imperative in finding resources and answers to a multitude of questions related to this issue.

3.2.2.2 Define manatee response to changes in industrial operations that affect warm-water discharges. Current power plant operations involve activities that affect their respective warm-water discharges. For example, in the absence of demand for electricity, power companies cut back on the amount of electricity produced by certain power plants. These cut-backs may result in temporary or long-term loss of warm water or diminished flows of warm water, thereby reducing their attractiveness to wintering manatees. These operational changes and the effects they have on wintering manatees should be monitored. Understanding the response of manatees to these changes will provide important information for managers seeking to improve short- and long-term management strategies.

3.2.3 **Protect, enhance, and investigate other non-industrial warm-water refuges.** Non-industrial warm-water refuges include areas such as dredged basins which provide warm water because of their configurations and other features. For example, deep dredged basins with few inputs from adjoining ambient waters may create solar-heated, manatee-accessible systems with water temperatures several degrees above ambient. Dredged areas accessible to manatees also may penetrate sources of groundwater. When tapped into, these warm-water seeps elevate ambient water temperatures and are attractive to manatees in need of refuge from the cold. Due to the uncertainty of some of the power plant discharges being available in the future for manatees, alternatives to these discharges should be identified and developed, if needed. New environmentally-sensitive, non-industry-dependent warm-water refuges should be considered. Sites should be identified and technologies tested while existing refuges remain available.

3.2.4 **Protect and enhance natural warm-water refuges.** The continued functioning of the natural springs, rivers, and creeks used by manatees is essential to their recovery. Of greatest immediate importance are the spring systems at Blue Spring, Kings Bay, Homosassa Springs, and Warm Mineral Springs. These springs are used as cold season warm-water refuges by at least 20% of the manatee population during winter cold fronts (FWC, unpublished data). Critical to the continued functioning of natural warm-water sites is the maintenance of minimum spring flows and levels, maintenance or improvement of water quality, and protection of adequate foraging habitat within and adjacent to these sites.

3.2.4.1 **Develop and maintain a database of warm-water refuge sites.** BPSM and FMRI staff should identify and maintain an active database of all natural and non-industrial warm-water refuge sites. When new sites are discovered, these should be added to the database. Manatee use and changes in system function these sites should be monitored over time. Sites should be prioritized based on extent of manatee use and regional importance to cold season populations. FWS and FWC staff also should identify potential natural refuge sites near industrial warm-water facilities used by manatees and assess whether enhancement of these sites should be pursued.

3.2.4.2 **Develop comprehensive plans for the enhancement of natural warm-water sites.** If the strategy for a site includes enhancement, then a comprehensive plan should be developed addressing: (1) agency responsibilities; (2) permitting requirements; (3) funding sources; and (4) physical modifications. Existing and additional needed protection measures for each site should be identified and assessed for effectiveness. To provide for maximum protection of these warm-water sites, protection strategies also should include land acquisition, use of regulatory mechanisms, and outreach.

3.2.4.3 **Establish and maintain minimum spring flows and levels at natural springs.** Water demands from the aquifer for residential and agricultural purposes have diminished spring flows at important manatee wintering areas. Additionally, paving and water diversion projects in spring recharge areas can reduce water levels at springs.

A database of priority springs and flowing systems accessible to manatees should be developed and maintained by FWC staff. The database should include baseline information on water availability and quality so that adverse changes can promptly be identified and impacts mitigated. FWC and FWS should coordinate with the WMDs to prioritize establishing minimum spring flows for high manatee use systems, such as King, Homosassa and Blue Springs. Agency staff should advocate maintaining spring flow rates above the minimum levels necessary to support manatees. FWS and FWC should develop a coordinated review program with FDEP and WMDs' permitting programs on applications requesting ground water withdrawal from applicable spring systems. In addition, FWC and FWS should participate in FDEP and/or WMD springs task force efforts where manatee warm-water refuge protection issues are involved. State legislation protecting spring flow should be sought. Other recovery partners should advocate the establishment of minimum flows and levels as appropriate.

3.2.5 **Assess changes in historical distribution due to habitat alteration.** Summarize what is known about historical distribution in order to clarify how and to what extent artificial warm-water refuge sites and flood control canals have altered distribution and habitat use patterns.

3.3 Establish, acquire, manage, and monitor regional protected area networks and manatee habitat. The establishment of manatee sanctuaries, refuges, and protected areas, along with the federal, state, local and private acquisition of coastal areas and essential manatee habitat has created regional networks of protected areas crucial for the long-term survival of the manatee population. Management of these refuges, sanctuaries, reserves, preserves, and parks in Florida offers assurance that habitat (e.g., warm-water springs, grassbeds, and quiet secluded waterways) important to manatees are protected. These efforts need to continue as well as efforts to manage key protected areas in ways that enhance achievement of the recovery objectives.

In addition, work should be undertaken to better understand and monitor the complex interactions among manatees, humans, and manatee habitat. Information from such a program will identify future threats to manatee populations and help to explain observed manatee population trends. Presently, there is no systematic approach to monitoring the condition of important manatee habitats. To provide a means of detecting potential problems in areas supporting manatee populations, essential manatee habitat features should be monitored and evaluated. This information also will assist in determining areas which may need some additional level of protection (i.e., sanctuaries or refuges).

3.3.1 Establish manatee sanctuaries, refuges, and protected areas. Under authority of the ESA and its implementing regulations at 50 CFR 17, FWS may designate certain waters as manatee sanctuaries (areas where all waterborne activities are prohibited) or manatee refuges (areas where certain waterborne activities may be regulated). In the 1980s and 1990s, FWS designated six manatee sanctuaries in Kings Bay, Citrus County. In addition, under the NWR System Administration Act, the FWS established a 24-square-km (15-square-mi) zone, in the upper Banana River south of the NASA Causeway, in which motorboats are prohibited. Any such established areas must be posted and enforced.

In 2000, FWS initiated an effort to assess and propose new manatee refuges and sanctuaries throughout peninsular Florida. The goal is to consider the needs of the manatee at an ecosystem level and to use this rule-making provision to ensure that adequately protected areas are available to satisfy the life requisites of the species, with a view toward recovery. The FWS will periodically assess the need for additional or fewer manatee refuges and sanctuaries.

The establishment of No Entry, Limited Entry and No Motorboat zones by state and local regulations function similarly to FWS manatee sanctuaries. These protection areas were established to prevent human disturbance. Examples of these types of zones include: (1) Winter No Entry Zones around power plant warm-water outfalls that attract manatees; (2) Winter No Entry Zone at Blue Spring in Volusia County; (3) Year-round No Entry at Pansy Bayou in Sarasota County; and (4) the Virginia Key and Black Creek Year-round No Entry Zones in Dade County.

3.3.2 **Identify and prioritize new land acquisition projects.** Manatee-related land acquisition, which helps to expand regional networks of essential manatee habitat, is particularly important. In this regard, identification of priority areas must consider regional manatee habitat requirements and relationships among essential manatee habitats. To promote and guide these efforts, the HWG will establish a subcommittee, to include individuals from FWS, FWC, USGS-Sirenia, and others, to convene an annual meeting regarding acquisition projects. The subcommittee will act as a clearinghouse on the status of manatee acquisition projects and otherwise help coordinate efforts for relevant land acquisition projects by federal and state agencies, The Nature Conservancy, and others. As new information on manatee habitat use patterns and essential habitats become available, new areas for acquisition should be identified as warranted. Recent examples of local, state and federal manatee-related acquisition efforts are at Weeki Wachi Spring, Blue Waters and Three Sisters Spring in Citrus County, Warm Mineral Spring Run in Charlotte County, and Munyon and Little Munyon Islands in Palm Beach County.

3.3.3 **Acquire land adjacent to important manatee habitats.** Several NWRs managed by FWS contain essential manatee habitat and are adjacent to other essential non-protected manatee habitat areas. Expanding these areas and establishing new refuges would significantly improve protection not only for manatees, but also for many other species. State land acquisition programs administered by the five regional WMDs, FDEP, FWC, and DCA have acquired many areas that will further manatee habitat protection and have many important acquisition projects in varying stages of development. Local and private land acquisition efforts also enhance manatee habitat protection. Particularly important areas utilized as warm-water refuges, such as Three Sisters Spring in Citrus County and Warm Mineral Spring in Sarasota County, should be considered. As possible, FWS and state land acquisition programs cooperatively should pursue expanding publically-owned lands to incorporate manatee habitat.

3.3.4 **Establish and evaluate manatee management programs at protected areas.** After essential manatee habitats are acquired as identified in Task 3.3.5, the agencies responsible for administering those areas should incorporate manatee protection and public awareness measures into these unit administration programs. Such management measures, depending on local conditions and human activity patterns, may be needed to ensure that activities and development projects within or adjacent to protected areas or affecting state-owned submerged lands do not adversely affect manatees or their habitat. Such measures should be updated as appropriate.

3.3.5 **Support and pursue other habitat conservation options.** Manatee habitat conservation can be achieved through existing regulatory means (Task 1.2 and its subtasks) and through coordination with private foundations with an interest in environmental protection. Federal and state regulatory programs can provide for additional protection of water quality and aquatic resource protection through establishment of conservation easements and mitigation. Private foundations should be approached to procure sensitive lands around important manatee habitat areas. Purchased lands can be managed with the purpose of maintaining water quality (and quantity in the case of springs) by existing local, state or federal programs or through the foundation itself. It is also possible to foster protection of privately held lands important to manatee habitat protection through government tax incentives and focused outreach efforts.

3.3.6 **Assist local governments in development of county MPPs.** Local governments in Florida are encouraged to develop comprehensive, multi-faceted MPPs with technical and financial assistance from FWS , FWC, FDEP, COE, special interest groups, and the general public. Each plan should be designed to ensure manatee protection by addressing a variety of recovery elements or components including: (1) regulating boat facility siting; (2) protecting manatee habitat; (3) providing for public outreach and education; and (4) ensuring appropriate levels of law enforcement. Each plan also should reflect manatee protection zones established by state and federal agencies (sanctuaries, refuges, boat speed zones) and consider if other locally-approved zones are needed. These comprehensive plans will assist in planning future development in a manner compatible with manatee protection, and will ensure local government involvement in manatee protection efforts. All efforts should be made to achieve concurrence among state and federal agencies regarding the approval of county plans.

If local governments are not willing or able to develop comprehensive plans, then FWS and FWC will offer assistance in the development of individual components which would aid in manatee recovery and form the basis for future comprehensive planning efforts. For example, such a component might outline local government's public outreach and education efforts and set forth funding needs and sources as well as an implementation schedule. While not as valuable as a comprehensive plan, these individual components would still be helpful in achieving recovery of the manatee.

In the absence of approved MPPs, or components thereof, case-by-case decision-making on permit applications by state and federal regulatory agencies will consider the best available scientific and commercial data in order to render their decisions. It is likely that some permits will be denied or required to undergo significant modifications because of uncertainties resulting in the absence of comprehensive planning. While plans or components do not have official status as state or federal laws, certain elements, such as boat facility-siting, can be adopted as local ordinances, and the implementation of these elements can strongly influence and streamline state and federal permitting systems.

Florida's Governor Jeb Bush convened a special manatee summit in October 2000, to examine improvements which might be made to achieve better manatee protection. A special panel, including representatives from marine-related industries, environmental organizations, local governments, and state and federal agencies, evaluated the elements of a MPP. After discussing boating speed limits, boater education, law enforcement, manatee refuges and sanctuaries, and marina siting, the panel unanimously agreed that improved law enforcement and improved boater education should be a priority. Additionally the panel agreed that speed zones and sanctuaries were both effective means of protecting manatees. Governor Bush envisioned that the results of the summit would be used to develop more detailed budget priorities, legislation, and local plans for the protection and conservation of manatees, while preserving Florida's traditional culture of recreational and commercial boating.

3.3.7 Implement approved MPPs. MPPs approved by FWC and FWS should be implemented with the assistance of the action agencies, as appropriate. Copies of these plans should be provided to federal and state agencies as reference documents for decision-making with regard to permitting, leasing submerged lands, project review, or other agency actions. To affirm federal support for the county MPP process, COE should incorporate county MPPs into their permit review process and consult with FWS regarding the adoption of MPPs for the purpose of permit review.

As new information becomes available on manatees and the effectiveness of measures to protect manatees and manatee habitat, there may be a need to modify MPPs. FWC and FWS shall take the lead in periodically reviewing MPPs and make recommendations regarding the need to modify and/or update them.

3.3.8 Protect existing SAV and promote re-establishment of NSAV. Manatees in most Florida waters depend upon the prolific growth of SAV (e.g., seagrass and freshwater submerged plant communities). Coastal construction activities (e.g., dock development, dredging, shoreline stabilization, and urbanization) have contributed to the destruction of SAV habitat. Water pollution contributing to reduced water transparency has reduced the abundance of SAV in most water bodies around the state. Introduction of exotic plant species has eliminated or threatened diverse assemblages of freshwater NSAV communities, providing manatees with restricted food resources in many accessible rivers, lakes, and springs. Nutrient pollution, through contamination of ground and surface waters at major manatee aggregation areas like Crystal and Homosassa Rivers, has contributed to a reduction of available food plants in these areas. Such pollution has caused dramatic increases in certain blue-green algae species (most notably *Lyngbia spp*.) that covers over SAV and prevents growth of manatee food plants.

All manatee research, resource protection, and conservation agencies/organizations should actively support the establishment of water quality standards that will protect the existing and promote the regeneration of SAV in all Florida waters. In particular, FDEP and WMDs actively should pursue changing water transparency and nutrient pollution standards to reflect the light requirements of seagrass and other NSAV species. Water transparency standards should be based on light regimes needed for native rooted aquatic plant species historically found in affected waters.

3.3.8.1 Develop and implement a NSAV protection strategy. Protection and restoration of NSAV communities can be accomplished by enforcing and augmenting existing regulatory programs. Prior to a permit being issued, an assessment of seagrass resources should be required, involving site sampling. This sampling should occur between May and October to coincide with the seagrass growing season and should be based on a standardized sampling methodology so that the assessments can be compared equitably. For seagrass communities, regulatory agencies should standardize monitoring of seagrass damage and alterations authorized through environmental resource permitting activities. The HWG should develop and implement standardized seagrass mitigation criteria for all projects proposing any activities resulting in damage to seagrass. Freshwater NSAV communities considered for state and federal permitting programs should be afforded the same level of protection as seagrass, because the destruction or alteration of such communities often leads to dominance of exotic species. FWS and FWC should participate actively in regional and local seagrass protection working groups (e.g., National Estuarine Program focus groups) to assist in directing protection efforts in areas important to manatees.

3.3.8.2 **Develop and implement a state-wide seagrass monitoring program.** FWS, NFS, FWC, and FDEP should develop and implement a regular statewide seagrass monitoring program based on a biennial remote sensing effort. Monitoring efforts should involve trend analysis and comparison to historical distribution of all areas supporting seagrass growth. The FMRI should continue to be the central repository for all collected seagrass monitoring information in Florida. FDEP and FWC should establish a task force to identify total state-wide losses of seagrass due to human activities including, but not limited to, dredge-and-fill projects, dock construction, propeller-scarring, vessel-groundings, freshwater diversion projects, and industrial/municipal pollution changing water transparency. This task force should use the best available scientific data to assess the magnitude of statewide seagrass loss and modify regulatory practices to allow for recovery of seagrass in areas where it has been lost and to protect it in areas where it currently exists.

3.3.8.3 **Ensure aquatic plant control programs are properly designed and implemented.** Aquatic plant control programs around the state are conducted mostly in freshwater systems and are designed to control the dominance of certain species of exotic or native nuisance plants. Introduced species quickly can displace native plant communities and cause a reduction of diversity, fluctuations in NSAV abundance, and nutritional value of the habitat for manatees. It should be noted, however, that manatees have come to rely on exotic vegetation in some areas. Therefore, while efforts should support NSAV restoration, care must be taken to ensure adequate supplies of winter forage, including both native and exotic species. Such programs are especially important in areas of large manatee aggregations, such as Crystal River, Homosassa River, Warm Mineral Spring, and Blue Spring.

FWC, FWS, FDEP, and COE should continue to coordinate aquatic plant control programs for these systems through established working groups that address the protection of manatee habitat. The focus of these groups should be to: (1) reduce the need for excessive aquatic herbicide use through a policy of maintenance control for nuisance species; (2) focus control efforts during periods of minimal manatee use; (3) remove infestations of new exotic plant species; and (4) maintain a historically diverse NSAV community accessible to manatees as much as possible. New working groups should be established for waterways where aquatic plant control programs may jeopardize the aquatic plant abundance and diversity needed to sustain recognized manatee aggregations. FWC, FDEP, and FWS should continue to coordinate state-wide aquatic plant control policies, such as the exclusion of the use of copper herbicides in manatee habitat and on areas where conflicts between manatees and aquatic herbicide use may develop.

3.3.9 **Conduct research to understand manatee ecology.** Habitat-oriented research is important in identifying key habitats and the factors that determine what features are important for manatees and their recovery. Research should focus on the interrelationships between humans, manatees and their environment. Researchers should continue to monitor free-ranging manatees throughout their habitat, observe behaviors, document habitat use, and define how these influence the status of the manatee. Such research will help to understand and protect the manatees' environment; therefore, efforts should be made to improve ongoing studies and methods and to develop new ones.

3.3.9.1 **Conduct research and improve databases on manatee habitat.** Habitat-related research should focus on: (1) evaluating food preferences, nutritional requirements, and freshwater requirements; (2) development of body condition indices as potential indicators of environmental conditions; (3) evaluation of and monitoring the extent and condition of seagrass beds; (4) the effects of manatee grazing on seagrass ecology and recovery; and (5) continuing current studies outside Florida on the relationships between manatee health and reproduction with habitat condition. Results from these studies should provide information useful in the design of monitoring studies, estimation of manatee carrying capacity of seagrass beds in key areas, and a better understanding of the manatee's role in maintaining healthy, diverse seagrass communities.

3.3.9.2 **Continue and improve telemetry and other instrumentation research and methods.** Radio tracking provides an extremely valuable tool to determine and monitor manatee habitat use and behavior associated with environmental and habitat changes. Studies using telemetry should be designed to monitor a large number of manatees for short periods (cross-sectional studies) and individual animals (longitudinal studies) to better understand both population and individual responses to habitat change and habitat use. These studies should be coupled with health and reproductive assessments in order to make comparisons with habitat condition.

The use of conventional VHF and satellite telemetry should continue. Data generated from tracking studies should be entered into GIS databases and analyzed for correlations with habitat preferences and requirements. Verified point data should be provided to management as quickly as possible through technical reports and data transfer. Telemetry results should be published with appropriate analyses in refereed journals as frequently as the data allow.

Emerging technologies such as radio tags utilizing a Global Positioning System (GPS) and data loggersshould be further investigated and incorporated to provide better resolution of manatee movements and habitat use. Tags allowing the compilation and transfer of environmental, acoustical, and physiological data should be developed further and implemented to improve our ability to correlate with environmental and habitat parameters or disturbances.

3.3.9.3 **Determine manatee time and depth pattern budgets.** Time/depth recorders will allow evaluation of risks to manatees from vessel traffic in various habitat types by identifying the position of the animals in the water column. Such information can be related to vessel draft in the area, availability of waters deeper than vessel drafts, and time spent by manatees at specific depths. This information will contribute to a comprehensive risk assessment described in Task 3.3.11.4.

3.3.10 **Define the response to environmental change.** The Florida environment is not static. Future variation and change are anticipated and could impact survival, reproduction, and distribution of animals among regions, which in turn may affect population growth rates. In order to assess recovery, a need to understand how individual manatees, and consequently the population at large, respond to changes in the environment (e.g., changes in minimum flows at natural springs and elimination of industrial warm-water sources) on the redistribution of fresh water through the Everglades. Research to address such response should proceed at two levels: (1) test for correlation of changes in population parameters with known changes in the environment during long-term monitoring studies; and (2) test of hypothesized cause-effect relationships with behavioral and physiological studies and/or manipulative experimental trials.

3.3.10.1 **Define response to changes in fresh water flow patterns in south Florida as a consequence of the Everglades' Restoration.** Restoration of the Everglades to its historic water flow pattern is scheduled for the near future. This restoration will affect not only the distribution of fresh water leaving the Everglades, but also the estuarine ecosystem located off the south Florida coast. Studies should be structured to define how changes in sedimentation, bathymetry, seagrass beds, and fresh water input from restoration affects the distribution, survival, and reproduction of manatees.

3.3.10.2 **Define response to degradation and rehabilitation of feeding areas.** Marine seagrasses and fresh water aquatic vegetation are primary foods for manatees. Regionally, there have been documented declines in seagrass beds and freshwater aquatics resulting from pollution, hurricane-related die-offs, and scarring from boat propellers. Management is making attempts to reverse those declines and has been successful in areas such as Tampa Bay. Studies should be structured to define how changes in the distribution or abundance of feeding areas impact the distribution, survival, and reproduction of manatees.

3.3.11 **Maintain, improve, and develop tools to monitor and evaluate manatee habitat.** Protection of the manatee from human-related threats in part requires the determination of what constitutes optimal manatee habitats. Resource managers need to know what types of habitat are important to the species, including both natural and manmade features. Understanding manatee distribution in relation to the spatial arrangement of their habitat requires: (1) volumes of data; and (2) specialized computer software and appropriate techniques to analyze the data. GIS is used as an important geo-spatial tool and data-management system to store, synthesize, retrieve, and analyze these large volumes of data on manatees and manatee habitat. Site-specific data stored in GIS include: (1) manatee carcass recovery sites; (2) manatee sighting from aerial surveys; (3) ground research; (4) telemetry studies; (5) water depths; (6) vegetation coverage; (7) waterway speed and access zones; (8) shoreline characteristics and development patterns; etc. Computer hardware, software, and databases are used by researchers, resource managers, and conservationists for scientific analyses, permit reviews, developing waterway speed and access rules, and preparing county MPPs. Programs with theoretical and technical expertise need to focus on research and development of geo-spatial techniques to foster proactive manatee conservation strategies.

3.3.11.1 Maintain, improve, and develop tools to monitor and evaluate natural and human-related habitat influences on manatee ecology, abundance, and distribution. Utilize spatial models linked to a GIS to synthesize data and knowledge and to predict the most suitable habitats for manatees in Florida. GIS tools have the potential of evaluating human use impacts on manatees and their habitat. Analyses should be conducted to determine how human activities, such as coastal development and boating, affect manatee habitats and manatee distribution. These analyses will contribute to a comprehensive risk analysis.

3.3.11.2 Maintain, improve, and develop tools to evaluate the relationship between boating activities and watercraft-related mortality. Utilize GIS and manatee carcass information to create density models to spatially explore areas where manatees may be at higher risk. Evaluate the mortality density information in combination with human-use data, such as boating, to contribute to a comprehensive risk assessment.

3.3.11.3 Evaluate impact of changes in boat design and boater behavior. In recent years, changes in boat designs have resulted in changing threats to manatees. For example, the development of shallow draft vessels, such as flats boats and personal watercraft, along with high speed operation of these vessels over seagrass and other shallow water habitats used by manatees have created new threats to manatees in habitats where they were previously free of vessel interactions. The level of risk imposed by changing boating patterns needs to be evaluated. The boating industry, boating community, scientists, and wildlife managers should work to develop predictions of threats resulting from changes in boat designs and market-trend projections.

3.3.11.4 Conduct a comprehensive risk assessment. Utilize the results from the above Recovery Tasks and information from other databases to conduct a comprehensive risk assessment for the manatee.

3.4 Ensure that minimum flows and levels are established for surface waters to protect resources of importance to manatees. Minimum flows and levels are being established by state WMDs for surface waters throughout the state, including those used by manatees (*e.g.,* Biscayne Bay, Florida Bay and the Caloosahatchee River). Current and future withdrawals from surface waters have the potential to impact aquatic resources (e.g., SAV) important to manatees. Managers and researchers should participate in WMD efforts to set these limits to ensure that resources of importance to manatees are minimally affected.

3.5 Assess the need to revise critical habitat. Critical habitat for the Florida manatee was designated in 1976 (50CFR 17.95(a)). Much has been learned about manatee distribution in the decades since manatee critical habitat was originally defined. The FWS should assess the need to revise critical habitat for the Florida manatee.

Objective 4. Facilitate manatee recovery through public awareness and education. Compliance with regulations and management plans depends on broad public support for manatee recovery, which includes both manatee and habitat protection elements. Public support, in turn, depends on an informed public who understands manatee conservation issues and the rationale behind necessary regulatory and management actions. Knowledge of manatees, their habitat requirements, general biology, and protection measures can contribute toward the minimization of manatee disturbance, harassment, injury, and mortality. This information must be clear, consistent, concise, and readily available to the general public and target user groups. Many manatee and habitat education programs and materials are produced and made available to school systems as well as the general public and user groups; however, such efforts need to be continually evaluated and updated.

4.1 Identify target audiences and key locations for outreach. The success of a manatee/habitat conservation effort requires identification of target audiences and locations. Target audiences and key locations should be prioritized by need, i.e., areas where manatee mortality and injury are highest, areas where manatee/human interaction occurs frequently, and areas where habitat is most at risk. These areas include, but are not limited to, the thirteen key manatee counties, high watercraft use areas, boat ramps, manatee aggregation sites, manatee observation areas, fishing piers, seagrass areas, and other areas identified as having important habitat features (e.g., fresh water areas and areas used for resting and/or calving).

4.2 **Develop, evaluate, and update public education and outreach programs and materials.** There are many existing manatee and habitat awareness and education materials. Materials should be developed and updated for the general public, including students. As future stewards of our environment, it is important for students to learn about endangered species and their habitats and how to take positive actions to care for our fragile ecosystems. It is also important that some materials explicitly target specific user groups, such as: (1) boaters in areas of high watercraft mortality; (2) snorkelers/divers in areas where interaction and harassment occur; (3) recreational and/or commercial fishermen in areas where entanglements are prevalent; and (4) commercial/port facilities. Innovative ways to reach the public should be explored.

4.2.1 **Develop consistent and up-to-date manatee boater education courses/programs.** Boater education is critical to minimizing disturbance, harassment, injury, and mortality to manatees throughout Florida. Both resident and non-resident boat use in Florida continues to increase as water-related activities become more popular throughout the state. With the increasing traffic on our waterways, education becomes crucial for both manatee and public safety. Educating the boating public about the manatee will provide a better understanding of how the manatee lives and create a greater public appreciation toward the species. Efforts should continue to update and implement a consistent manatee education program for use in federal, state, and local boater education and training programs (e.g,. USCG Auxiliary Boating Safety Courses, U.S. Power Squadron Boat Safety Course, FWC On-Line Boating Safety Course).

4.2.2 **Publish and post manatee protection zone information.** To educate the boating community and public, organizations that produce materials (e.g., boater's guides, waterway guides, and fishing guides) should add or update the manatee protection zone information in forthcoming editions of their documents. A standardized format should be utilized to develop consistency throughout manatee habitat. Further, at all boat ramps, marinas, vessel rental operations and other access areas, efforts should be made to post signs containing information on manatee zones and "you are here" maps. Additionally, a website should be established allowing the public easy access to manatee protection zone information on the internet. This website could contain rules and regulations, detailed maps of the zones, sign locations within individual zones, examples of each type of sign, and definitions and explanations of manatee protection zones.

4.2.3 Update nautical charts and Coast Pilot to reflect current manatee protection zone information. FWS should request National Oceanic and Atmospheric Administration (NOAA) to update these documents to include: (1) a chart note referencing manatee protection zones for applicable nautical charts; and (2) information regarding the manatee protection zones for specific water bodies in Coast Pilot 4 and 5.

4.3 Coordinate development of manatee awareness programs and materials in order to support recovery. There are overlap and conflicting messages among existing materials produced by various agencies and conservation organizations. A Manatee Education Committee should be convened to review materials and programs with emphasis on reducing redundancy, providing consistent, standardized messages, and coordinating production of materials among participating organizations. All appropriate recovery plan tasks for education and public awareness materials and programs which have not been developed should be identified by the committee, and any unmet needs should be addressed.

4.4 Develop consistent manatee viewing and approach guidelines. Harassment is a violation of federal and state laws such as the MMPA, ESA, and Florida Manatee Sanctuary Act. While manatees may occasionally approach people on their own accord, people often chase after and pursue interactions with the animals. Human interference can disturb manatees and disrupt their natural behaviors (e.g., feeding, breeding, parenting, sheltering). Manatees which are harassed may leave preferred habitats or flee into areas with heavy vessel traffic. With increasing popularity of ecotourism, manatee harassment is an issue of growing concern statewide. Consistent viewing guidelines and education programs will be developed to teach responsible manatee viewing and approach practices, while ultimately serving to minimize disturbance. Coordination with agencies responsible for upholding marine mammal protection laws will allow for pooling of resources, thereby increasing the effectiveness of outreach materials and projects. A working group to address manatee harassment has been formed; the objective of this group is to develop easy-to-understand and comprehensive marine mammal and marine wildlife viewing education materials that promote responsible wildlife watching ethics.

4.5 Develop and implement a coordinated media outreach program. Public awareness and understanding is crucial to the recovery of the manatee in Florida. Whenever possible, when media opportunities occur, all recovery partners should make an effort to coordinate information prior to release. This coordination would serve to inform the general public with a consistent message on manatee biology, status, laws affecting them, how those laws benefit their quality of life, and why these laws are important to the recovery of the species. Such opportunities include, but are not limited to, annual mortality updates, synoptic survey results, manatee rescues and releases, and annual implementation of seasonal manatee protection zones and sanctuaries.

4.6 Utilize the rescue, rehabilitation, and release program to educate the public. The media heavily publicize rescues and releases and millions of visitors see and learn about manatees at critical- and long-term care facilities every year. Program participants should incorporate accurate, up-to-date information in their news releases, publications, presentations, displays, and other media to accurately portray the status of the manatee.

4.7 Educate state and federal legislators about manatees and manatee issues. Legislators in Tallahassee and Washington, D.C. can enact manatee protection regulations, or conversely, they can enact legislation that could result in harm to the species and/or its habitat. Holders of some legislative seats change as frequently as every two years, making the issue of educating legislators an ongoing one. To the greatest extent possible, at a frequency of at least every to years, recovery team partners should provide legislators with manatee awareness and education materials, as well as available status reports on the species and its management.

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PART III. IMPLEMENTATION SCHEDULE

The Implementation Schedule indicates task priorities, task numbers, task descriptions, duration of tasks, potential or participating parties, and lastly estimated costs (Table 6). These tasks, when accomplished, will bring about the recovery of the Florida manatee as discussed in Part II of this plan.

Parties with authority, responsibility, or expressed interest to implement a specific recovery task are identified in the Implementation Schedule. When more than one party has been identified the proposed lead party is indicated by an asterisk (*). The listing of a party in the Implementation Schedule does not imply a requirement or that prior approval has been given by that party to participate or expend funds. However, parties willing to participate will benefit by being able to show in their own budget submittals that their funding request is for a recovery task which has been identified in an approved recovery plan and is therefore part of the overall coordinated effort to recover the Florida manatee. Also, Section 7(a)(1) of the ESA directs all federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species.

Following are definitions to column headings and keys to abbreviations and acronyms used in the Implementation Schedule:

PRIORITY NUMBER

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

TASK NUMBER AND TASK Recovery tasks as numbered in the Narrative Outline.

RESPONSIBLE OR PARTICIPATING PARTY

C Fish Industry	Commercial Fishing Industry
COE	U.S. Army Corps of Engineers
CZS	Chicago Zoological Society
DERM	Miami-Dade Department of Environmental Resources Management
EPA	U.S. Environmental Protection Agency
Ecotour Ind	Ecotourism Industry
FDEP	Florida Department of Environmental Protection
FIND	Florida Inland Navigation District
FPL	Florida Power and Light Company
FWC	Florida Fish and Wildlife Conservation Commission Bureau of Protected Species Management Florida Marine Research Institute Division of Law Enforcement
FWS	U.S. Fish and Wildlife Service
GDNR	Georgia Department of Natural Resources
LE	Law Enforcement
Local Gov'ts	Local Governments
M Industry	Marine Industries
MML	Mote Marine Laboratory
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
OC	The Ocean Conservancy (formerly the Center for Marine Conservation)
Oceanaria	Cincinnati Zoo, Columbus Zoo, Homosassa Springs State Wildlife Park, Living Seas, Lowry Park Zoo, Miami Seaquarium, Mote Marine Laboratory, Sea World Florida and California, South Florida Museum
P Industry	Power Industries
Port Auth	Port Authorities
R Fish Industry	Recreational Fishing Industry
Sirenia	U.S. Geologic Survey - Sirenia Project
SMC	Save the Manatee Club
USCG	U.S. Coast Guard
USN	U.S. Navy
WMD's	Water Management Districts

ESTIMATED ANNUAL BUDGETS AND OTHER PROJECTIONS OF RECOVERY PARTNERS

Based upon recovery partners' current or proposed FY2001 budgets, it is estimated that close to $10 million is being spent annually on manatee recovery. This estimate does not include several significant recovery initiatives. Costs for USCG and FWC-DLE's manatee law enforcement efforts are not included in this total, nor are estimates included for COE, FDEP, and WMD regulatory programs which work regularly on manatee issues. Additionally, the COE's and the South Florida WMD's multi-million dollar project to retrofit navigational locks and water control structures with manatee protection technology in South Florida and FDEP's plan to retrofit structures at the Rodman Reservoir are not included in this total. It is possible that these programs may total an additional $4 to 5 million annually.

FWS FY 2001-2002 budget proposal for $1.36 million includes staff salary, recovery implementation projects, and a $1 million congressional add-on for: (1) manatee law enforcement; (2) a new manatee sanctuary and refuges initiative; and (3) a warm-water refuge initiative. In addition, regulatory consultations pertaining to manatee issues cost approximately $350 thousand annually in Florida. There is a need for two additional full time employees to handle the projected increase in consultations at a cost of $150 thousand.

COE, USCG, FDEP, and WMD's regulatory programs work regularly on manatee issues; however it was not possible to project the annual costs of these programs.

COE and South Florida WMD have partnered through the Central and Southern Florida Project, including matching funds, over $6.3 million has been budgeted to retrofit navigational locks and water control structures in South Florida with manatee protection technology during the next five years. In designing and constructing critical projects for the Everglades Restoration Project, water control structures are being designed to be manatee-safe, and cost estimates are not available for these projects.

USCG No estimate regarding the cost of USCG enforcement efforts has been provided. When on patrol, the USCG enforces all applicable federal laws and regulations. Costs of enforcing specific regulations, such as manatee speed zones, are not determinable. However, the USCG spends a significant amount of time patrolling navigable waterways that have speed zone regulations, and enforcement of speed zones is a high priority.

Sirenia FY 2001-2002 projected budget is $683 thousand.

FWC **BPSM** FY July 2000 - June 2001 budget of $1.566 million.

FMRI FY July 2000 - June 2001 budget of $3.325 million. This includes: (1) FMRI's research budget for $1.9 million; (2) $1.1 million administered by FMRI and earmarked for the critical care Oceanaria facilities and to the University of Florida Veterinary School; and (3) an additional $325 thousand in research contracts with MML that are administered by FMRI.

DLE No estimates were made regarding manatee law enforcement efforts, but the effort probably exceeds $1.0 million.

FDEP is budgeting to retrofit the Buchman Lock and Kirkpatrick Dam with manatee protection technology. Costs are anticipated to exceed $600 thousand over the next several years, however, this total is not included in the annual estimate.

GDNR FY 2001 budget of $19 thousand.

SMC FY 2001 proposed budget of $1.535 million.

MML FY 2001 manatee budget is $366 thousand. This includes $325 thousand in research contracts administered by FMRI and $41 thousand from MML and CZS.

Oceanaria estimated costs of $1.5 million for 50 manatees annually at $30 thousand per animal for basic maintenance of captive and rehabilitating animals. The critical care facilities receive $400 thousand from the Florida's Save the Manatee Trust Fund, and these funds are administered through the FWC-FMRI budget.

FPL projects FY 2001 budget that includes $110 thousand for studying warm-water refuge issues and for education.

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	1.1	Promulgate special regulations for incidental take under the MMPA for specific activities.	5 yrs	**FWS** COE	95	95	95	50	50	
2	1.2	Continue state and federal review of permitted activities to minimize impacts to manatees and their habitat.	Continuous	**FWS** **FWC** COE FDEP **GDNR** M Industry SMC USCG WMDs	500 278 4	500 278 4	500 278 4	500 278 4	500 278 4	
2	1.2.1	Continue to review coastal construction permits to minimize impacts.	Continuous	FWS FWC COE GDNR SMC WMDs						
2	1.2.2	Minimize the effect of organized marine events on manatees.	Continuous	FWS FWC GDNR M Industry SMC USCG						

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	1.2.3	Continue to review NPDES permits to minimize impacts.	Continuous	FWS FWC EPA FDEP GDNR P Industry SMC						
2	1.2.4	Pursue regulatory changes, if necessary, to address activities that are "exempt," generally authorized, or not covered by state or federal regulations.	2 yrs	FWS COE M Industry SMC						
1	1.3	Minimize collisions between manatees and watercraft.	Continuous	**FWS** **FWC** FIND GDNR Local Gov'ts Local LE M Industry OC SMC USCG	25 439	25 439	25 439	25 439	25 439	

Implementation Schedule

Florida Manatee Recovery Plan — **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
1	1.3.1	Develop and refine state waterway speed and access rules.	5 yrs to Develop Continuous to Refine	FWS FWC Local Gov'ts M Industry OC SMC						
1	1.3.2	Develop and refine federal waterway speed and access rules.	3 yrs to Develop Continuous to Refine	FWS FWC COE Local Gov'ts M Industry NPS OC SMC						
1	1.3.3	Post and maintain regulatory signs.	Continuous	FWS FWC FIND Local Gov'ts NPS USCG						

Implementation Schedule										
Florida Manatee Recovery Plan									**U.S. Fish and Wildlife Service**	
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
1	1.4	Enforce manatee protection regulations.	Continuous	**FWS** **FWC** Local LE MML NPS USCG	655 9	655 9	655 9	655 9	655 9	
2	1.4.1	Coordinate law enforcement efforts.	Continuous	FWS FWC Local LE NPS USCG						
2	1.4.2	Provide law enforcement officer training.	Continuous	FWS FWC Local LE NPS USCG						
2	1.4.3	Ensure judicial coordination.	Continuous	FWS						
2	1.4.4	Evaluate compliance with manatee protection regulations.	Periodic	FWS FWC MML SMC						

Implementation Schedule										
Florida Manatee Recovery Plan										**U.S. Fish and Wildlife Service**
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
1	1.4.5	Educate boaters about manatees and boater responsibility.	Continuous	FWS FWC Local Gov'ts Local LE M Industry MML OC SMC USCG						
2	1.4.6	Evaluate effectiveness of enforcement initiatives.	Periodic	FWS FWC Local Gov'ts MML						
2	1.4.7	Provide updates of enforcement activities to managers.	Continuous	FWS Local LE USCG						
1	1.5	Assess and minimize mortality caused by large vessels.	1 yr to Assess Continuous to Reduce	**FWS** FWC COE Port Auth. USCG USN	5	5	5	5	5	
2	1.5.1	Determine means to minimize large vessel-related manatee deaths.	2 yrs	FWS						

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
1	1.52	Provide guidance to minimize large vessel-related manatee deaths.	Continuous	FWS FWC COE FDEP USCG						
1	1.6	Eliminate manatee deaths in water control structures, navigational locks, and drainage structures.	Continuous	FWS FWC **COE** DERM FDEP **WMDs**	10 10	10 10	10 10	10 10	10 10	
1	1.6.1	Install and maintain protection technology at water control structures where manatees are at risk and monitor success.	5 yrs to Install Continuous to Maintain & Monitor	FWS FWC COE FDEP WMDs						
1	1.6.2	Install and maintain protection technology at navigational locks where manatees are at risk and monitor success.	5 yrs to Install Continuous to Maintain & Monitor	FWS FWC COE FDEP WMDs						

Implementation Schedule

Florida Manatee Recovery Plan — **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
1	1.6.3	Minimize injuries and deaths attributable to entrapment in drainage structures.	Install or Retrofit as Needed	FWS COE FDEP FWC Local Gov'ts WMDs						
1	1.6.4	Assess risk at existing and future water control structures and canals in South Florida.	2 yrs to Assess Continuous Monitoring	FWS COE FDEP FWC Local Gov'ts WMDs						
2	1.7	Minimize manatee injuries and deaths caused by fisheries and entanglement.	Continuous	**FWS** FWC GDNR SMC C Fish Indus R Fish Indus	10 10 1	10 10 1	10 10 1	10 10 1	10 10 1	
2	1.7.1	Minimize injuries and deaths attributed to crab pot fishery.	Continuous	FWS FWC C Fish Indus R Fish Indus						

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	1.7.2	Minimize injuries and deaths attributed to commercial and recreational fisheries, gear, and marine debris.	Continuous	FWS FWC Local Gov't C Fish Indus R Fish Indus OC SMC						
3	1.8	Investigate and prosecute all incidents of malicious vandalism and poaching.	As Needed	**FWS** **FWC** Local LE SMC USCG						
3	1.9	Update and implement catastrophic plan.	As Needed	**FWS** **FWC**	2	2	2	2	2	
2	1.10	Rescue and rehabilitate distressed manatees and release back into the wild.	Continuous	**FWS** Sirenia **FWC** GDNR MML **Oceanaria** SMC	50 1,130 1,000	50 1,130 1,000	50 1,130 1,000	50 1,130 1,000	50 1,130 1,000	
2	1.10.1	Maintain rescue network.	Continuous	FWS FWC MML						

Implementation Schedule Florida Manatee Recovery Plan U.S. Fish and Wildlife Service										
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
2	1.10.2	Maintain rehabilitation capabilities.	Continuous	FWS Oceanaria						
2	1.10.3	Release captive manatees.	Continuous	FWS FWC Oceanaria						
3	1.10.4	Coordinate program activities.	Continuous	FWS						
3	1.10.5	Provide assistance to international Sirenian rehabilitators.	Continuous	FWS FWC Oceanaria SMC						
3	1.10.6	Provide rescue report.	Annually	FWS						
2	1.11	Implement strategies to eliminate or minimize harassment due to other human activities.	Continuous	**FWS** FWC Local Gov't OC SMC	5	5	5	5	5	
2	1.11.1	Enforce regulations prohibiting harassment.	Continuous	FWS FWC USCG						
2	1.11.2	Improve the definition of "harassment" within the regulations promulgated under the ESA and MMPA.	2 yrs	FWS						
		Totals for Objective 1.			4,238	4,238	4,238	4,193	4,193	$21,100

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	2.1	Continue the MPSWG.	Continuous	**FWS** **Sirenia** FWC	5 20 12	5 20 12	5 20 12	5 20 12	5 20 12	
2	2.2	Conduct status review.	1 yr	**FWS**			25			
2	2.3	Determine life history parameters, population structure, distribution patterns, and population trends.	Continuous	FWS **Sirenia** Academia **FWC** GDNR MML	110 342 360 3	110 383 360 3	110 415 360 3	110 430 360 3	110 445 360 3	
2	2.3.1	Continue and increase efforts to collect and analyze mark/recapture data to determine survivorship, population structure, reproduction, and distribution patterns.	Continuous	Sirenia FWC MML SMC						
2	2.3.2	Continue collection and analysis of genetic samples to determine population structure and pedigree.	Continuous	Sirenia FWC MML						
2	2.3.3	Continue carcass salvage data analysis to determine reproductive status and population structure.	Continuous	FWC						

Implementation Schedule

Florida Manatee Recovery Plan **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	2.3.4	Continue and improve aerial surveys and analyze data to evaluate fecundity data and to determine distribution patterns, population trends, and population size.	Continuous	FWS Sirenia FWC MML						
2	2.3.5	Continue collection and analysis of telemetry data to determine movements, distribution, habitat use patterns, and population structure.	Continuous	Sirenia FWC						
2	2.3.6	Continue to develop, evaluate, and improve population modeling efforts and parameter estimates and variances to determine population trend and link to habitat models and carrying capacity.	Continuous	Sirenia FWC						
2	2.3.7	Conduct a PVA to help assess population parameters as related to the ESA and MMPA	2yrs	FWS						
2	2.4	Evaluate and monitor causes of mortality and injury.	Continuous	**FWS** **Sirenia** **FWC** CZS GDNR MML	15 12 1,102 5	15 12 1,022 5	15 12 1,022 5	15 12 1,022 5	15 12 1,022 5	

Implementation Schedule

Florida Manatee Recovery Plan **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	2.4.1	Maintain and improve carcass detection, retrieval, and analysis.	Continuous	FWS FWC GDNR						
2	2.4.2	Improve evaluation and understanding of injuries and deaths caused by watercraft.	Continuous	FWS Sirenia FWC M Industry						
2	2.4.3	Improve the evaluation and understanding of injuries and deaths caused by other anthropogenic causes.	Continuous	FWS Sirenia FWC COE FDEP M Industry OC WMDs						
2	2.4.4	Improve the evaluation and understanding of naturally-caused mortality and unusual mortality events.	Continuous	FWS Sirenia Academia FWC MML						

Implementation Schedule **Florida Manatee Recovery Plan** / **U.S. Fish and Wildlife Service**										
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
2	2.5	Define factors that affect health, well-being, physiology, and ecology.	Continuous	FWS **Sirenia** Academia **FWC** MML Oceanaria	10 22 470	10 22 470	10 22 470	10 22 470	10 22 470	
2	2.5.1	Develop a better understanding of manatee anatomy, physiology, and health factors.	Continuous	Sirenia Academia FWC MML Oceanaria						
2	2.5.2	Develop a better understanding of thermoregulation.	Continuous	FWC Academia Oceanaria						
2	2.5.3	Develop a better understanding of sensory systems.	Continuous	FWS Sirenia Academia FWC MML Oceanaria						
2	2.5.4	Develop a better understanding of orientation and navigation.	Continuous	Sirenia Academia FWC Oceanaria						

Implementation Schedule										
Florida Manatee Recovery Plan									**U.S. Fish and Wildlife Service**	
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
2	2.5.5	Develop a better understanding of foraging behaviors during winter.	Continuous	Sirenia FWC Academia Oceanaria						
2	2.5.6	Develop baseline behavior information.	Continuous	FWC Academia Oceanaria						
2	2.5.7	Develop a better understanding of disturbance.	Continuous	FWS Academia CZS FWC MML Oceanaria						
2	2.5.7.1	Continue to investigate how a vessel's sound affects manatees.	Continuous	FWS Academia FWC M Industry MML Oceanaria						

Implementation Schedule										
Florida Manatee Recovery Plan									**U.S. Fish and Wildlife Service**	
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
2	2.5.7.2	Investigate, determine, monitor, and evaluate how vessel presence, activity, and traffic patterns affect manatee behavior and distribution.	Continuous	FWS Sirenia Academia FWC CZS M Industry MML Oceanaria						
2	2.5.7.3	Assess boating activity and boater compliance.	Periodic Assessment Continuous to Improve Compliance	FWS Sirenia FWC Local Gov'ts M Industry MML SMC						
2	2.5.7.4	Evaluate the impacts of human swimmers and effectiveness of sanctuaries.	2 yrs	FWS FWC						
2	2.5.7.5	Evaluate the impacts of viewing by the public.	2 yrs	FWS FWC						
2	2.5.7.6	Evaluate the impacts of provisioning.	2 yrs	FWS FWC						
		Totals for Objective 2.			2,488	2,449	2,506	2,496	2,511	$12,450

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
2	3.1	Convene a Habitat Working Group.	Continuous	**FWS** **Sirenia** **FWC** M Industry OC SMC	5 20 80	5 22 80	5 24 80	5 26 80	5 28 80	October 2002, HWG will make recommendations to refine and improve habitat criteria
1	3.2	Protect, identify, evaluate, and monitor existing natural and industrial warm-water refuges and investigate alternatives.	Continuous	**FWS** **Sirenia** **FWC** FPL MML P Industry SMC	10 120 50 80	10 126 50 20	10 132 50	10 160 50	10 160 50	
2	3.2.1	Continue the Warm- Water Task Force.	Continuous	FWS Sirenia FWC FPL P Industry SMC						
1	3.2.2	Develop and implement an industrial warm-water strategy.	2 yrs to Develop Continuous to Implement	FWS Sirenia FWC EPA FDEP P Industry						

Implementation Schedule

Florida Manatee Recovery Plan — **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
1	3.2.2.1	Obtain information necessary to manage industrial warm-water refuges.	3 yrs	FWS FWC FPL P Industry						
2	3.2.2.2	Define manatee response to changes in industrial operations that affect warm-water discharges.	Continuous	FWS Sirenia FWC FPL						
1	3.2.3	Protect, enhance, and investigate other non-industrial warm-water refuges.	Continuous	FWS FWC FDEP SMC WMDs						
1	3.2.4	Protect and enhance natural warm-water refuges.	Continuous	FWS FWC FDEP SMC WMDs						
3	3.2.5	Assess changes in historical distribution due to habitat alteration.	1yr	FWS MMC Sirenia FWC						

Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
2	3.2.4.1	Develop and maintain a database of warm-water refuge sites.	Continuous	FWS Sirenia FWC						
1	3.2.4.2	Develop comprehensive plans for the enhancement of natural warm-water sites.	Continuous	FWS FWC						
1	3.2.4.3	Establish and maintain minimum spring flows and levels at natural springs.	Continuous	FWS FWC EPA SMC WMDs						
1	3.3	Establish, acquire, manage, and monitor regional protected area networks and manatee habitat.	Continuous	**FWS** **Sirenia** **FWC** FDEP Local Gov'ts SMC WMDs	290 165 547	290 180 547	290 190 547	290 160 547	290 170 547	
1	3.3.1	Establish manatee sanctuaries, refuges, and protected areas.	2 yrs Periodic Update	FWS FWC						

Implementation Schedule										
Florida Manatee Recovery Plan								U.S. Fish and Wildlife Service		
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
	3.3.2	Identify and prioritize new land acquisition projects.	Annually	FWS Sirenia FWC FDEP FWC SMC WMDs						
2	3.3.3	Acquire land adjacent to important manatee habitats.	Continuous	FWS FDEP Land Trusts Local Gov'ts WMDs						
2	3.3.4	Establish and evaluate manatee management programs at protected areas.	Continuous	FWS FWC						
3	3.3.5	Support and pursue other habitat conservation options.	Continuous	FWS FWC SMC						
1	3.3.6	Assist local governments in development of county MPPs.	Continuous	FWS FWC Local Gov'ts M Industry R Fish Indus OC SMC						

Implementation Schedule

Florida Manatee Recovery Plan | **U.S. Fish and Wildlife Service**

Priority	Task Number	Task Description	Task Duration	Participants	Estimated Fiscal Year Costs ($1000s)					Comments
					FY1	FY2	FY3	FY4	FY5	
1	3.3.7	Implement approved MPPs.	Continuous	FWS FWC Local Gov'ts						
2	3.3.8	Protect existing SAV and promote re-establishment of NSAV.	Continuous	FWS FWC FDEP FWC WMDs Local Gov'ts						
2	3.3.8.1	Develop and implement a NSAV protection strategy.	2 yrs to Develop Continuous to Implement	FWS Sirenia FWC FDEP FWC WMDs Local Gov'ts						
2	3.3.8.2	Develop and implement a state-wide seagrass monitoring program.	Continuous	FWS Sirenia FWC FWC NMFS WMDs Local Gov'ts						

Implementation Schedule										
Florida Manatee Recovery Plan									U.S. Fish and Wildlife Service	
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
21	3.3.8.3	Ensure aquatic plant control programs are properly designed and implemented.	Continuous	FWS Sirenia FWC COE FDEP FWC						
2	3.3.9	Conduct research to understand and define manatee ecology.	Continuous	Sirenia Academia FWC MML SMC						
2	3.3.9.1	Conduct research and improve databases on manatee habitat.	Continuous	Sirenia FWC						
2	3.3.9.2	Continue and improve telemetry and other instrumentation research and methods.	Continuous	Sirenia FWC						
2	3.3.9.3	Determine manatee time and depth pattern budgets.	Continuous	FWC MML						
2	3.3.10	Define the response to environmental change.	Continuous	FWS Sirenia FWC						

Implementation Schedule Florida Manatee Recovery Plan — U.S. Fish and Wildlife Service										
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
2	3.3.10.1	Define response to changes in fresh water flow patterns in south Florida as a consequence of the Everglades' Restoration.	Continuous	Sirenia Academia FWC						
2	3.3.10.2	Define response to degradation and rehabilitation of feeding areas.	Continuous	Sirenia FWC						
2	3.3.11	Maintain, improve, and develop tools to monitor and evaluate manatee habitat.	Continuous	FWS Sirenia FWC						
2	3.3.11.1	Maintain, improve, and develop tools to monitor and evaluate natural and human-related habitat influences on manatee ecology, abundance, and distributions.	Continuous	FWS Sirenia FWC						
1	3.3.11.2	Maintain, improve, and develop tools to evaluate the relationship between boating activities and watercraft-related mortality.	Continuous	FWS FWC M Industry MML						
3	3.3.11.3	Evaluate impact of changes in boat design and boater behavior.	Continuous	FWS M Industry MML						
2	3.3.11.4	Conduct a comprehensive risk assessment.	1 yr	FWS						

Implementation Schedule										
Florida Manatee Recovery Plan										**U.S. Fish and Wildlife Service**
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
2	3.4	Ensure that minimum flows and levels are established for surface waters to protect resources of importance to manatees.	Continuous	**FWS** FWC SMC WMDs	3	3	3	3	3	
3	3.5	Assess the need to revise critical habitat.	1yr	**FWS**						
		Totals for Objective 3.			1,370	1,333	1,331	1,331	1,343	$6,708
3	4.1	Identify target audiences and key locations for outreach.	3 yrs Periodically Update	FWS FWC GDNR OC SMC	5 5 2	5 5 2	5 5 2	5 5 2	5 5 2	
2	4.2	Develop, evaluate, and update public education and outreach programs and materials.	3 yrs to Develop Periodically Update	FWS FWC FPL GDNR OC SMC	5 205 30 2	5 205 2	5 205 2	5 205 2	5 205 2	
1	4.2.1	Develop consistent and up-to-date manatee boater education courses/programs.	2 yrs to Develop Periodically Update	FWS FWC M Industry OC SMC USCG						

Implementation Schedule										
Florida Manatee Recovery Plan									**U.S. Fish and Wildlife Service**	
Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
1	4.2.2	Publish and post manatee protection zone information.	Annually Publish Continuous	FWS FWC COE Local Gov'ts M Industry						
1	4.2.3	Update nautical charts and Coast Pilot to reflect current manatee protection zone information.	1 yr	FWS NOAA						
3	4.3	Coordinate development of manatee awareness programs and materials in order to support recovery.	Continuous	FWS FWC COE FDEP GDNR Local Gov'ts OC SMC USCG WMDs	5 14 2	5 14 2	5 14 2	5 14 2	5 14 2	
2	4.4	Develop consistent manatee viewing and approach guidelines.	2 yrs	**FWS** FWC OC SMC Ecotour Ind	3 1	3 1	3 1	3 1	3 1	

Implementation Schedule

Florida Manatee Recovery Plan — **U.S. Fish and Wildlife Service**

Priority	**Task Number**	**Task Description**	**Task Duration**	**Participants**	**Estimated Fiscal Year Costs ($1000s)**					**Comments**
					FY1	**FY2**	**FY3**	**FY4**	**FY5**	
3	4.5	Develop and implement a coordinated media outreach program.	1 yr to Develop Continuous to Implement	FWS FWC Local Gov'ts OC Oceanaria SMC	5	5	5	5	5	
3	4.6	Utilize the rescue, rehabilitation, and release program to educate the public.	Continuous	**FWS** FWC Oceanaria	3 1	3 1	3 1	3 1	3 1	
3	4.7	Educate state and federal legislators about manatees and manatee issues.	Continuous	FWS FWC M Industry OC P Industry SMC						
		Totals for Objective 4.			288	258	258	258	258	$1,320
		Total for Recovery.			8,384	8,278	8,333	8,278	8,305	$41,578

Manatee Population Status Working Group's (MPSWG) Recommendation of Population Benchmarks To Help Measure Recovery

RECOMMENDED POPULATION BENCHMARKS

The Manatee Population Status Working Group developed the following population benchmarks to assist in evaluating the status of the Florida manatee for reclassification to threatened status. In each of the four regions of the Florida manatee population (Northwest, Southwest, Atlantic, and Upper St. Johns River):

1. the average annual estimated rate of adult survival is at least 94%, with statistical confidence that the rate is not less than 90%;
2. the average annual percentage of adult females with calves during winter is at least 40%; and
3. the average annual rate of population growth is at least 4%, with statistical confidence that the rate is not less than 0 (no growth).

The MPSWG recommended that estimates of the benchmark statistics (survival, reproduction, and population growth rate) be determined over a minimum of a 10-year time period, and that no significant downward trend be detectable in these parameters, before FWS considers reclassification of the Florida manatee from endangered to threatened status. The MPSWG did not propose delisting criteria, as specific, quantitative habitat criteria have yet to be developed.

Table 4. Published population benchmark values for each region.

Region	Percent Survival	Proportion of Females with Calves	Percent Growth
Northwest	96.5 (95.1 - 97.5)[a] (1982 -1993)	.431 (1977 - 1991)	7.4 (1978 - 1991)
Southwest	unknown	unknown	unknown
Upper St. Johns River	96.1 (90.0 - 98.5)[a] (1978 - 1993)	.407 (1979 - 1993)	5.7 (3 - 8) (1978 - 1991)
Atlantic	90.7 (88.7 - 92.6)[a] (1985-1993)	.423 (1979 - 1992)	1.0 (1985 - 1991)

[a] 95% Confidence Interval

Data Sources: **Percent Survival** - Langtimm, O'Shea, Pradel, and Beck 1998. **Proportion of Females with Calves** - Rathbun, Reid, Bonde, and Powell, 1995 (Northwest); O'Shea and Hartley, 1995 (St. Johns River); and Reid, Bonde, and O'Shea, 1995 (Atlantic). **Percent Growth** - Eberhardt and O'Shea, 1995.

METHODS FOR DETERMINING THE POPULATION BENCHMARKS

Criterion A: average annual adult survival estimates, is based upon a mark-recapture approach, using resightings of distinctively marked individual manatees (Langtimm et al. 1998; see p. 11 for further details). Using open population models, adult survival probabilities were estimated for manatees in the Northwest, Upper St. Johns River, and Atlantic regions of Florida. After using goodness-of-fit tests in Program RELEASE to search for violations of the assumptions of mark-recapture analysis, survival and sighting probabilities were modeled with Program SURGE. Statistically robust population models with explicit assumptions will continue to be the basis for estimation of this benchmark.

Criterion B: average annual percentage of adult females with calves, is also based upon resightings of distinctively marked individual manatees. Ongoing development of multi-state models that account for misclassification of breeders and non-breeders will improve the accuracy of regional estimates of productivity. Efforts are also being made to develop a statistically valid method for estimation of a confidence interval for this benchmark.

Criterion C: average annual rate of population growth, is based upon a deterministic population model (Eberhardt and O'Shea 1995). Parameters in the model were primarily derived from life history information obtained through resightings of distinctively marked individual manatees in the Northwest, Upper St. Johns River, and Atlantic regions. It is a simple, 2-stage (calves and adults) model that does not incorporate stochasticity (variability in survival and fecundity rates caused by changes in environmental, demographic, and genetic factors). Future models of population growth rates will undoubtedly incorporate more stages (e.g., juvenile and subadult year classes) and stochasticity. New analyses of life history data (obtained through both carcass salvage data and resightings of known individuals), will undoubtedly improve parameter estimates and reduce uncertainty in modeling results.

BASIS FOR THE POPULATION BENCHMARKS

The benchmarks were based on published estimates of survival, reproduction, and population growth rate (Table 1). Adult survival is the most influential factor determining manatee population dynamics (Eberhardt and O'Shea 1995; Marmontel et al. 1997; Langtimm et al. 1998). Since there is currently no method for determining juvenile survival rates, the MPSWG included a reproduction benchmark. Manatee population growth is less sensitive to changes in reproductive rates than adult survival rates (Marmontel et. al. 1997); however, the average proportion of females with calves over long time spans (at least 10 years) is remarkably consistent across regions (O'Shea and Hartley 1995). The MPSWG concluded that changes in reproductive rates could be a useful indicator of manatee population status, but recognized that a relatively high level of variation in reproductive rates among years requires that a period of at least 10 years be used to estimate this parameter.

Survival rates are estimated from resightings of known individuals in the photo-identification catalog, using adults only (at least 5 years of age), resighted between December and February each year (Langtimm *et al.* 1998). Survival rates for three regions (the Northwest, Upper St. Johns, and Atlantic) were estimated using state-of-the-art statistical methods (Langtimm *et al.* 1998). The target is an adult survival rate of at least 94%, that is, at least 94 of each 100 adult manatees survive from one year to the next. This benchmark is less than the estimated survival rates (96%) in two regions (the Northwest, Upper St. Johns), and higher than the lowest estimated survival rate (91%) in the Atlantic region. The lower bound of the 95% confidence interval should be greater than 0.90 (95% certainty that survival rate is actually greater than 0.90).

Similarly, reproductive rates were estimated from resightings of known individuals in the photo-identification catalog, using adult females only (at least 5 years of age), resighted between December and February of each winter (O'Shea and Hartley 1995, Rathbun *et al.* 1995, Reid *et al.* 1995). The target is 40% of known adult females seen with calves in winter each year (1st or 2nd year calves). The target level has been reached in all three regions (the Northwest, Upper St. Johns, and Atlantic) for which adequate data exist to determine reproductive status of adult females (Table 2). The similarity across regions in the average proportion of adult females observed with calves in winter (43%, 41% and 42%, respectively) suggests that Florida manatees may have achieved a maximum level of reproduction (O'Shea and Hartley 1995).

The population growth rates for each region were calculated using a population model that incorporated estimated survival rates for adults, subadults, and calves, and reproductive rates (Eberhardt and O'Shea 1995). The target is a population growing at 4% per year, which is below the estimated growth rate for the Northwest and Upper St. Johns regions (Table 2). There is a one-to-one correspondence between adult survival above 90% and population growth rate (Eberhardt and O'Shea 1995). Thus, an adult survival rate of 94% corresponds to an annual population growth rate of 4%. In addition, 4% is mid-way between 0 and 8% growth, and 8% is likely to be the maximum manatee population growth rate through internal recruitment. Eberhardt and O'Shea (1995) estimated an annual growth rate of 7.4% for the Crystal River. Without any human-related deaths, this population could almost certainly attain a growth rate of 8%.

The proposed benchmark for population growth (4%) is based upon the results of the Eberhardt and O'Shea (1995) deterministic population model. These authors did not attempt to estimate confidence intervals for two of the three regions for which they estimated population growth rates (Northwest and

Atlantic), and used two different methods to estimate (relatively large) confidence intervals for the growth rate of the Upper St. Johns region. There is clearly uncertainty in their model results. Additionally, they did not attempt to account for the effect of environmental variability over time on population trend. It is essential either to be conservative in selecting a minimum growth rate benchmark, as in selecting 4%, or to require a high degree of statistical confidence that the average growth rate is not lower than 0 in all regions. The latter alternative will require development of new models that include statistically robust methods for estimating confidence intervals.

Research Plan to Determine and Monitor the Status of Manatee Populations

The success of efforts to develop and implement measures to minimize manatee injury and mortality depends upon the accuracy and completeness of data on manatee life history and population status. Population data are needed to identify and define problems, make informed judgments on appropriate management alternatives, provide a sound basis for establishing and updating management actions, and to determine whether or not actions taken are achieving management objectives.

MANATEE POPULATION STATUS WORKING GROUP

The interagency Manatee Population Status Working Group (MPSWG) was established in March 1998. The group's primary tasks are to: (1) assess manatee population trends; (2) advise the U.S. Fish and Wildlife Service (FWS) on population criteria to determine when species recovery has been achieved; and (3) provide managers with interpretation of available information on manatee population biology. The group also has formulated strategies to seek peer review of their activities. The working group should continue to hold regular meetings, refine recovery criteria, annually update regional and statewide manatee status statements, and convene a population biology workshop early in 2002, analogous to the one held in 1992.

STATUS REVIEW

Following the Population Status Workshop in 2002, FWS will conduct a status review of the Florida manatee. The review will include: (1) a detailed evaluation of the population status of the species; (2) an evaluation of existing threats to the species and the effectiveness of existing mechanisms to control those threats, particularly with respect to the five listing factors identified under the Endangered Species Act of 1973, as amended (ESA); and (3) recommendations, if any, regarding reclassification and additional and/or revised recovery objectives, criteria and tasks to deal with remaining threats.

LIFE HISTORY PARAMETERS AND POPULATION TREND

Many manatees have unique features, primarily scars caused by boat strikes. When carefully photographed, these features can provide a means of identifying individuals. **Photographs of distinctively-marked manatees** collected by researchers in the field are compiled in a database begun in 1981 by the U.S. Geological Service Sirenia Project (USGS-Sirenia) with support from the Florida Power and Light Company (FPL). Since its inception, the database has been expanded greatly and improved. It is now a photo CD-based computerized system, known as the Manatee Individual Photo-identification System (MIPS), that utilizes digitized images and PC-based search technologies. The Florida Fish and Wildlife Conservation Commission's (FWC) Marine Research Institute (FMRI) and Mote Marine Lab (MML) now assist in maintaining portions of the database.

It is essential to maintain the photography efforts of the USGS-Sirenia, FMRI, and MML to ensure that vital information on manatee sightings, movement patterns, site use and fidelity, reproductive histories, and related databases remain current for further analyses of survival and reproductive rates. Photos routinely should be collected in the field, especially at the winter aggregation sites, according to standardized protocols for data collection and coding by all cooperators. Annual collection of photographs is essential, as the loss of feature information for individuals in one season could result in an inability to recognize the individual in subsequent years, and potentially compromise the value of the database. Efforts to gather photographic documentation of known females should be continued and expanded to the Southwestern region (Naples through Ten Thousand Islands and the Everglades).

One of the most important parameters for estimating trends in population status is age-specific survival. Photographs documenting sightings of individually-identifiable manatees can be used to estimate minimum ages of manatees in the database and **annual survival rates**. Data on manatees overwintering at specific sites (e.g., Crystal River, Blue Spring, and the warm-water discharges on the Atlantic Coast) are extensive. Analyses using mark-resighting modeling procedures to estimate annual survival rates at these sites have been completed through 1993. Analyses to update these estimates and add additional survival estimates for sites in Southwest Florida (Tampa Bay to the Caloosahatchee River) are underway.

Dead manatees previously identified by photographic documentation must be noted in the database before sight-resighting analyses are undertaken. It is crucial that carcasses continue to be photographically documented and those images distributed to managers of the photo-ID databases, to enhance the accuracy and precision of survival estimates.

Concurrently with photography of individual manatees, information on the **reproductive status of each manatee** (e.g., calf associated with female) should continue to be collected whenever possible. Minimum ages of documented manatees and information such as age at first reproduction, calving interval, and litter size can be determined either during photo-documentation or by timely examination of the database. Long-term studies of reproductive traits and life histories of individual females provide data on age-specific birth rates and success in calf-rearing. The relative success of severely- and lightly-scarred females in bearing and rearing calves should be determined.

Information and tissue samples should continue to be collected from all carcasses recovered in the **salvage program** to determine reproductive status. Resulting estimates of reproductive parameters complement information obtained from long-term data on living manatees and will help to determine trends and possible regional differences in reproductive rates.

Paternity cannot be established in wild manatees without the ability to determine family pedigrees. This information is needed to determine if successful reproduction is limited to a small proportion of adult males, which has important implications for the **genetic diversity** of the Florida manatee population. By continuing the development of nuclear DNA markers, pedigree analysis can be applied to the growing collection of manatee tissue samples. Pedigree analysis also would greatly improve our knowledge of matrilineal relationships and female reproductive success. Identification of factors associated with successful breeding by males is important in assessing reproductive potential in the wild and in captivity.

Aerial surveys provide information on the proportion of calves which may provide insights on reproductive trends when a long time-series of surveys have been conducted by one or relatively few individuals in the same geographic regions. Calf counts from such surveys should be continued (particularly the state-wide surveys conducted by FMRI since 1991, the power plant surveys sponsored by FPL since 1977, and the Crystal/Homosassa River surveys conducted by FWS since 1983). The results should be compared to those obtained by photo-ID methods (particularly for the Crystal/Homosassa River wintering group).

Passive Integrated Transponder (PIT) tags should be inserted under the skin of all manatees captured during the course of ongoing research or rescues. All manatees that are recaptured, rescued, or salvaged should be checked for PIT tags, and identification information should be provided to FMRI. By comparing data on manatee size, reproductive status, and general condition between time of tagging and recovery, one can increase the amount of information obtained on life history parameters. This technique is particularly useful in identifying carcasses, which is very important in obtaining accurate survival estimates. Methods for checking for PIT tags reliably on free-swimming manatees should further be developed and tested. When the latter work shows promise, plans should be developed for re-examining the utility of PIT-tagging manatees of certain age classes (juveniles and subadults) or in specific areas where photo-ID is not a feasible way to re-identify individuals. This research should include estimates of sample sizes required to determine population traits, such as survival and reproductive rates.

POPULATION STRUCTURE

Information on population structure can be obtained through the carcass salvage program, the

MIPS database, and telemetry studies. This information is important for the development of realistic population models.

Collection of tissue samples from salvage specimens and from living manatees at winter aggregation sites, captured during research, or rescued for rehabilitation should continue. Continued genetic analysis through collaborations with state and federal genetics laboratories may reveal greater population structure than has been demonstrated thus far (i.e., a significant difference between east and west coasts, but not within coasts). Such research will improve our ability to define regional populations and management units. Stock and individual identity for forensic purposes ultimately will be possible. Analytical techniques recently developed for identifying the structure of other marine stocks also should be investigated.

To aid in characterizing population structure, life history information (e.g., sex and size class) should continue to be collected concurrent with photographs to augment similar information collected from other sources (e.g., carcasses and telemetry). Long-term patterns of fidelity to winter aggregation sites and summer ranges, as well as movement among sites, also can be documented.

Radio-tracking has provided substantial documentation of seasonal migrations, other long-distance movements, and local movements that reveal patterns of site fidelity and habitat use. In Brevard County, for example, a large group of manatees overwinters in the Indian River, using two power plants for thermal refuge, and another group travels south to Palm Beach and Dade counties, using several power plants for refuge along the way. While these two groups are not entirely mutually exclusive, many individuals consistently display the same pattern each year, in timing and distance of moves as well as destinations. Such information is needed from other regions, particularly Southwest Florida, in order to develop management strategies for all significant subgroups within the regional population, however transitory they may be.

The **salvage program** yields important information on the manatee population sex ratio and proportion of age classes (adult, subadult, juvenile, and perinatal) within each cause-of-death category. Annual changes in these proportions may indicate increases or decreases in certain types of mortality, and thus should be considered as part of the weight of evidence that supports (or rejects) a downlisting decision. Ear bone growth-layer-group analysis should be continued to determine more exact ages of dead manatees, particularly those that have a known history through the photo-ID or telemetry studies, or received PIT tags. Although the age structure of the carcass sample is biased toward younger animals, opportunities may occur to document better the natural age structure within specific regions because of age-independent mortality events.

DISTRIBUTION PATTERNS

Shifts in manatee distribution over time may interfere with our ability to assess accurately regional population trends. Changes may occur in response to human activities, such as modifications of warm-water discharges, enforcement of boat speed regulations, or restoration programs, and because of natural events, such as hurricanes or red tides. Efforts to document manatee distribution through aerial surveys, photo-ID, and telemetry should continue, particularly at important wintering sites, areas of high use, and poorly-studied regions. The validity of the four regional subpopulation designations should be periodically re-evaluated, as they may change over time.

As discussed above, **photographs documenting individual manatees** are important to provide information on life history parameters, population trends, and population structure. Such photographs are also important to provide information on fidelity to winter and summer sites, high-use of and seasonal movements among sites. These photos should continue to be taken at aggregation sites primarily in Florida, but also opportunistically at other sites in the Southeastern United States. Photo-ID efforts recently were initiated in the Ten Thousand Islands region, and should be continued and expanded to other sites in Southwestern Florida.

As appropriate and possible, local and regional **aerial surveys** should be undertaken or continued to improve information on habitat use patterns and changes in distribution. Documentation of changes in distribution at power plants will be particularly important when changes in warm water availability occur.

Telemetry research has proceeded as a series of regional studies with tracking efforts concentrated in different areas in different years. Multi-year studies have been completed for the Atlantic coast and Southwest Florida from Tampa Bay through Lee County, and research findings have been summarized in manuscripts currently undergoing peer review. Verified high quality satellite telemetry location information, with descriptive meta data, will be added to the Marine Resources CD-ROM produced by FMRI. Areas not well-studied, such as the Everglades or where anticipated changes are likely to impact manatees, will be targeted for future research.

POPULATION MODELING

Population models are mathematical representations of the underlying biological processes that control population dynamics. In order to be useful in describing the true behavior of population growth, existing models must be evaluated and improved continually. The underlying assumptions of models, the importance of parameters used in the models, the accuracy and uncertainty of the parameter estimates, the relationships of the parameters, and the appropriateness of the mathematics implemented in the models need to be evaluated critically. Comparisons also need to be made between predicted outcomes from the models and estimates or indices of population trend from other modeling efforts or other data sets.

Eberhardt and O'Shea (1995) developed a deterministic population model using estimates of mortality, reproduction, and survivorship to calculate estimates of population growth rates for three subpopulations of manatees. They considered this a provisional model requiring further development and modification. Steps should be taken to continue to improve this model and to develop more complex models incorporating additional life history information and which reflect better our understanding of the processes involved in population dynamics. Examples of additional population parameters that most likely will be needed in future models are stochastic variation in survival and reproduction rates, genetic population structure, and movement of individuals between regional subpopulations.

To construct valid models, accurate **estimates of population parameters** are required. Where estimates of model parameters need to be developed or improved, other relevant tasks should be modified or strengthened. Because parameters can vary over space and time and such variation affects population growth rates, emphasis should be placed on **estimating variance** and 95% confidence intervals along with developing best estimates of particular population parameters.

It is important for those **developing manatee population models** to coordinate their activities and to interact directly with research biologists who have collected manatee life history data or who are very familiar with manatee ecology. Biologists will understand better how models were derived, and the modelers will obtain feedback on the reasonableness of their assumptions and interpretation of their results. Interaction with management also is needed to help focus the questions addressed by present and future modeling efforts. For example, FWS wants to know if modelers can estimate the number of manatee deaths that can be sustained per region, while still allowing population stability or growth to be achieved. The coordination and interaction of all players will lead to the adaptive development of newer and better models that meet the needs of manatee biologists, policy makers, and managers. The multi-agency MPSWG is best positioned to track research developments, link important players, and provide one level of peer review and evaluation. Peer review from internal and external sources is essential to such evaluations.

Uncorrected aerial survey data do not permit statistically valid population estimation or trend analyses. However, models to correct for some of the inherent bias and uncertainty have been developed, and these efforts should be continued. Methods to correct for various types of visibility bias in surveys should be developed. Standard procedures for survey teams involved in annual statewide surveys need to be developed and implemented. Use of strip transect aerial surveys make it possible to use survey data to detect regional population trends, e.g., in the Banana River and perhaps in Southwest Florida between the Ten Thousand Islands and Whitewater Bay. Strip transect surveys should be continued on an annual basis in the Banana River, and their feasibility should be investigated in remote coastal areas of Southwest Florida. To the extent possible, surveys should be designed to estimate accurately a minimum population number.

As manatee habitat requirements are documented and recovery criteria are identified (based on habitat needs), it will become possible to **link regional population and habitat models and estimate optimum sustainable populations for regions and subregions**. Integration of population and habitat information is essential to understand the implications of habitat change before negative impacts on manatee population trends can occur. The Population Status and Geographic Information System (GIS) working groups should meet jointly on an annual basis to coordinate their activities and progress. Reports of these meetings should be distributed to all agencies and interested parties involved in manatee recovery efforts.

The manatee salvage/necropsy program is fundamental to **identifying causes of manatee mortality and injury**. The program is responsible for collecting and examining virtually all manatee carcasses reported in the Southeastern United States, determining the causes of death, monitoring mortality trends, and disseminating mortality information. Program data help to identify, direct, and support essential management actions (e.g., promulgating watercraft speed rules, establishing sanctuaries, and reviewing permits for construction in manatee habitat). The program was started by FWS and the University of Miami in 1974 and was transferred to the State of Florida in 1985.

The current manatee salvage and necropsy program is administered through FWC 's FMRI. The major program components are: (1) receiving manatee carcass reports from the field; (2) coordinating the retrieval and transport of manatee carcasses and conducting gross and histological examinations to determine cause of death; (3) maintaining accurate mortality records (including out-of-Florida records); and (4) carrying out special studies to improve understanding of mortality causes, rates, and trends. The carcass salvage program also has permitted scientists to: (1) describe functional morphology of manatees; (2) assess certain life history parameters of the population; and (3) collect data on survival of known individuals. Program staff also coordinate rescues of injured or distressed manatees. To implement the salvage program, FWC maintains a central necropsy facility called the Marine Mammal Pathobiology Laboratory (MMPL), located on the Eckerd College campus in St. Petersburg. FWC also has three field stations on the east coast situated in Jacksonville, Melbourne, and Tequesta, and one field station on the west coast at Port Charlotte.

To improve the program, FWC is hosting a series of manatee mortality workshops to review critically its salvage and necropsy procedures and methods. These workshops: (1) establish and improve "state-of-the-art" forensic techniques, specimen/data collection, and analyses; (2) identify and create projects focusing on unresolved death categories; (3) prepare for and assist with epizootics; (4) generate reference data on manatee health; and (5) generate suggestions for attainment of a "healthy" manatee population. In addition, FMRI personnel are urged to move forward with models based on life history and mortality data, and process improvement is being implemented to expedite data dissemination.

Georgia Department of Natural Resources, South Carolina Department of Natural Resources, Louisiana Department of Wildlife and Fisheries, Texas Marine Mammal Stranding Network, University of North Carolina at Wilmington, and others help to coordinate carcass salvages and rescues in other Atlantic and Gulf coast states. Mortality information collected from these efforts needs to be centralized and should be kept in the mortality database maintained by FWC. FWS and FWC should provide assistance to these manatee salvage and rescue programs through workshops, providing equipment and assistance when possible.

While it is believed that most dead manatees are found and reported to the salvage program, an unknown proportion are unreported. Annual manatee carcass totals, therefore, under-represent the actual number of deaths, indicating the need to **improve carcass detection, retrieval, and analysis**. Decomposition, increased in part by delayed carcass retrieval, reduces the ability to assign cause of death in some cases. To estimate the number of unreported manatee carcasses, studies should be done on carcass detection and reporting rates. Studies focusing on carcass drift, rate of decomposition, and how decomposition affects necropsy results should be conducted. Periodic peer reviews should take place on necropsy methods, data recording and analysis, and documentation of tissues collected. Representative samples should be archived with appropriate national tissue banks. Workshops such as the FWC Manatee Mortality Workshop should continue to be conducted to strengthen collaborative research and information sharing. Partnerships with other agencies and process analysis of carcass retrieval protocols should be ongoing in order to improve efficiency.

Collisions between manatees and boats is the largest known cause of manatee mortality, both human and non-human related; in the late 1990s, watercraft-related deaths constituted at least 25% of the total known annual mortality. Therefore, it is essential to **improve the assessment and understanding of manatee injuries and deaths caused by watercraft**. Under-reporting of watercraft mortality may occur because individuals may not die immediately but rather may develop complications resulting from injuries sustained by boats; such deaths are difficult to attribute to watercraft.

Benchmarks have been established for survival, reproduction, and population growth.

Longitudinal studies should be established to examine the effect of boats and boating activity on these parameters. Investigations of the characteristics of lethal compared to non-lethal injuries and causes should be developed using data from carcasses, photo-ID records, and characterizing healing in rescued injured animals. Investigations on lethal and non-lethal injuries also should attempt to characterize size of vessels, relative direction of movement of vessel, and propeller vs. blunt trauma statistics. Research on mechanical characteristics of skin and bones should be developed to obtain a better understanding of the effects of watercraft-related impacts. Regional studies are needed to characterize boating intensity, types of boats, boating behavior, and boating hot spots in relation to manatee watercraft-related mortality.

Increasing numbers of manatees in the Northwest region of Florida may lead to increasing numbers of animals killed by watercraft. However, such population increases would not explain the recent increase in the percent of mortalities related to watercraft. In addition, this explanation cannot be used for areas where the number of manatees is stable or decreasing. The available data suggest that on average in 2000, collisions with watercraft killed a manatee every 4.6 days. However, these data may underestimate the number of manatee mortalities. More effective diagnosis of watercraft-related injuries and mortalities is important for describing the extent and nature of the threat posed by watercraft. Mortality workshops are intended to improve our ability to diagnose watercraft-related mortalities more effectively on both fresh and decomposed carcasses.

Prevention of such injuries and mortalities is the goal. **Research is needed to address the causes of watercraft mortality and the effectiveness of management actions**. Importantly, such research also should investigate the effects of sublethal injuries and stress occurring as a result of boating activity. Injuries and stress may: (1) lead to reductions in animal condition and reproductive success; (2) cause animals to abandon habitat important for foraging, reproduction, or thermal regulation; or (3) impair immune system function thereby increasing the vulnerability of animals to disease, pollutants, or toxins. Thus, indirect or secondary effects of boating activity also may impede population recovery in ways that have not yet been assessed.

Studies are underway to **identify and evaluate adherence to manatee speed zone restrictions through statewide boater compliance studies**. The following should be continued and assessed: (1) the frequency of boater compliance with posted manatee speed zone restrictions; (2) the degree of boater compliance with posted manatee speed zone restrictions; (3) the levels of compliance among boat classes, seasonally, and temporally; (4) changes in compliance resulting from different enforcement regimes; and (5) changes in compliance resulting from different signage. Underlying sociological factors that affect compliance also should be investigated.

MML recently completed a **study that characterizes the intensity and types of boating**

activities in Southwest Florida. Similar studies should be conducted at selected locations around the state, with emphasis on areas where boat-related mortality of manatees is highest.

MML, FWC, and others are **investigating reactions of manatees to boats**. Preliminary information indicates that manatees perceive boats, but may, under certain circumstances, react in ways that place the animals in the path of, rather than away from, the boats. Additional studies of manatee responses to boats and vessel acoustics are needed. Indirect deleterious effects of shallow-draft or jet boats that can disturb manatees and cause them to move to boating channels or interrupt normal behaviors need to be studied. An evaluation of spatial and temporal factors associated with risk to manatees (i.e., proportion of time manatees are exposed to vessels relative to depth, habitat, and manatee activity) should be conducted.

In the 1970s, Odell and Reynolds described the extent to that flood control structures killed manatees in southeastern Florida. In response, the South Florida Water Management District modified the way that the structures operate, to determine if this change would mitigate the problem. The problem, however, continues to exist, and it involves flood control structures and navigational locks located throughout the state. The U.S. Army Corps of Engineers and various flood control agencies (among others) have devoted considerable time and money to possible solutions, but mortality in the structures was the second highest ever in 1999 (15 manatees died, accounting for approximately 5% of the total deaths during this year). **Research is needed to continue to assess manatee behavior leading to vulnerability around these structures**, as well as operational or structural changes that can prevent serious injury or death of manatees.

Presently, pressure-sensitive strips are being installed on vertical lift structures, and acoustic arrays are being installed on navigational locks. Efforts continue to understand better how and why manatees are killed by structures. The MMPL will associate forensic observations obtained at necropsy with specific characteristics of the structure that caused the death. Continued testing and improvement of manatee protection technology is encouraged.

Commercial fishing is not a major culprit involved in manatee mortality, unlike the case with most other marine mammals. Commercial fishing accounts for far fewer manatee deaths than do either collisions with boats or entrapment in water control structures. Nonetheless, manatees are killed by shrimp trawls, hoop nets, monofilament entanglement, hook and line ingestion, and crab pot/rope entanglement, indicating the need to **improve the evaluation and understanding of injuries and deaths of manatees caused by commercial and recreational fishing**.

Since the introduction of Florida's ban on the use of commercial nets in inshore waters in July

1995, manatees have been exposed to fewer opportunities to become entangled in nets. Because of the net ban, however, some former commercial net fishermen switched to crabbing using crab pots. Probably as a result of this increased number of crab pots, rescues of manatees entangled in crab pot lines have more than tripled since 1995. To reduce the increasing numbers of fishing gear entanglements by manatees, a multi-agency Manatee Entanglement Task Force has been established, focusing on creating changes in data collection protocols, potential technique/gear modifications, innovative tag designs, entanglement research, gear recovery/clean-up, and education/outreach efforts. Research on rates of entanglement, types of gear involved, and geographical and temporal changes in rates and types of entanglements should be developed. Studies on behavioral characteristics of manatees contributing to entanglement should be pursued. Hubbs-Sea World Research Institute currently is studying how manatees become entangled. Research on the amount of marine debris in inshore waters should be conducted, particularly where there are high levels of manatee entanglement. Programs to remove marine debris and recycle monofilament line also should be encouraged and continued.

Tests for several types of man-made compounds and elements have been conducted on manatee tissues. Although no known death or pathology has been associated with toxicants, some concentrations of contaminants have caused concern. Over time, concentrations of chemicals found in manatees from early studies have changed, possibly as a result of the regulation of chemical use. Such changes highlight the need to monitor tissues for chemical residues. In addition, survey studies provide insight into the presence of different or new compounds in the environment. While a broad range of tests have been conducted, there needs to be a greater focus on endocrine disruptor compounds. These compounds can alter reproductive success and have a dramatic effect on population growth.

By definition, **natural causes of mortality** are not directly anthropogenic and thus not easily targeted by management strategies. However, some aspects of natural mortality may be influenced by human activities. These activities include but are not limited to: (1) sources of artificial warm water; (2) nutrient loading; and (3) habitat modification.

Cold stress- and cold-related death are both factors contributing to manatee deaths. Acute cold-related mortality is related to hypothermia and metabolic changes which occur as a consequence to exposure to cold. Cold stress is related to the amount of cold exposure, nutritional debt, age and size of the animals, and time; cold stress can last as long as several months before the individual dies. The syndrome was originally described based upon the gross internal appearance of carcasses, combined with age of the animal (e.g., recently-weaned) and time of year (late winter to early spring). More recently, the appearance of skin lesions, not unlike frostbite, have been associated with cold stress, although the presence of these lesions is not considered to be a definitive indicator. Research continues to focus on critical cold air and water temperatures that affect manatee physiology (particularly as it pertains to acute cold- and cold stress-related mortality). To provide important clues as to how manatees deal with cold temperature, future research should study behavioral adjustments to cold (e.g., directed movement to warm-water refuges, time budget during cold periods, and surface resting intervals during warm spells). Research identifying the manatee's anatomical and physiological mechanisms for heat exchange are important to understanding the biological limitation of the species. Ancillary research should include identification of natural warm-water sites, because a growing population of manatees may be seasonally-limited by overcrowding at the larger well-known warm-water refuges.

In Florida, there are many species (approximately 20) of marine alga that can produce harmful **naturally-occurring biotoxins**. These toxins have the potential to cause massive deaths of fish, fish-eating predators (e.g., birds and dolphins), some species of sea turtles, and manatees. Many of the toxins also affect humans after they consume contaminated fish or shell fish (although human deaths are rare). One biotoxin (brevetoxin) has been the suggested cause of deaths of manatees. Brevetoxin is produced by the marine dinoflagellate, *Gymnodinium breve*, and is responsible for the red tides that occur along coastal Florida. The most recent epizootic of manatees in 1996 was attributed to brevetoxin and underscores the catastrophic effect such events can have on the population; in just 8 weeks, 145 manatees died in Southwestern Florida, representing a substantial loss to the population. Research is needed to improve our ability to detect brevetoxin in manatee tissues, stomach contents, urine, and blood. At the same time, environmental detection of red tides, their strengths, and the development of retardants are necessary. More advanced immunological research utilizing manatee cell cultures may result in the development of better treatment of manatees exposed to brevetoxin as well as the development of prophylactic vaccine.

Perinatal mortality has averaged approximately 24% of the total annual mortality for the last ten years; ranging from 11% in 1981 to 30% in 1991. The category termed "perinatal" is based on a size classification and is not a true cause of death; all manatees measuring 150 cm or less are grouped into this category regardless of developmental stage. Since the developmental stage of a young manatee may have important implications in the analysis of overall deaths, the MMPL initiated the generation of a protocol to identify characteristics of specific stages within this category. The protocol includes the documentation of changes in the circulatory system which occur around the time of birth. Improved methods are needed to subdivide the perinatal category into categories of: (1) clearly fetal; (2) at or near the time of birth; and (3) clearly born. Once these categories are well-defined, analysis can ascertain the life stage subject to the greatest impact, thus allowing for the future development of appropriate management policies. Field research focusing on factors affecting calf survival should be conducted (e.g., age of mother at reproduction, behavior, characteristics of calving areas, and human disturbance).

Periodically, **unusual mortality events** occur in which large numbers of manatees die or become moribund. In 1982 and again in 1996, manatees died or became ill from inhalation and ingestion of brevetoxin (see discussion above). Spikes in mortality also occur during periods of extreme or prolonged cold. Such events represent: (1) the potential for disastrous reductions in numbers of manatees occupying certain regions of the state; (2) the opportunity to learn about manatee response to disease agents or about manatee life history; and (3) a logistic ordeal if proper steps for coordination and communication have not been taken ahead of time. Consequently, FWS and FWC have created complementary manatee die-off contingency plans (Geraci and Lounsbury 1997; FWS 1998) that have been merged into one comprehensive document (FDEP *et al*. 1998). The document contains information and guidance from the two plans together with advice and provisions outlined in the executive summary from Wilkinson (1996). Research and investigations should follow the protocols and recommendations found in the Contingency Plans. In addition, there should be ongoing collection and storage of tissues and samples from healthy and non-mortality event manatees to establish a baseline and to aid interpretation of test results obtained during a catastrophic event and for retrospective studies. Investigators should contact and work closely with other research projects monitoring and evaluating harmful algal blooms. FWC mortality workshops should continue to facilitate and develop cooperative arrangements among investigators and institutions.

FACTORS AFFECTING MANATEE HEALTH, WELL-BEING, PHYSIOLOGY AND ECOLOGY

Relatively little attention has been paid to the health and well-being of individual manatees, although factors affecting individuals ultimately influence the overall status of the population. A variety of factors go into the making of a healthy individual, and health is defined by ranges of values rather than specific ones. Scientists discuss these ranges of values in terms of biological limits. Assessment of what is outside the range of normal values is important, and to make such assessments, baseline data are needed. This generally requires multiple samples from individuals representing a range of ages, different sexes, and a variety of reproductive stages.

There is a need to determine the relatively constant internal state in which factors such as temperature and chemical conditions remain stable and therefore within a range of values that permit the body to function well, despite changing environmental conditions. Stress is part of existence, and not all stress is bad for an individual. However, a stressor can affect homeostasis and health, and thereby precipitate a chain of events that can compromise the survival of an individual. There is also a need to understand the factors underlying large-scale trends. For example, individual manatees compromised by severe injury or disease may not be able to reproduce successfully. Similarly, sublethal effects of toxicants and even the effects of nutritional, noise-related, and disturbance-related stresses can impair immune function and potentially reduce the ability of individuals to reproduce. Study plans and protocols should be developed, collaborators identified, and results published.

Blood serum is the watery portion of the blood remaining after cells and fibrin are removed. Analysis of serum permits assessment of electrolyte levels, hormones, antibodies indicative of exposure to certain pathogens, and other factors important to the health of individual manatees. Serum can be banked for retrospective analyses. Efforts should be made to develop and publish a synthesis of: (1) current knowledge of **manatee serology**; (2) ranges of values associated with manatees in various demographic groups; (3) anomalies identified in manatees via serum analyses; and (4) any remaining unanswered questions.

Major organs and organ systems have been examined by a variety of scientists over the years. The compilation of anatomical observations by Bonde *et al*. (1983) reflects the fact that early in the evolution of manatee programs, efforts were made to understand **anatomy of manatees**. Such assessments have assisted scientists performing necropsies of dead manatees to determine morphologies and pathologies. Some systems or organs have been ignored but are important to assessing manatee health; these include: (1) the lymphatic system; (2) most parts of the endocrine system; and (3) non-cerebral parts of the brain. In addition, potential changes in reproductive tracts routinely should be assessed as part of ongoing life history assessments.

Manatee histology (microscopic anatomy) has been relatively unstudied, compared to gross anatomy. However, it is of no less importance in understanding normal organ or tissue functions, as well as abnormalities thereof. Responsible agencies should respond to this important deficiency.

Although work has been ongoing to assess effects of environmental temperatures on metabolism of manatees, the relationship among temperature change, metabolic stress, onset of chronic or acute disease symptoms, and even mortality of manatees is not perfectly understood. As noted above, the relationships among manatee reproductive status, body condition, thermal stress levels, and metabolic responses to such stress remain unclear. Answers to these **thermoregulation** questions are needed urgently as the specter of decreased availability of both natural and artificial warm-water sources looms. The research should focus not only on lower critical temperatures (the cold temperatures where metabolic stress occurs), but also on the upper critical temperature.

It is unclear whether or not manatees physiologically require fresh water to drink, and it is unknown what stresses may be created when fresh water is not available. Anatomical and experimental studies have indicated that manatees **osmoregulate** well in either fresh or salt water. The extent to which manatees seek fresh water suggests that the animals prefer it to drink, and they may be healthiest when they have at least occasional access to fresh water. Managers attempting to protect resources sought by, if not required by, manatees should bear in mind that fresh water is a desirable and possibly necessary resource for healthy manatees.

Stirling *et al*. (1999) provided an important assessment of polar bear **body condition indices** and related those values to changes in the environment and in consequent availability of polar bear food. They also related changes in reproductive performance and survival of offspring with changes in female body condition. This study exemplifies the importance of long-term data regarding animal health (as assessed by body condition), reproduction, and environmental quality. In Florida, where environmental quality varies considerably over time and space, the value of such a study is enormous. Body indices research at FMRI has initiated certain measurements documenting body condition of manatees. Maintenance of this work and refinements/extensions thereof, should be continued to gain a better understanding of physiology and health of individuals and the population.

Continuous long-term monitoring of the **health histories of individual manatees** allows for documentation of an animal's health. Information should be gathered on: (1) the acquisition and severity of new wounds to facilitate research on the length of time required for injuries to heal; and (2) any effects of injuries on behavior or reproduction. Natural factors affecting the health of the population also should be monitored during the course of photo-ID studies on wild individuals (e.g., cold-related skin damage, scars caused by fungal infections, and papilloma lesions).

As discussed earlier, brevetoxin, a **naturally-occurring toxin**, has been implicated or suspected in major and minor mortality events for manatees for decades. Tests now exist to allow pathologists to assess, even retrospectively, manatee tissues for signs of brevetoxicosis. The important questions include: (1) how many manatee deaths can be truly attributed to exposure to brevetoxin over the years; (2) if red tides are a natural occurrence, how can effects of red tides on manatees be reduced or mitigated; (3) would changes in human activities (i.e., creation of warm-water refuges which lead to aggregations of manatees) appreciably change vulnerability of the animals; and (4) have human activities contributed to increased prevalence and virulence of red tides.

Inasmuch as a single epizootic event can cause 2 to3 times as many manatee deaths as watercraft causes annually, gaining a better understanding of the issue is vital and urgent. Development of cell lines and testing of manatee tissues would represent an extremely useful approach. In particular, preliminary results indicate that exposure to brevetoxin reduces manatee immune system function. Further study of the immune system will define levels of concern and will help to identify when rehabilitated manatees are ready for release into the wild.

Other natural toxins have affected marine mammals (e.g., saxitoxin) and may represent another potential problem for manatees. Exposure of cultured cells of manatees to saxitoxin and assessment of the responses of those cells, would be useful.

To date, the only efforts to assess levels of **toxicants** in manatees have involved some organochlorines and a few metals. This situation is typical of toxicological work for marine mammals in general (O'Shea 1999; Marine Mammal Commission 1999). These studies demonstrate that a few metals occur in high concentrations in manatee tissues. Testing for toxicants can be extremely expensive; thus, a carefully-constructed study plan should be developed first to address the most critical uncertainties and to make the assessments as cost-effective as possible. Some important habitats in Dade County (e.g., Miami River and Black Creek) contain sediments contaminated with trace metals and/or synthetic organic chemicals to the extent that the sediments are considered to be toxic. Sediment chemistry/toxicity testing could be used as an indicator to direct toxicant studies in these types of areas.

A **disease** involves an illness, sickness, an interruption, cessation, or disorder of body functions, systems, and organs. In other words, disease represents the antithesis of homeostasis. As previously noted, scientists need to learn the boundaries of normal structure and function before they can diagnose what is normal or diseased. This process has occurred to some degree through the necropsy program, but it needs considerable refinement. Over the years, cause of death for about 1/3 of all manatee carcasses has been undetermined; this percentage probably would drop considerably with better information about and diagnosis of manatee disease states. Planned workshops by FMRI will attempt to bring scientists conducting necropsies on manatees together with pathologists and forensic scientists working with humans and other species. This effort should be very useful as a first step in an ongoing process of refinement.

Nutritional characteristics of manatee food plants and the importance of different food sources for different manatee age and sex classes in various regions are understood poorly. Such information is needed to help assure that adequate food resources are protected in different areas of the population's range. Ongoing studies should be completed to identify manatee food habits and the nutritional value of different aquatic plants important to manatees. In addition, seasonal patterns of food availability in areas of high manatee use need to be documented. Research also should address **manatee foraging behavior**, emphasizing ways that manatees are able to locate and utilize optimal food resources.

Catalogs of **manatee parasites** were prepared two decades ago (Forrester *et al*. 1979). A recent description of parasites for cetaceans (including manatees) in Puerto Rico also was published (Mignucci-Giannoni *et al*. 1998). Since degrees of parasitic infestation may be associated with the changes in the health of manatees, assessments of changes in prevalence of parasites over time should be undertaken. Inasmuch as parasite loads are assessed, at least qualitatively, during necropsies, this should be easy to accomplish, relatively speaking.

Vision in manatees has been well studied relatively. Tactile ability and acoustics also have been assessed. Conclusions reached as a result of acoustic studies are somewhat inconsistent and controversial, especially in terms of the extent that manatees may hear approaching watercraft. Since the auditory sense of manatees appears to be vital to their ability to communicate and to avoid injury, further studies are warranted. In addition, although chemoreception has been suggested as a mechanism by which male manatees locate estrous females, chemosensory ability of manatees is virtually unknown. Studies should continue on these topics to **develop a better understanding of manatee sensory systems**.

It is clear from various lines of evidence that manatees show site fidelity, especially in terms of their seasonal use of warm-water refuges, but also in their use of summer habitat. To some extent, calves learn locations of resources from their mothers. However, the way that manatees perceive their environment, cues they use to navigate, and the hierarchy of factors they use to select a particular spot or travel corridor are all unknown. As humans continue to modify coastal environments (physically, acoustically, visually, and chemically), it would be useful to understand better how such changes may interfere with the manatee's ability to **orient and to locate or select optimal habitat**.

Relatively few studies have been directed at **manatee behavior** since Hartman's work in the late 1970s. Rathbun (1999) summarized existing information on activity and diving, foraging, thermoregulation and movements, resource aggregations, mating, social organization, and communication. He concluded that, although the manatee's herbivorous diet is perhaps the most important factor in understanding their life history and behavior, it is the least studied aspect of manatee behavioral ecology. Both field studies and controlled experiments at captive facilities are needed to document basic behaviors. This documentation will allow detection and understanding of changes in behavior that occur through changes in allocation of essential resources, such as vegetation and warm water. To date, telemetry, photo-ID, and aerial videography have been useful tools for behavioral research. New innovative approaches are needed, particularly in habitats where visibility is poor.

Captive dolphins have developed ulcers and died when subjected to excessive human activity or excessive noise (i.e., from pumps) around their enclosures. Chronic levels of **disturbance** may create stresses to manatees; certainly, manatees change their behavior or actually leave certain areas to avoid disturbance. The stress involved would be difficult to document, but if manatees move away from critically important resources (e.g., warm water in winter) to avoid being disturbed, this movement could place the animals in immediate and acute jeopardy. Buckingham *et al*. (1999) provide an interesting case study for manatees, and data exist to support problems created by disturbance for a variety of marine mammals, including animals sympatric with Florida manatees (i.e., dolphins). Sources and level of activities eliciting disturbance responses need to be characterized further.

Manatees, particularly mothers and calves, communicate vocally. Often, while vessels are still outside of visual range, manatees initiate movements as boats approach, suggesting that they respond on the basis of hearing the boats. Noise from boats or other sources may interfere with communications or provide a source of stress. Hearing capabilities have been examined through studies involving two individuals in captivity (Gerstein 1995, 1999). There is a need for further research on hearing capabilities and the **effects of noise on manatees**. In particular, it is important to determine: (1) the sensitivity of manatee hearing to the different kinds of vessels to which they are exposed; (2) the range of frequencies of importance to manatee communication; (3) the abilities of manatees to localize sound sources; and (4) the role that habitat features may play in altering sound characteristics. The levels and characteristics of vessel sounds leading to behavioral changes, including potentially vacating an area, need to be determined.

Manatee distributions have been found to be **affected by boat traffic** in at least one study, with manatees moving into established sanctuary areas during periods of heavy boat traffic (Buckingham *et al*. 1999). Factors to be investigated include types and frequency of approaches, numbers of boats, distance of nearest approach, individual variations in manatee responses to boats, influences on diurnal activity patterns and habitat use, and effects on mothers and young.

Human swimming (and to a lesser extent diving) with manatees occurs in many parts of the species' range. In a few warm-water refuges, sanctuary areas have been established for manatees to escape from contact with human swimmers, but few data from systematic studies are available to evaluate the potential **impacts of human swimmers** or the effectiveness of the sanctuaries. The specific circumstances or characteristics of human swimming, snorkeling, or SCUBA-diving that may result in changes in manatee behavior, including vacating an area, remain to be determined. Factors to be investigated include types and frequency of approaches, numbers of swimmers, distance of nearest acceptable approach, occurrence of contact, individual variations in manatee responses to humans, influences on diurnal activity patterns and habitat use, and effects on mothers and young.

Public viewing of manatees has become increasingly popular in recent years and now occurs in many parts of the species' range. Commercial operations as well as private individuals are bringing increasing numbers of people to view manatees in areas where the animals can be found predictably. The opportunity for the public to move into close proximity to the animals typically is associated with other potentially disturbing activities such as swimming, diving, boating, or provisioning. The relative benefits of burgeoning human attention as compared to potential adverse impacts on the animals have not been evaluated properly to determine the desirability of increasing or decreasing control over manatee viewing activities. Studies relating marketing and overall levels of human viewing activities to changes in manatee behavior, including vacating an area, need to be conducted. Conversely, benefits accrued to the manatees from increased viewing by the public also should be evaluated for comparison.

In many parts of the species' range, people provide food or water to manatees, in spite of regulations prohibiting such activities. A systematic evaluation should be conducted to determine if these **provisioning** activities potentially adversely affect manatees in terms of changing their behavior, placing them at greater risk from other human activities, or encouraging them to use inappropriate habitat.

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FLORIDA MANATEE CAUSE OF DEATH BY REGION (1991-2000)
ATLANTIC, UPPER ST. JOHNS RIVER, NORTHWEST AND SOUTHWEST

Manatee carcasses reported in Florida from 1991 to 2000 (FWC, unpublished data) were assigned to four regions of the state: (1) Atlantic Coast (St. Johns River and tributaries downstream (north) of Palatka); (2) Upper St. Johns River (St. Johns River upstream (south) of Palatka); (3) Northwest (Homosassa/Crystal River and north); and (4) Southwest (Tampa Bay area). The percentage of carcasses by each cause of death was calculated for each region (Tables 5-6 and Figures 17-21).

Two regions contained most of the 2,306 carcasses located state-wide (Atlantic 50%, Upper St. Johns River 2%, Northwest 5%, Southwest 43%); however, the Atlantic and Southwest regions also have the highest numbers of living manatees. Therefore, results should be viewed cautiously because percentages among causes of death can seem contradictory. Large numbers of deaths in one region in one category can make another category seem less important. A mortality event in one region can make all the other causes seem less important (smaller percentages), when actually all of the causes take on even greater importance due to the high number of deaths in a short time period.

Carcasses (n=145) from the 1996 red tide epizootic in southwest Florida were omitted from the following analysis, because this was considered to be a non-typical situation; their inclusion here would make other human-related and natural causes of death seem less important.

Causes of death varied among regions. The percentage of watercraft-related deaths was highest in the St. Johns River region (15 carcasses, 34%) and lowest in the Atlantic (264 carcasses, 24%) region. The highest number of watercraft deaths occurred in the Atlantic and in the Southwest regions (252 carcasses, 27%).

The highest percentage of flood gate and lock deaths occurred in the Atlantic (69 carcasses, 6%) and St. Johns River regions (4 carcasses, 8%), and lowest percentage occurred in the Northwest region (1 carcasses, 1%). The highest number of gate/lock deaths occurred in the Atlantic and Southwest (19 carcasses, 2%) regions. Only a few water control structures and navigational locks are present on the west coast, and percentages were lower there.

All other human-related causes of deaths combined accounted for the highest percentage of deaths in the Atlantic (40 carcasses, 4%) and Northwest regions (4 carcasses, 4%), and accounted for the lowest in the St. Johns River (0 carcasses, 0%). The highest number of other human-related deaths occurred in the Atlantic and Southwest (14 carcasses, 2%) regions.

Perinatal deaths accounted for the highest percentage of deaths in the Northwest region (32 carcasses, 33%). The highest number of perinatal deaths occurred in the Atlantic (296 carcasses, 27%) and Southwest (190 carcasses, 20%) regions.

Cold-related deaths accounted for the highest percentage of deaths in the Atlantic region (29 carcasses, 3%). The only recent large cold mortality event primarily in Brevard County during the winter of 1989-1990. Cold-related deaths were lowest in the two regions with major natural springs, the St. Johns River (0 carcasses, 0%) and Northwest (3 carcasses, 3%) regions.

Other natural causes of death combined accounted for the highest percentage of deaths in the Southwest Region (154 carcasses, 17%), and accounted for the lowest percentage in the St. Johns River (2 carcasses, 5%). The highest number of other-natural deaths occurred in the Southwest and Atlantic (112 carcasses, 10%) regions. The high number of deaths from natural causes in the Southwest region may partly reflect occasional small red tide events.

Undetermined deaths (including verified but not recovered carcasses) accounted for the highest percentage in the Southwest Region (277 carcasses, 30%), and accounted for the lowest percentage in the Northwest (20 carcasses, 20%). The highest number of undetermined deaths occurred in the Southwest and Atlantic (279 carcasses, 26%) regions. The high number of undetermined deaths in the Southwest region may be related to the high levels of carcass decomposition because of the warm temperatures and remoteness of large parts of the region (i.e., few observers to find carcasses and long travel times required to retrieve carcasses). The high percentage of undetermined causes in the Southwest makes all the other categories proportionately smaller in that region.

Deaths of adult-sized animals (276 to 411 cm total length) were summarized separately. Analysis using only deaths of adult-sized animals eliminates all of the perinatal carcasses and most of the cold-related deaths, which are mostly sub-adult manatees. Percentages of deaths, by causes, were similar among the four regions. Regions with high percentages of perinatal and cold-related deaths showed the greatest differences when adults were considered separately.

Statewide, watercraft-related deaths accounted for 39% of adult deaths, and all human-related deaths combined comprised 53% of deaths. All human-related causes combined constituted the highest percentage of deaths in the St. Johns region (14 carcasses, 64%) and in the Atlantic region (181 carcasses, 58%). The Atlantic region has the largest coastal human population of the four regions. The health of a regional population is closely tied to the adult survival rate. Therefore, it is very important that the percentages of human-related deaths be kept as low as possible.

Table 5. Manatee deaths in Florida, 1991-2000, by 4 regions and statewide. **All size classes** (FWC, unpublished data).

CAUSE OF DEATH	ATLANTIC		ST. JOHNS		NORTHWEST		SOUTHWEST		STATEWIDE	
	Number	%	Number	%	Number	%	Number	%	Number	%
Watercraft	264	24.2	15	34.1	26	26.5	252	27.1	557	25.8
Gate/Lock	69	6.3	4	9.1	1	1.0	19	2.0	93	4.3
Other Human	40	3.7	0	0.0	4	4.1	14	1.5	58	2.7
Perinatal	296	27.2	11	25.0	32	32.7	190	20.4	529	24.5
Cold-Related	29	2.7	0	0.0	3	3.1	24	2.6	56	2.6
Other Natural	112	10.3	2	4.5	12	12.2	154*	16.6	280*	12.9
Undetermined	279	25.6	12	27.3	20	20.4	277*	29.8	588*	27.2
TOTAL	1089	100.0	44	100.0	98	100.0	930*	100.0	2161*	100.0

* Omit n=145 Red Tide deaths in Southwest Florida, 1996

Table 6. Manatee deaths in Florida, 1991-2000, by 4 regions and statewide. **Adult-only size class** (>275 cm total length). FWC unpublished data.

CAUSE OF DEATH	ATLANTIC		ST. JOHNS		NORTHWEST		SOUTHWEST		STATEWIDE	
	Number	%	Number	%	Number	%	Number	%	Number	%
Watercraft	122	39.0	11	50.0	8	33.3	103	39.3	244	39.3
Gate/Lock	37	11.8	3	13.6	0	0.0	13	4.9	53	8.5
Other Human	22	7.0	0	0.0	2	8.3	6	2.3	30	4.8
Perinatal	—	—	—	—	—	—	—	—	—	—
Cold-Related	1	0.3	0	0.0	2	8.3	0	00.0	3	0.5
Other Natural	35	11.2	1	4.6	5	20.9	51*	19.5	92*	14.8
Undetermined	96	30.7	7	31.8	7	29.2	89*	34.0	199*	32.1
TOTAL	313	100.0	22	100.0	24	100.0	262*	100.0	621*	100.0

* Omit n=145 Red Tide deaths in Southwest Florida, 1996

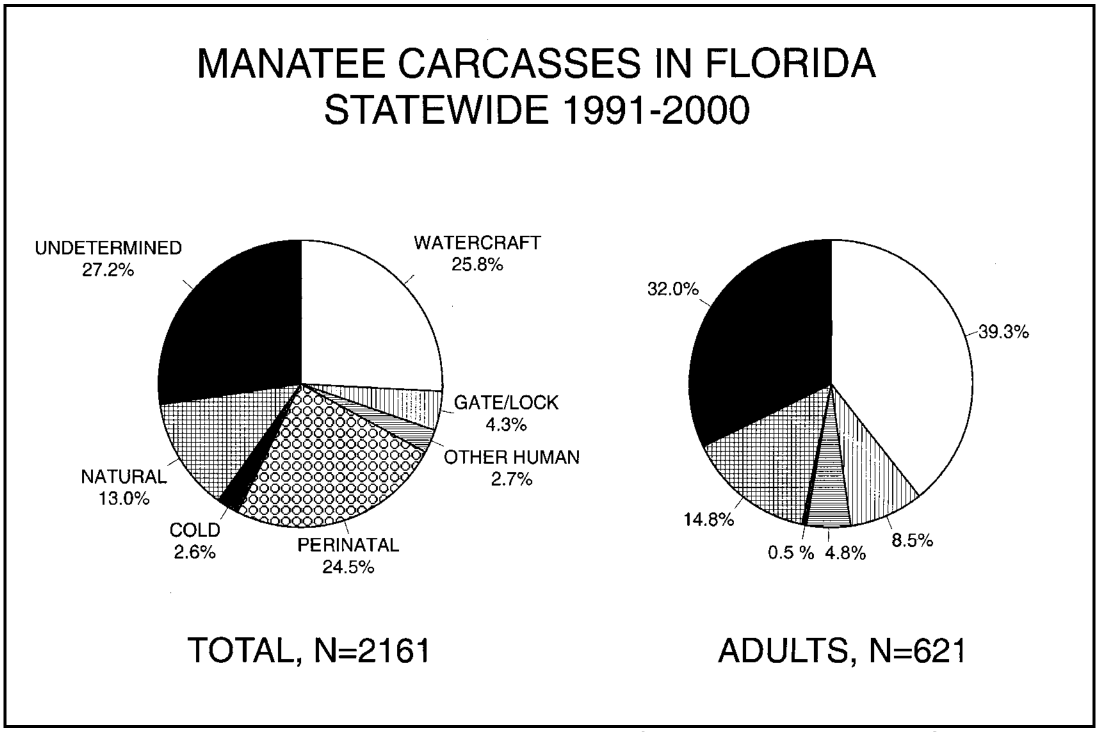


Figure 17. Manatee deaths in Florida by cause of death, 1991-2001. FWC unpublished data.

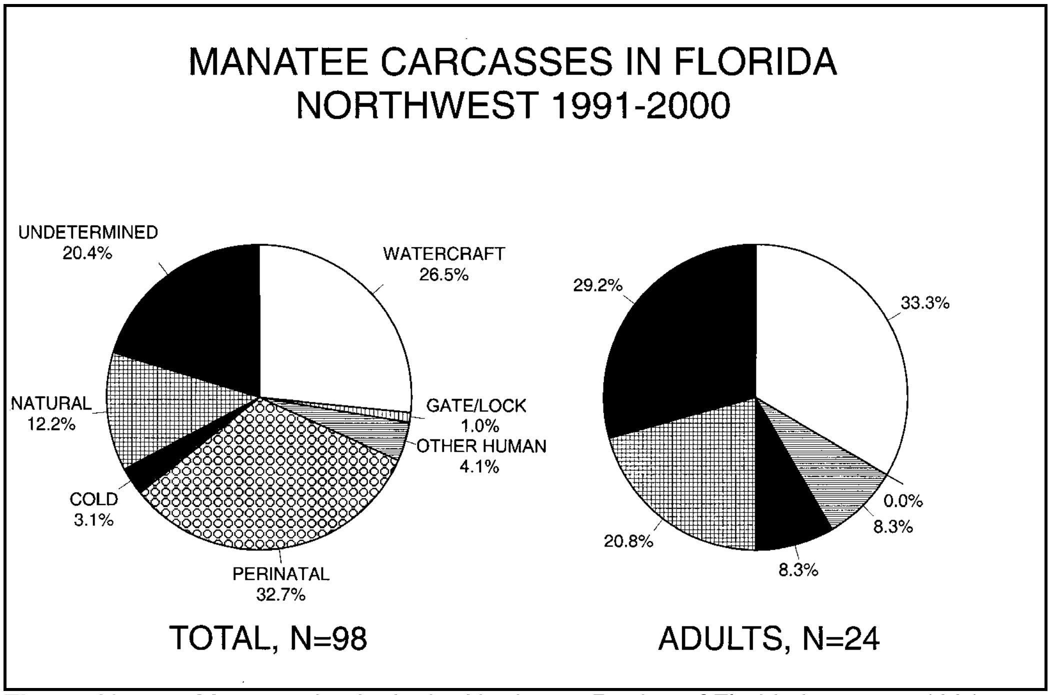


Figure 18. Manatee deaths in the Northwest Region of Florida by cause, 1991-2000. FWC unpublished data.

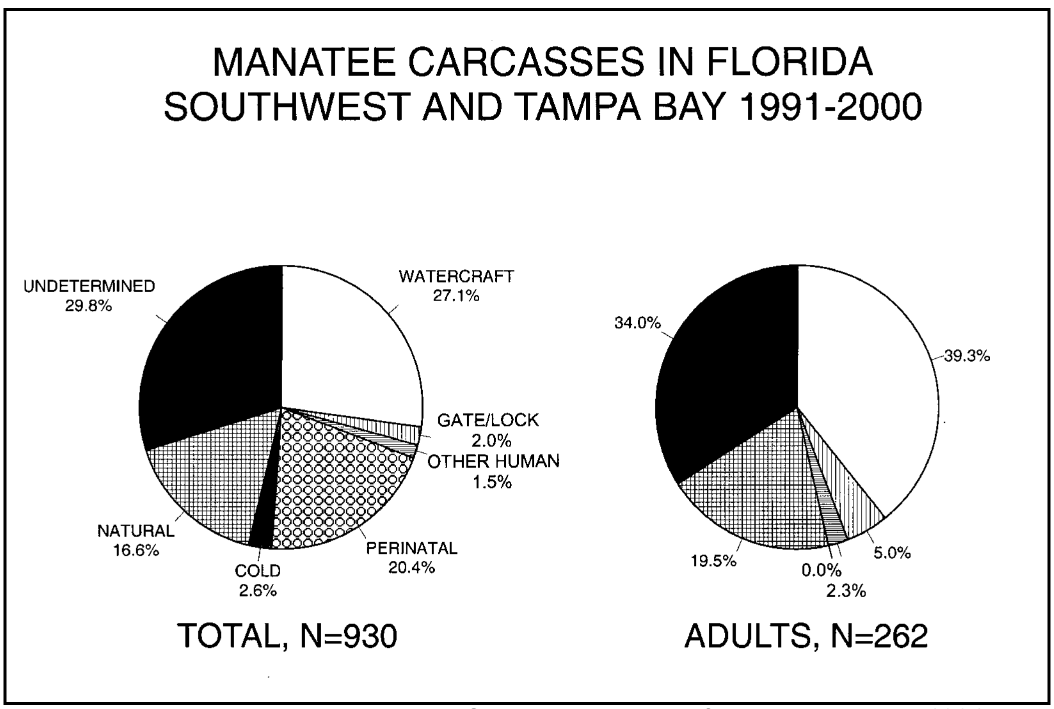


Figure 19. Manatee deaths in the Southwest Region of Florida by cause, 1991-2000. FWC unpublished data.

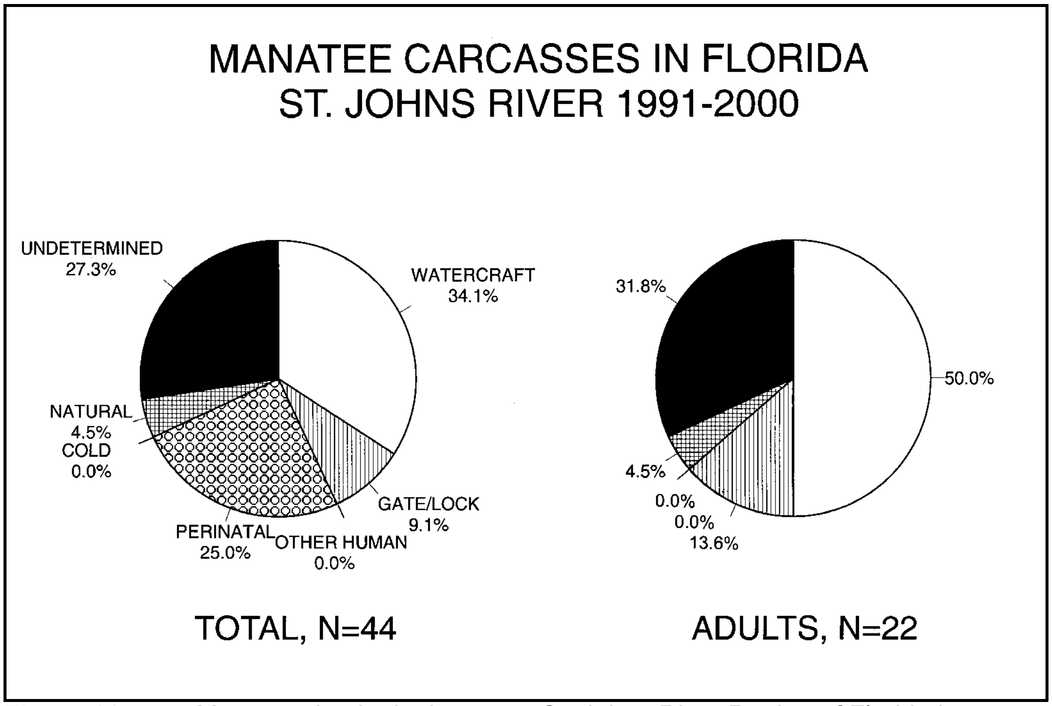


Figure 20. Manatee deaths in the upper St. Johns River Region of Florida by cause, 1991-2000. FWC unpublished data.

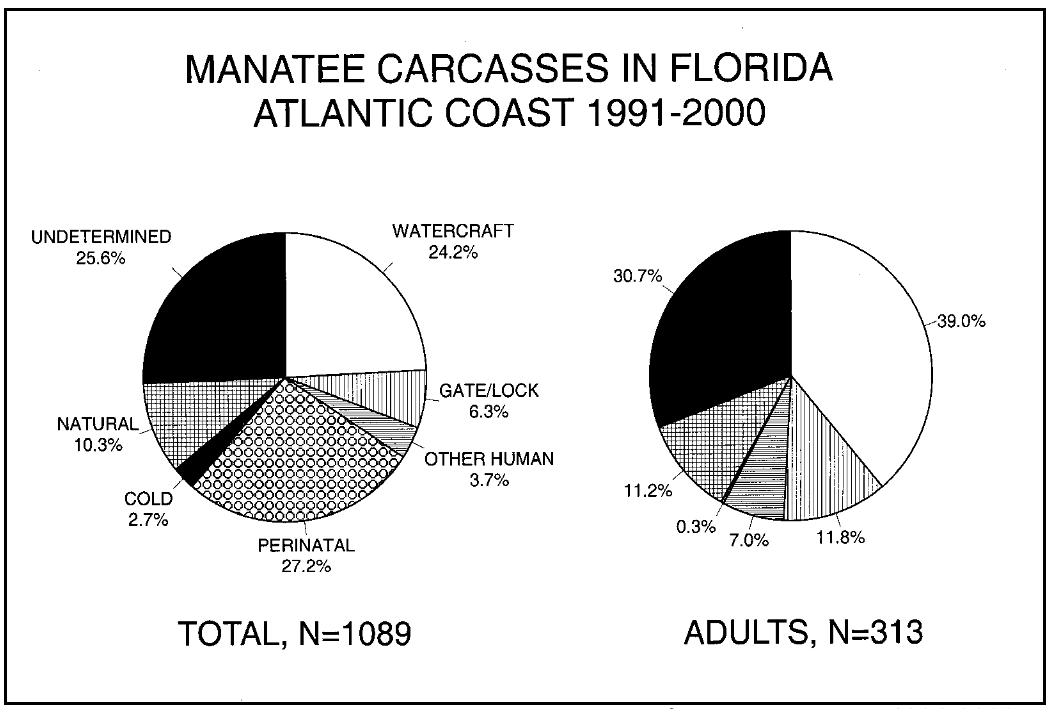


Figure 21. Manatee deaths in the Atlantic Region of Florida by cause, 1991-2000. FWC unpublished data.

FLORIDA MANATEE STATUS STATEMENT

Manatee Population Status Working Group

9 March 2001

Years of scientific study of the Florida manatee have revealed both good news and some cause for concern regarding the status of this endangered aquatic mammal, according to the interagency Manatee Population Status Working Group. The Manatee Population Status Working Group comprises biologists from the U.S. Geological Survey, U.S. Fish and Wildlife Service, Florida Fish and Wildlife Conservation Commission, Chicago Zoological Society, and Wildlife Trust. The group's primary tasks are to assess manatee population trends, to advise the U.S. Fish and Wildlife Service on population criteria to determine when species recovery has been achieved, and to provide managers with interpretation of available information on manatee population biology.

Long-term studies suggest four relatively distinct regional populations of the Florida manatee: Northwest, Southwest, Atlantic (including the St. Johns River north of Palatka), and St. Johns River (south of Palatka). These divisions are based primarily on documented manatee use of wintering sites and from radio-tracking studies of individuals' movements. Although some movement occurs among regional populations, researchers found that analysis of manatee status on a regional level provided insights into important factors related to manatee recovery.

The exact number of manatees in Florida is unknown. Manatees are difficult to count because they are often in areas with poor water clarity, and their behavior, such as resting on the bottom of a deep canal, may make them difficult to see. A coordinated series of aerial surveys and ground counts, known as the statewide synoptic survey, has been conducted in most years since 1991. The synoptic survey in January 2001 resulted in a count of 3,276, the highest count to date. The highest previous count was 2,639 in 1996. Survey results are highly variable, and do not reflect actual population trend. For example, statewide counts on 16 and 27 January 2000 differed by 36% (1,629 and 2,222, respectively). Excellent survey conditions and an unusually cold winter undoubtedly contributed to the high count in 2001.

Evidence indicates that the Northwest and Upper St. Johns River subpopulations have steadily increased over the last 25 years. This population growth is consistent with the lower number of human-related deaths, high estimates of adult survival, and good manatee habitat in these regions. Unfortunately, this good news is tempered by the fact that the manatees in these two regions probably account for less than 20% of the state's manatee population.

The picture is less optimistic for the Atlantic coast subpopulation. Scientists are concerned that the adult survival rate (the percentage of adults that survives from one year to the next) is lower than what is needed for sustained population growth. The population on this coast appears to have been growing slowly in the 1980s but now may have leveled off, or could even be declining. In other words, it's too close to call. This finding is consistent with the high level of human-related and, in some years, cold-related mortality in the region. Since 1978, management efforts to reduce human-related manatee deaths have included strategies focused on reducing manatee collisions with boats, reducing hazards such as entrapment in water control structures and entanglement in fishing gear, and protecting manatee winter aggregation sites to reduce cold-related mortality. Managers are continually challenged to develop innovative protection strategies, given the rapidly growing human population along Florida's coasts.

Estimates of survival and population growth rates are currently underway for the Southwest region. Preliminary estimates of adult survival are similar to those for the Atlantic region, i.e., substantially lower than those for the Northwest and Upper St. Johns River regions. This area has had high levels of watercraft-related deaths and injuries, as well as periodic natural mortality events caused by red tide and severe cold. However, pending further data collection and analysis, scientists are unable to provide an assessment of how manatees are doing in this part of the state.

Over the past ten years, approximately 30% of manatee deaths have been directly attributable to human-related causes, including watercraft collisions, accidental crushing and drowning in water control structures, and entanglements in fishing gear. In 2000, 34% (94 of 273) of manatee deaths were human-related. The continued high level of manatee deaths raises concern about the ability of the overall population to grow or at least remain stable. The Manatee Population Status Working Group is also concerned about the negative impacts of factors that are difficult to quantify, such as habitat loss and chronic effects of severe injuries.

The group agrees that the results of the analyses underscore an important fact: Adult survival is critical to the manatee's recovery. In the regions where adult survival rates are high, the population has grown at a healthy rate. In order to assure high adult survival the group emphasizes the urgent need to make significant headway in reducing the number of human-related manatee deaths.

Biological Opinion

Coastal Zone Consistency Determination

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, NEW ORLEANS DISTRICT
7400 LEAKE AVE
NEW ORLEANS LA 70118-3651

22 February 2022

Charles Reulet
Interagency Affairs - LADNR
Field Services Division
P.O. Box 44487, Capital Station
Baton Rouge, LA 70804-4487

Attn: Ms. Sara Krupa

Dear Ms. Krupa:

A Louisiana Coastal Zone Consistency Determination prepared by the U.S. Army Corps of Engineers, New Orleans District (CEMVN), is enclosed. The consistency determination examines the potential impacts associated with implementing the proposed Maurepas Swamp Alternative 2 (MSA-2). Compensatory mitigation for impacts due to construction of the West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Project (hereafter WSLP Project) was described previously in the 2016 WSLP Environmental Impact Statement (EIS) and in the 2020 Environmental Assessment (EA) 576, which addressed mitigation for habitat impacts associated with each of CEMVN's Bipartisan Budget Act (BBA) of 2018 funded risk reduction projects (e.g., the WSLP Project). The Finding of No Significant Impact for EA 576 was signed by the CEMVN District Commander on April 4, 2020. Public comment on EA 576 included requests by the Louisiana's Coastal Protection Restoration Authority and others that the Mississippi River Diversion into Maurepas Swamp Project (hereafter MSP), a proposed ecosystem restoration project that shares construction features with the WSLP Project, be considered as a mitigation alternative for impacts to swamp habitat associated with the construction of the WSLP Project. The MSP was converted into two viable compensatory mitigation alternatives, and recently MSA-2 was selected as the Tentatively Selected Alternative (TSA). Anticipated Impacts associated with the TSA will be described in the forthcoming Supplemental EIS, which will be provided to your office upon public release. Implementation of the TSA would incur impacts to swamp, BLH-wet, and marsh. The mitigation plan for those impacts is included in the SEIS and consists of projects that were previously approved in EA#576. These projects have already received consistency (#C20190208). This consistency letter is an attachment to this consistency determination.

We request your concurrence with the enclosed consistency determination, which addresses the applicable Coastal Use Guidelines. Based on this enclosed information, we believe that the proposed action is consistent to the maximum extent practicable, with the State of Louisiana's approved Coastal Resources Program.

Please provide any comments within 45 days of the date of this letter. Comments should be mailed to the attention of Mr. Landon Parr; U.S. Army Corps of Engineers; Regional Planning and Environment Division, South; Environmental Compliance Branch; CEMVN-PDC-C; 7400 Leake Avenue; New Orleans, Louisiana 70118.

Comments may also be provided by email to landon.parr@usace.army.mil. Mr. Parr may be also be contacted at (504) 862-1908.

Sincerely,

Eric M. Williams
Acting Chief, Environmental Planning Branch

CONSISTENCY DETERMINATION

Louisiana Coastal Use Guidelines

Supplemental Environmental Impact Statement to West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study

St. John the Baptist, St. James, Ascension, and Livingston Parishes, Louisiana

Supplemental Environmental Impact Statement

INTRODUCTION

Section 307 of the Coastal Zone Management Act of 1972, 16 U.S.C. 1451 et. seq. requires that "each federal agency conducting or supporting activities directly affecting the coastal zone shall conduct or support those activities in a manner which is, to the maximum extent practicable, consistent with approved state management programs." In accordance with Section 307, a Consistency Determination has been prepared for the proposed construction of the Maurepas Swamp Alternative 2 – MSA-2 (public lands only) [or Tentatively Selected Alternative (TSA)]. Coastal Use Guidelines were written in order to implement the policies and goals of the Louisiana Coastal Resources Program and serve as a set of performance standards for evaluating projects. Compliance with the Louisiana Coastal Resources Program (LCRP), and therefore, Section 307, requires compliance with applicable Coastal Use Guidelines.

PURPOSE AND NEED FOR THE PROPOSED ACTION

The purpose of the proposed action is to compensate for lost functions and services to swamp habitat within the Louisiana Coastal Zone (CZ) incurred as a result of the construction of the West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Project (hereafter WSLP Project). The proposed mitigation would replace the lost functions and services of impacted CZ swamp habitat through enhancement activities designed to increase/improve CZ swamp functions and services in the Maurepas swamp. The WSLP Project is expected to impact ~ 10,892 acres and ~ 947 Average Annual Habitat Units (AAHUs) of CZ swamp habitat.

DESCRIPTION OF THE PROPOSED ACTION

The planning area is in southeast Louisiana between the Mississippi River, and Lakes Maurepas and Pontchartrain. Area communities include St. James, St. John and Ascension Parishes. The area occupies a portion of one of the oldest delta complexes in the Mississippi River Deltaic Plain. It is in the lower Mississippi River alluvial plain in the Lake Pontchartrain Basin (LPB). The area north of I-10 comprises the State of Louisiana's Maurepas Swamp Wildlife Management Area (WMA). Waterways and water bodies in the area include Lake Maurepas, Amite River Diversion Canal, Amite River, Tickfaw River, Reserve Relief Canal, Blind River, Hope Canal, Dutch Bayou, Mississippi Bayou, Pearl River, Tchefuncte River, Bayou Lacombe, Mississippi River, Lake Pontchartrain, Lake Borgne, Mississippi River Gulf Outlet, and Chandeleur Sound. The proposed compensatory alternative for the WSLP Project is found within LPB and the CZ (Figure 1). As mentioned above, the MSA-2 was recently selected as the TSA, this alternative is discussed in the following sections.

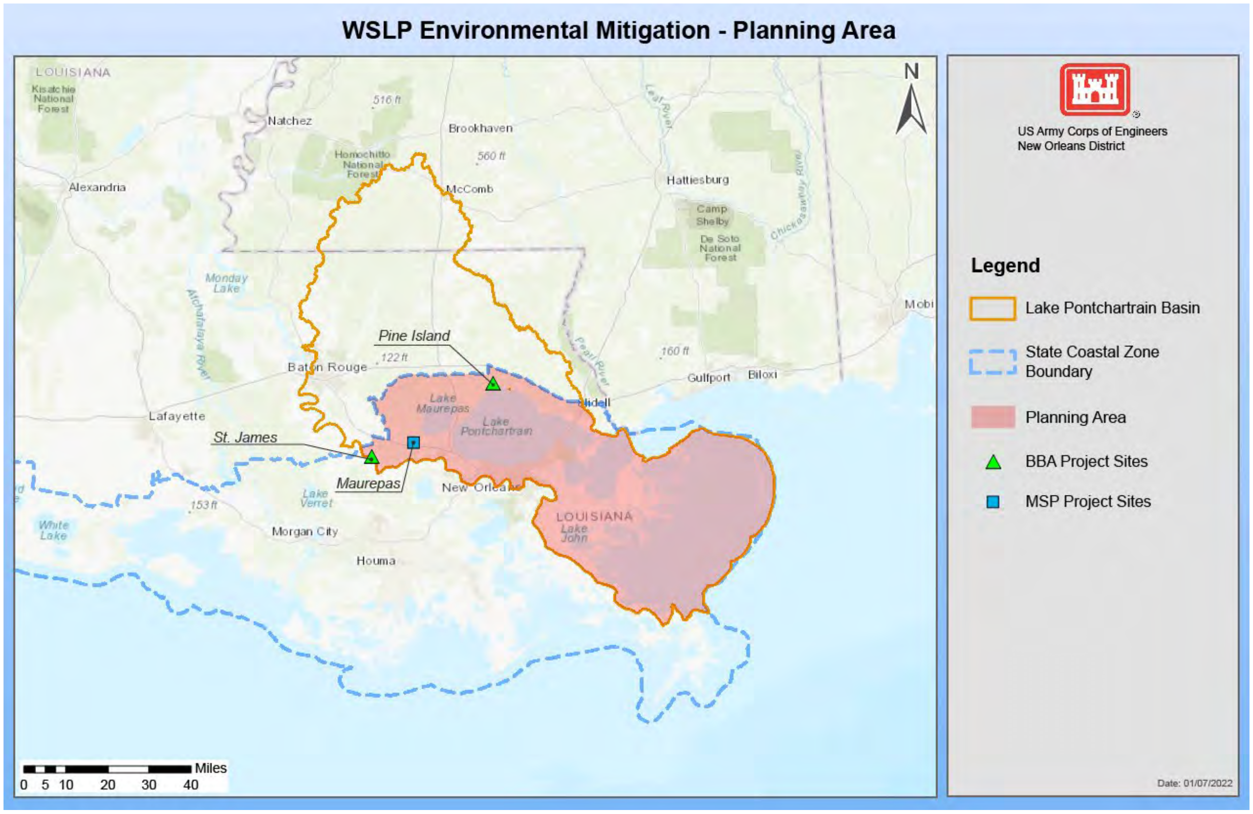


Figure 1. WSLP Project Environmental Mitigation Planning area.

The proposed MSA-2 consists of a 2,000 cubic foot per second (cfs) freshwater diversion that would reconnect the Mississippi River to the Maurepas Swamp, strategically delivering nutrient-laden river water to improve Cypress-Tupelo swamp habitats within primary, secondary, and tertiary mitigation areas (Figure 7). Construction of MSA-2 would include three main groups of features, the conveyance channel (which includes the intake and outfall features), embankment features, and weirs (Figure 2). The conveyance channel would be located on the East Bank of the Mississippi River in St. John the Baptist Parish, immediately west of Garyville, Louisiana, at River Mile 144 Above Head of Passes. The construction corridor for the conveyance channel extends from LA 44 (River Road) northward. It extends northward for 5½ miles, terminating approximately (~) 1,000 ft north of Interstate 10 (I-10). The majority of the open conveyance channel, excluding vehicular and railroad crossings, would consist of a 40' to 60' excavated channel bottom, tightly positioned between a guide levee on the west and the West Shore Lake Pontchartrain levee and I-wall system on the East. The conveyance channel levee would be constructed of compacted fill material and have a 1:4 slope. The 1:4 slope would decrease to 1:5 after Airline Highway until the channel outfall north of I-10.

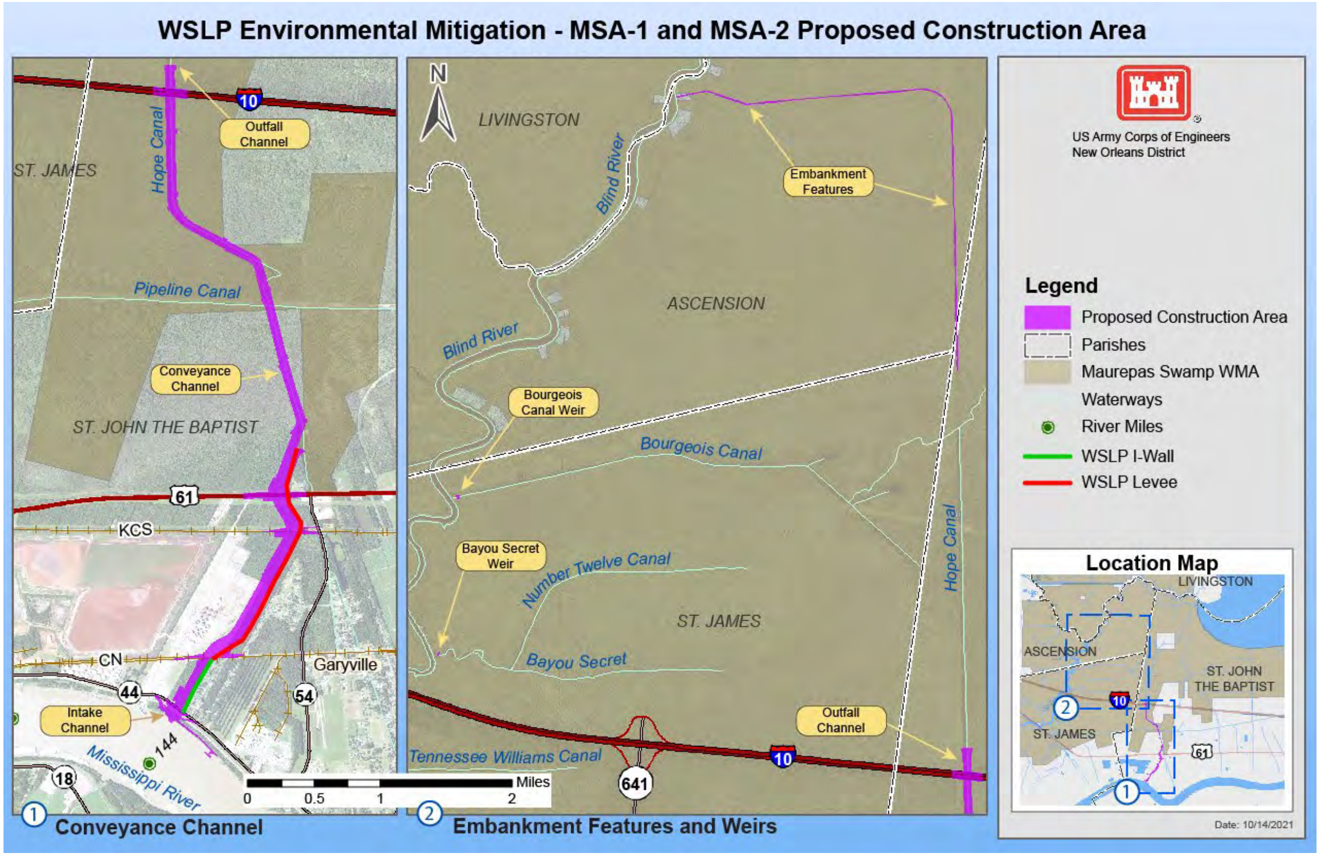
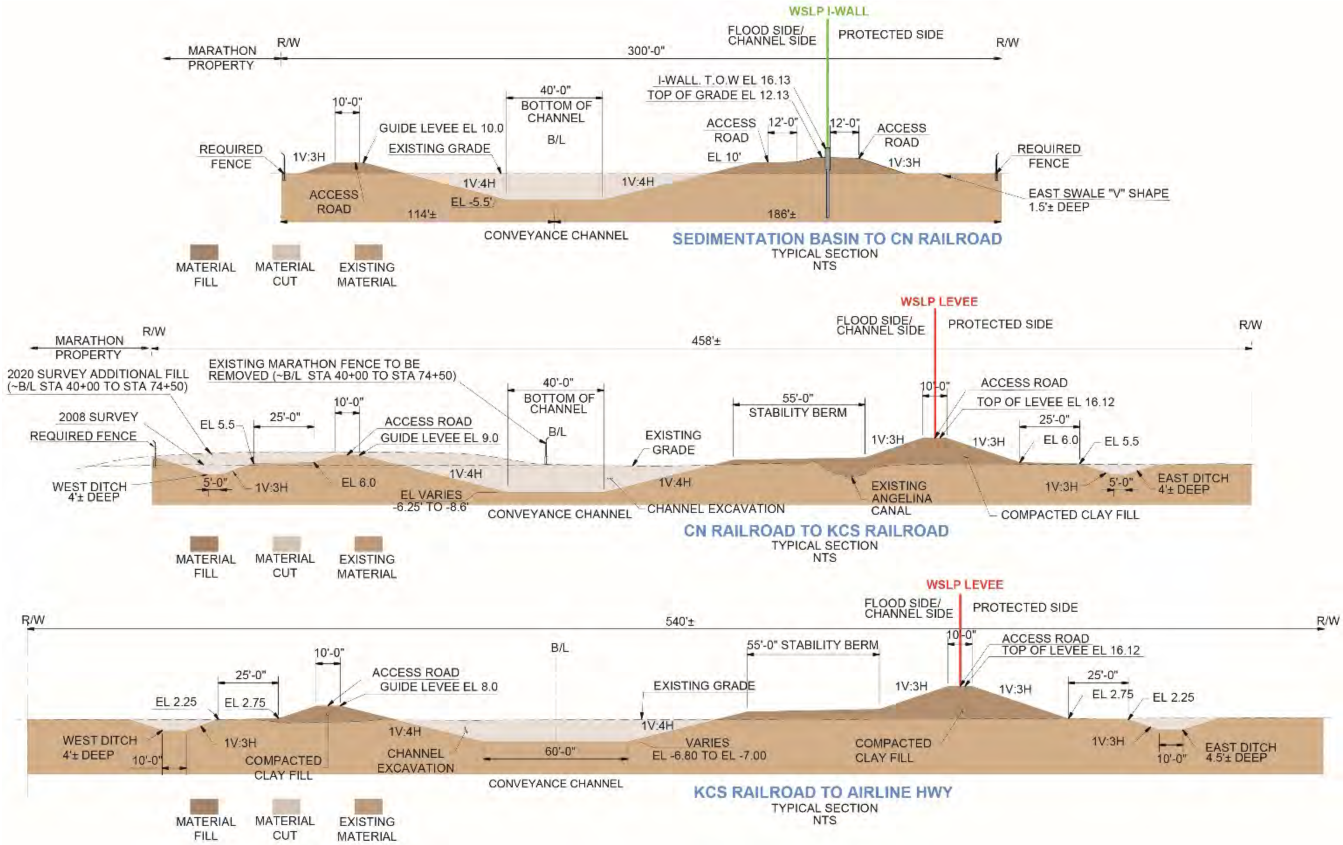


Figure 2. Maurepas Diversion proposed construction area. Overall proposed construction area is 288.30 acres. Temporary Impacts are 26.48 acres and Permanent Impacts are 261.82 acres.

The following Figure 3 illustrates typical construction corridor sections of the conveyance channel and the WSLP Project alignment from the sedimentation basin to the outfall north of I-10.



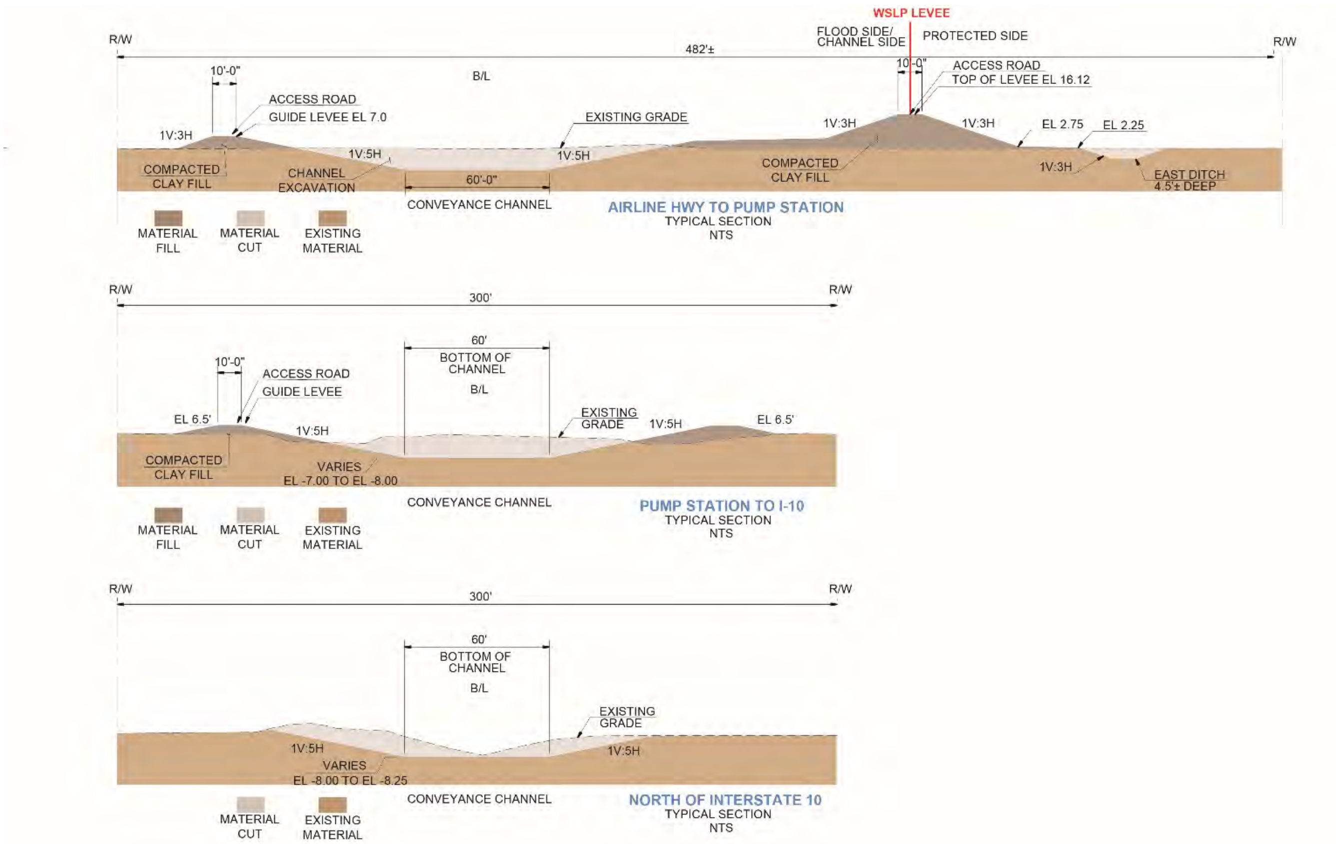


Figure 3. Typical construction corridor sections of the conveyance channel and the WSLP Project alignment from the sedimentation basin to the outfall north of I-10.

The majority of MSA-2 features are located in St. John the Baptist Parish and are comprised of the following elements. Features located partially or wholly outside of St. John the Baptist are indicated as such *(Tables and Figures)*:

- an intake channel from the Mississippi River; *(Table 1, Figure 2, Figure 4)*
- an automated gate structure in the Mississippi River Levee (MRL); *(Table 1, Figure 4)*
- a sedimentation basin; *(within the conveyance channel)*
- a 5.5-mile long open conveyance channel; *(Figure 2)*
- box culverts under River Road, Canadian National Railroad (CN), and Airline Highway; *(Figure 2)*
- a bridge over the channel at Kansas City Southern Railroad (KCS); *(Table 1, Figure 2)*
- up to ~ 32 lateral discharge valves between Airline Highway and I-10 to carry flow from the conveyance channel to areas east and west of the channel;
- check valving on culverts underneath I-10 to reduce or eliminate southward backflow;
- reshaping the geometry of the existing Hope Canal channel under I-10
- embankment cuts in the existing ridge of an old railroad embankment located in St. John the Baptist and Ascension Parishes; *(Table 1, Figure 2)* and
- submerged rock rip-rap weirs in Bayou Secret and Bourgeois Canal located in St. James Parish; *(Table 1, Figure 2)*

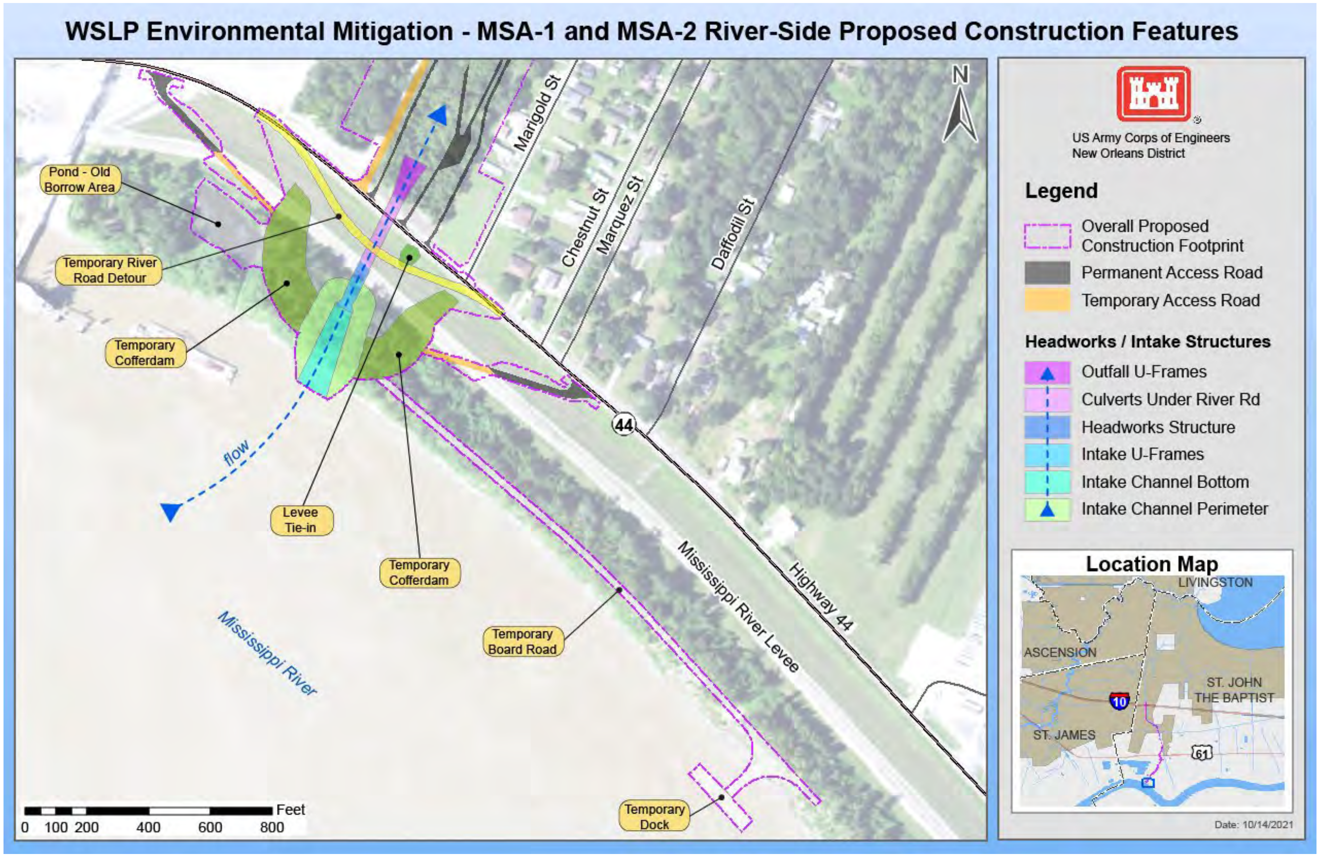


Figure 4. MSA-1 and MSA-2 features from the Mississippi River to LA-44.

The intake channel would be roughly 400 ft long by 200 ft wide, with a bottom depth at EL (-) 4 ft NAVD88 excavated into the batture to route flow from the Mississippi River into the diversion headworks. This channel would be lined with riprap to prevent scour. The diversion headworks structure would include a multi-cell box culvert with vertical lift gates (sluice gates). The primary function of the headworks structure is to convey flow from the intake channel underneath the MRL.

Table 1. MSA-2 Features.

Grouping	Feature Name	Acres	Description
Down-river Features	Dock	0.29	Temporary dock to be constructed for offloading of materials.
	Board Road	1.37	Temporary board road to be constructed offloading of materials.
River-side Features	Intake Channel Bottom	0.55	The bottom of the Intake Channel.
	Intake Channel Perimeter	0.98	The banks of the Intake Channel where it comes up to existing grade.

	Cofferdam	**2.95**	Temporary Cofferdam to provide flood protection during construction.
	Intake U-Frames	**0.11**	U-frames to be constructed on Flood Side of the Headworks Structure.
	Headworks Structure	**0.05**	Structure housing the sluice gates and operating equipment.
	Pond	**0.93**	Old borrow area on batture to be filled in for cofferdam.
	Levee Tie-In	**0.08**	Connection of River Road flood gate to the Mississippi River levee.
	Culverts Under River Rd	**0.23**	Culverts connecting the headworks structure to the outfall U-frames.
	River Road Detour	**0.65**	Area used to temporarily re-route River Road during construction.
	Outfall U-Frames	**0.19**	U-frames to be constructed on Protected Side of the Headworks Structure.
Railroad Crossings	**CN RR Shoofly**	**4.89**	CN RR shoofly crossing at diversion channel.
	KCS RR Shoofly	**3.72**	KCS RR shoofly crossing at diversion channel.
Lateral Discharge Valves	**Lateral Discharge Valves**	**0.01**	up to ~ 32 lateral discharge valves between Airline Highway and I-10
Features at Blind River	**Bayou Secret Weir**	**0.15**	Submerged weir is to be constructed in Bayou Secret, near Blind River.
	Bourgeois Canal Weir	**0.30**	Submerged weir is to be constructed in Bourgeois Canal, near Blind River.
Embankment Features	**Embankment Degrading**	**1.03**	5 individual areas along old RR embankment that would be excavated to existing grade.
	Embankment Spoil Areas	**1.84**	20 individual areas where excavated spoils would be placed.
	Embankment Clearing	**7.51**	Area along the old RR embankment to be cleared for access.

Between I-10 and US 61 there would be up to ~ 16 points at which pipes with lateral discharge valves (LDVs) would traverse the conveyance channel levee and carry flow to the areas east and west of the channel. The flow would be carried by means of 24-in reinforced concrete pipes ~ 80-ft long. There would be a total of up to ~ 32 pipes, 16 on each side. The LDVs would discharge 140 cfs on each side of the conveyance channel (280 cfs total) for at least 7 days at the end of each pulse. This surface flow would disperse throughout the area between the two roadways and follow the natural drainage gradient to the north. One-way check valving on culverts underneath I-10, between Mississippi Bayou and LA 641 would allow for northward flow and reduce or eliminate southward backflow. Operating LDVs to coincide with the end of each pulse would deliver flowing water, nutrients, and potentially some sediments into portions of the swamps between the said roadways while ensuring the introduced water can adequately drain post-pulse. The LDVs would be actively operated and would be bidirectional to facilitate drainage of discharged water and precipitation to minimize potential impacts from increased inundation duration. The Habitat Evaluation Team (HET) has specifically evaluated 7 days of discharge through the LDVs via Delft3D modeling; however, it may be necessary to operate the LDVs differently in practice as part of the adaptive management approach to MSA-2.

The outlet for the conveyance channel would be along the existing centerline of Hope Canal. Guide levee elevations from the I-10 bridges to the termination point would gradually transition to existing grade. At that point, 2-D hydrodynamic modeling results suggest the diverted water would generally spread radially outward into the area north of I-10, south of Lake Maurepas (Figure 2, Figure 8). According to 2-D Hydrodynamic modeling, diversion flow would generally spread radially outwards north of Interstate 10. Approximately, one-third of the diverted water flows westward through the swamp, one-third flows through Dutch Bayou and the remaining third flows eastward through the swamp. The westward flow enters Blind River and largely proceeds to Lake Maurepas. The eastward flow enters the Reserve Relief Canal and mostly proceeds to Lake Maurepas. During operation, most of the existing swamp water is displaced by the introduced Mississippi River water.

Earthwork

Required earthwork would consist of clearing, grubbing, excavation, and removal of ~ 1,279,232 CY of earthen material for the Project's conveyance channel and disposal at an approved disposal site (Table 2). If a borrow study in subsequent design phases indicates sufficient suitability within the excavated material, the Contractor may elect to use that material on-site. Any material used on site would stay within the right-of-way (ROW) and would be used to construct features as described in the Plans and Specs. Any material not used on site would be hauled off to an approved disposal site. The majority of fill material used throughout the proposed construction area would be imported from an USACE approved borrow sources as described in SEA 571.

Table 2. Material Quantities

Activity	Cubic Yards (CY)	Description
Excavation	1,279,232	Intake channel, conveyance channel, outfall channel, and all crossings.

Excavation	5,345	Embankment cuts where spoil would not be removed
Fill	756,060	Intake channel, conveyance channel, outfall channel, and all crossings.

Project features within the construction ROW would be cleared, grubbed, and graded to establish a stable base upon which to construct. With the relatively flat topography of the area, the primary erosion control measure used would be silt fencing around all affected areas during construction and a turbidity curtain adjacent to the river. Seeding and grassing would also be conducted on compacted earthen slopes and areas disturbed by construction activity at the end of construction. Other erosion control measures may be implemented as needs are identified. The proposed grading plan, with elevations and slopes for MSA-2, is included in the 15% Design Plans (see CPRA's 2020 15% Basis of Design Report). The plans also include detailed sheets showing the erosion control measures to be employed.

Water must be circulated throughout the swamp to reestablish the vitality of the wetland vegetation. Water movement into the northwest corner of the swamp is restricted by an embankment that was constructed decades ago to support a defunct Cypress logging railroad spur. As such, cuts in the existing embankment would be established north of the conveyance channel in the northern part of the swamp to facilitate water movement. Access to the embankment would be from the north, via a small reach of waterway from Blind River. The waterway ends at a stand of trees, which would require removal for equipment to reach the proposed embankment cut areas. There would be no clearing on or adjacent to Blind River itself (Figure 5b). To establish the cuts, 7.51 acres along the old railroad embankment would be cleared for equipment access, 5 individual cuts along the embankment would be excavated to existing grade of adjacent habitat to allow for water flow while all spoil would be placed in 20 sites along the embankment. It is anticipated that no material would be removed from the proposed construction area (Figure 5a).

In order to limit the amount of diverted Mississippi River water entering Blind River, two submerged riprap weir features would be constructed in Bayou Secret and Bourgeois Canal. These submerged weirs would be set back from Blind River and be built to an elevation that would still allow shallow draft navigation between Blind River and Bayou Secret/Bourgeois Canal.

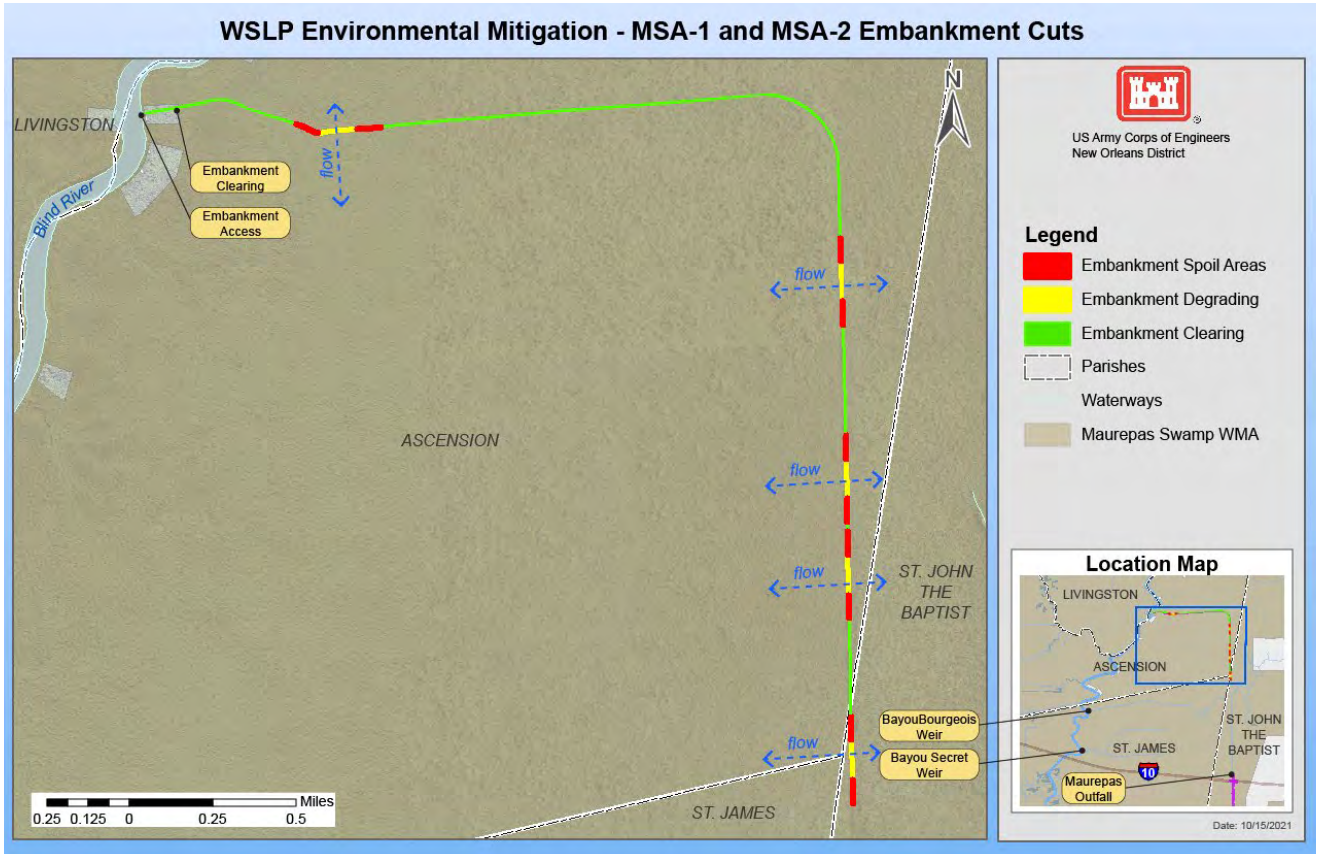


Figure 5a. MSA-1 and MSA-2 Embankment Cuts

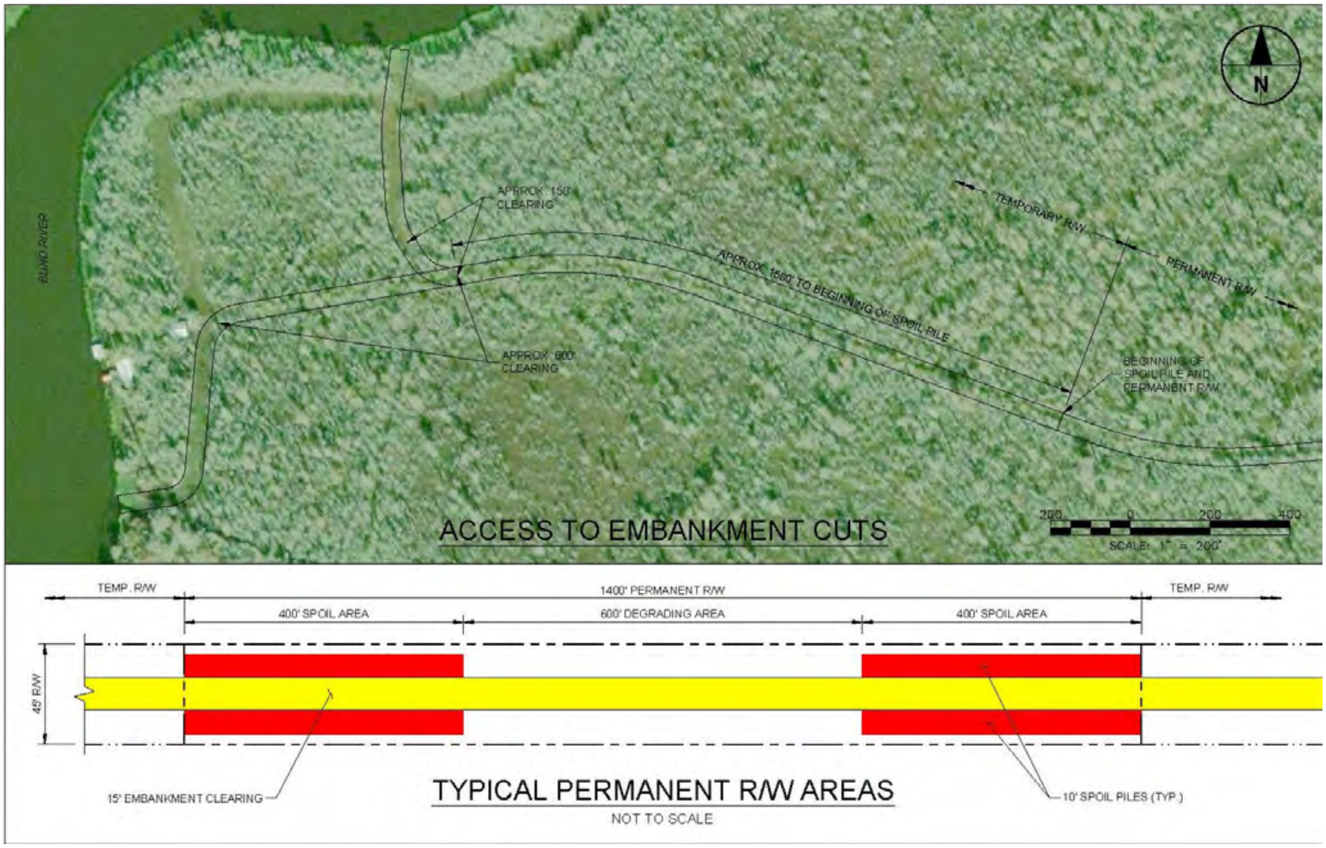


Figure 5b. MSA-2 Embankment Cut Access

Construction Methods, Timing, and Sequence:

The following are the assumptions about equipment, methodology, and durations made in the 15% basis of design report:

- Construction Duration would be 33 months.
- Construction is scheduled for 5 days a week, 8 hours a day.
- A haul road would be used for clearing and grubbing.
- Two Entergy transmission poles would be reinstalled, and the line would need to be raised due to elevation adjustment from construction.
- Headworks cofferdam would be constructed using a barge with a combination of land support.
- Pumps and sediment basins would be used to manage water for construction.
- The majority of fill material used throughout the project would be imported from an USACE approved borrow pit.
- Any excavated material not suitable for project construction would be taken to an approved disposal site. This would likely be the case for the vast majority of the material excavated from the project site.

- Excavated material suitable for construction could be left on the site. Such material would be worked to obtain the proper moisture content, and could mixed with imported material, to meet the USACE requirements for levee construction. The excavated material worked and/or mixed with imported material to the required technical specifications could be used for levee construction according to the final designs and specifications. All such working and/or mixing of materials would take place within the designated staging areas.
- The access for the dam and the diversion would be the same as shown in the 15% plans. Table 3 below details the equipment anticipated to be utilized and the utilization duration by location for the potential construction of the MSA-2 /WSLP Project.

Table 3. Equipment Anticipated to be Utilized and Utilization Duration by Location

Item No.	Project Component	Duration (days)	Equipment Used
1	**River Side of Levee**		
1a	Cofferdam	111	Dump Trucks
			Bull Dozers
			Fuel Tanks
			Pumps
			Air Compressor
			Fill Compactor
			Front-End Loader/Backhoe
			Auger Equipment
			Generator
1b	Headworks Structure	280	150-Ton Crane
			80-Ton Crane
			Excavator
			Pile Driver
			Concrete Trucks
			Concrete Vibrators
			Welding Machine, Cutting Torch
1c	River Intake	150	Dump Trucks
			Bull Dozers
			Fuel Tanks
			Front-End Loader/Backhoe
			80-Ton Crane
			Barges
			Tug Boats
2	**Conveyance Channel**		
	Pump Sta. to End of Project	427	Dump Trucks
			Bull Dozers
	River Rd to CN RR	129	Fuel Tanks
			Pumps
	CN RR to KCS RR	319	Air Compressor
			Fill Compactor
	KCS RR to Airline Hwy	126	Front-End Loader/Backhoe
			Auger Equipment
	Airline Hwy to Pump Sta.	229	Generator
	Sedimentation Basin	178	Tree Sheer
3	**Roadways**		Jackhammers

Item No.	Project Component	Duration (days)	Equipment Used
	River Rd Detour	153	Dump Trucks
	River Rd Restoration	180	Bull Dozers
	Airline Hwy Detours	300	Fuel Tanks
			Asphalt Mixing Trucks
	Airline Hwy Reconstruction	204	Asphalt Laying Equipment
			Asphalt compaction equipment
	Airline Hwy Raise	300	Dump Trucks
			Bull Dozers
			Fuel Tanks
			Fill Compactor
			Front-End Loader/Backhoe
			Auger Equipment
			Generator
4	**Flood Wall**		150-Ton Crane
	River Road to CN RR	180	80-Ton Crane
			Excavator
			Pile Driver
			Concrete Trucks
			Concrete Pumps
			Concrete Vibrators
			Welding Machine, Cutting Torch
5	**Levees**		Dump Trucks
	CN RR to KCS RR	289	Bull Dozers
			Fuel Tanks
	KCS RR to Airline Hwy	149	Fill Compactor
			Front-End Loader/Backhoe
	Airline Hwy to Pump Station	246	Auger Equipment
			Generator
6	**Floodgates**		
	River Road Floodgate	118	80-Ton Crane
			Excavator
			Pile Driver
	CN RR Floodgate	150	Concrete Mixing Trucks
			Concrete Pumps
	KCS RR Floodgate	210	Concrete Vibrators
			Welding Machine, Cutting Torch
7	**Culverts & Headwalls**		150-Ton Crane
	CN RR Crossing	167	80-Ton Crane
			Excavator
	KCS RR Crossing	227	Pile Driver
			Concrete Mixing Trucks
			Concrete Pumps
	Airline Hwy Crossing	236	Concrete Vibrators
			Welding Machine, Cutting Torch
8	**Railroads**		150-Ton Crane
	CN Shoo-fly & RR Removal	239	80-Ton Crane
			Excavator

Item No.	Project Component	Duration (days)	Equipment Used
	CN Reconstruct Railroad	124	Pile Driver
			Concrete Mixing Trucks
			Concrete Pumps
	KCS Railroad Bridge	250	Concrete Vibrators
			Welding Machine, Cutting Torch
9	**Interstate 10 Crossing**	148	Dredge Vessel
			Hydraulic Dredge
			Dump Trucks
10	**Utilities Relocations**	378	Excavator
			HDD Drill Rig
11	**Embankment Cuts**	41	Compact Excavators
			Marsh Pull Buggy
			Tree Chipper
			Flatboats
12	**Weirs at B. Secret & B. Canal**	20	Chain Saws
			Marsh Buggy Excavator
			Tree Chipper
			Flatboats
			30- Ton Crane
13	**I-10 Check Valves**	8	Compact Utility Vehicles (Bobcats)

Site Access:

In general, construction site access would be obtained by both barge and vehicle via the following (Figure 6):

- barge access from the Mississippi River at the intake structure.
- vehicular access at State Hwy-44/River Road.
- vehicular access from Daffodil Street immediately north of CN RR.
- vehicular access from State Hwy 54/ Garyville Northern St. both North and south of KCS RR.
- vehicular access from eastbound and westbound US Hwy 61/Airline Hwy.
- vehicular access from eastbound and westbound Interstate 10.
- barge access from the Hope Canal and Blind River for the embankment cuts and weirs.

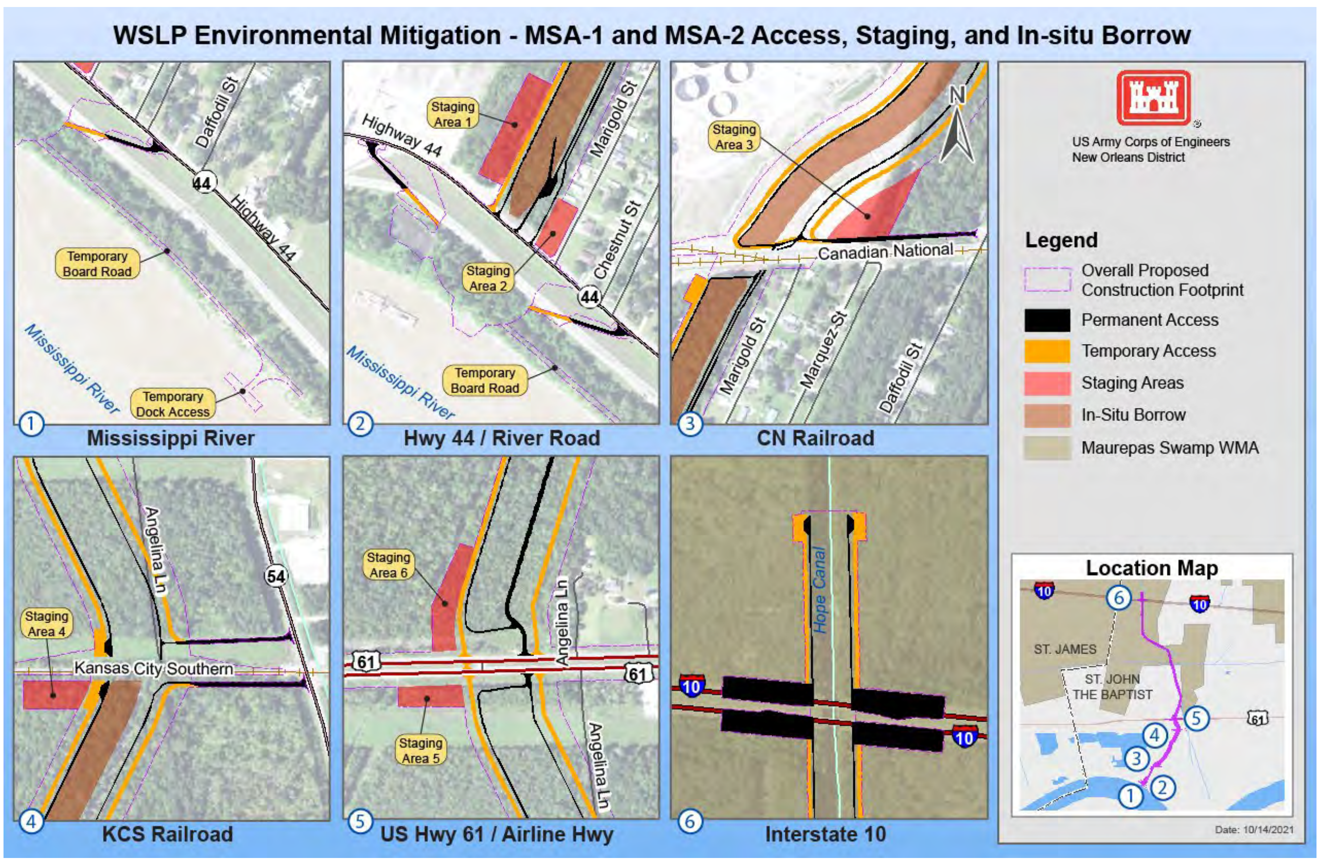


Figure 6. Access, Staging, and In-Situ Borrow Features.

Staging

In general, construction staging areas would be in the vicinity of the site access locations. Staging areas are described in Table 4.

Table 4. Access, Staging, and Borrow Features.

Access, Staging, Borrow	Acres	Description
Permanent Access Roads	**22.53**	Roads to remain after construction.
Temporary Access Roads	**32.83**	Areas to be restored to pre-construction condition after construction.
Temporary Staging Areas	0.79	Area 1 – WSLP Project River Road to CN RR
	1.95	Area 2 - Diversion Intake System and River Road Crossing
	1.67	Area 3 - North of CN RR
	1.15	Area 4 - South of KCS RR
	0.88	Area 5 - South of Airline Hwy
	1.51	Area 6 - North of Airline Hwy
	7.94	**Total**
In Situ Borrow Areas	7.32	Area between River Rd and CN RR.
	20.53	Area between CN RR and KCS RR.
	27.85	**Total**

Maintenance/Management Activities

The TSA would include various maintenance and inspection activities associated with the head works and secondary features. Maintenance features and a general description of activities are as follows:

- Head Works: inspect and maintain in operable condition
- Sedimentation Basin: dredging* and structural maintenance
- Access Roads: maintain in operable condition
- Outfall Channel: mowing, spraying, erosion control, etc.
- Airline Highway Culverts: maintain in operable condition
- I-10 Check Valves: inspect and maintain in operable condition
- Weirs: inspect and maintain in operable condition
- Railroad Embankment Cuts: inspect and maintain in operable condition

* A sediment removal and disposal plan will be developed during Final Design; the methodology could be suction dredging, clam-shell excavation, front-end loader and dump trucks, or other means. The accumulated material is anticipated to be similar to batture sand and therefore has value as structural fill, offsetting all or part of the removal and disposal costs (source: Maintenance Plan).

Ancillary Channel Maintenance would be conducted as follows:

- Routine inspections would involve visually observing the condition of the ancillary channels. Hydrographic surveying would be conducted periodically (every 5 years). The survey data would be used to evaluate whether deposition or scouring has significantly affected the channel invert elevation or the overall cross-section.
- Maintenance would include the removal of debris and deposited material as needed (every 25 years or based on inspection results).
- Maintenance would include management of invasive species, as needed, when inspections determine that invasive species are adversely affecting the structural integrity and/or functions of the project. Additional information on invasive species management is provided in the MSA-1 and MSA-2 Adaptive Management Plan.

Boat Launch Relocation

The WSLP Project levee and associated Hope Canal drainage features would directly impact access to a boat launch owned and operated by the Louisiana Department of Wildlife and Fisheries (LDWF). This boat launch is located on the very southern portion of Hope Canal near U.S. 61 to allow access to the Maurepas Wildlife Management Area (WMA) and consists of an earthen parking area with a gravel launch into Hope Canal. The parking area is less than 0.2 acres and can accommodate ~ 6 vehicles and boat trailers. There are no other features or facilities associated with this boat launch.

A replacement boat launch would be located along the western guide levee of the MSA-2 /WSLP Project just north of U.S. 61 (Airline Hwy.) This would provide similar public access via boat into the conveyance channel (which follows Hope Canal) and to the LDWF Maurepas WMA. A parking lot to accommodate an equal or greater than number of vehicles and trailers would be constructed.

Currently, the boat launch is closed to recreational access due to WSLP Project construction activities. The timing for construction for the new, replacement boat launch is uncertain, but would be undertaken as soon as is practicable. Consequently, recreational access at this location may not be available for a maximum of 3 years (the entire construction period for MSA-2).

Wetland Impacts

The Wetland Value Assessment (WVA) models were developed under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) program to determine benefits of proposed coastal wetland restoration projects. Subsequently, these models were certified for Civil Works use by the Eco-PCX. Initially, the WVA was utilized to determine the environmental benefits of the original, larger Coastal Wetlands Planning and Restoration Act (CWPRA) project PO-0029 River Reintroduction into Maurepas Swamp Project, (hereafter MSP) to assess whether the MSP would be a viable mitigation project to compensate for unavoidable impacts to CZ bald cypress (*Taxodium distichium*) – water tupelo (*Nyssa aquatica*) swamp habitat associated with construction and implementation of the WSLP Project. Once the HET determined that the MSP could be considered as a viable compensatory mitigation alternative, results of Delft 3D hydrodynamic and water quality modeling was utilized to determine the extent of the mitigation areas for the MSA-2. Examination of the H&H modeling showed obvious breaks in modeling results that were used to establish the primary benefit area. After WVA analysis of this area was complete, it was determined that additional benefit areas would be needed to completely satisfy the WSLP Project mitigation need. As such, additional breaks in the modeling results were used to establish the Secondary and Tertiary Benefit areas and determine the AAHUs they would produce.

Previous research has found that an increase in nutrients could stimulate plant growth and improve forest health in the Maurepas Swamp (Effler et al., 2006, and Shaffer et al., 2016). The Primary Benefit area was determined using model-generated contours of total nitrogen (TN) during summer, and the Future With-Project water surface elevation (WSE) increase relative to no action (for 2,000 cfs steady state discharge). It was assumed that the zone of more rapid WSE drop would be where flow through the swamps was strongest and would carry dissolved oxygen and nutrients through that portion of the swamp before being consumed in more remote regions where the flow rates were slower.

MSA-2 boundaries remove private land from the mitigation benefit area. The benefits attributed to existing swamp through hydrologic improvement includes 8,814 acres of which 2,324 acres are in tertiary benefit area (farther away from outfall). With the avoidance of private land, the MSA-2 takes 25% less of its benefits from the primary benefit area as compared to the private/public land alternative, MSA-1, and is more dependent than MSA-1 on the secondary benefit area (38%) to satisfy the WSLP Project mitigation need.

Considering only public lands, the MSA-2 would provide 634.65 AAHUs to swamps in the Primary Benefit Area and 408.15 AAHUs to swamps in the Secondary Benefit Area. The Tertiary Benefit Area would provide 196.61 AAHUs. Total MSA-2 related swamp benefits on public lands would be 1,032.92 AAHUs (see Table 5). Under this scenario, only private lands in the construction footprint would have to be purchased in fee or through non-standard estates.

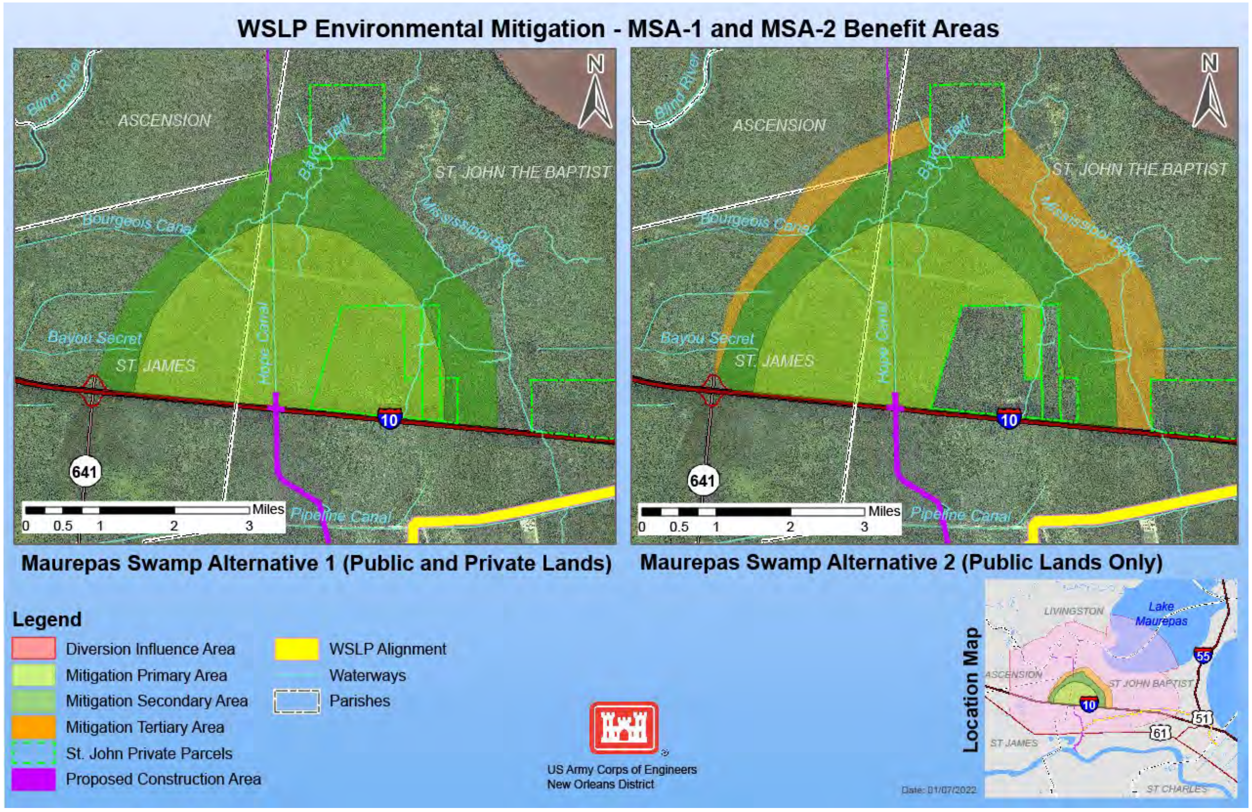


Figure 7. Primary, Secondary, and Tertiary Benefit areas.

The WSLP Project is expected to impact ~ 10,892 acres of swamp and 4,877 acres of wetland bottomland hardwoods (BLH-Wet) in the Louisiana Coastal Zone (CZ). This equates to a compensatory mitigation need of ~ 947 Average Annual Habitat Units (AAHUs) of CZ swamp habitat and ~ 293 AAHUs of CZ BLH-Wet habitat. BLH-Wet habitat impacted by the construction of the WSLP Project would be mitigated in accordance with EA #576 and is not part of the subject of this determination.

The TSA (i.e., MSA-2) can generate 1,032.92 AAHUs to CZ swamp in all three of the benefit areas (primary, secondary, and tertiary) combined. This can satisfy the mitigation need of the WSLP Project. Based on the design changes to date, the TSA could have direct impacts to 79 acres and indirect impacts to ~ 1,830 acres of CZ BLH-Wet. This equates to a compensatory mitigation need of ~ 35.8 AAHUs of CZ BLH-Wet. This impact would be mitigated in accordance with EA #576's Mitigation Plan for CZ BLH-Wet.

North of I-10, Keim et al. (2010) habitat classification data were used to estimate marsh acres for each mitigation area. Results suggest that implementation of MSA-2 would have adverse effects on mitigation area marshes. Although the marsh WVA indicates negative AAHUs it also shows more marsh acres for the Future with Project condition. Under the currently certified marsh model, negative AAHUs are being assessed due to more intact marshes under Future with Project conditions versus more fragmented marshes under Future Without Project conditions. The WVAs score marshes with some interspersion or fragmentation higher than completely intact marshes. It is the opinion of the Habitat Evaluation Team (HET) that the negative AAHUs are misleading, and these results should not be used to assess marsh mitigation benefits/impacts associated with MSA-2. Therefore, no mitigation would be needed for impacts to marsh north of I-10.

South of I-10, implementation of the TSA would incur indirect impacts to ~ 2,743 acres of CZ fresh marsh. This equates to a compensatory mitigation need of ~ 19.5 AAHUs of CZ fresh marsh. This impact would be mitigated as specified in the mitigation section below.

Table 5. Impacts associated with the TSA's Primary, Secondary, and Tertiary Benefit Areas.

MSA-2 (Public Lands Only) Intermediate RSLR WVA Summary						
Area	Swamp AAHUs	Swamp Acres*	BLH AAHUs	BLH acres*	Marsh AAHUs	Marsh acres*
Primary	634.65	3651	0.00	0	0.00	208
Secondary	408.15	2839	0.00	0	0.00	244
Tertiary	196.61	2324	0.00	0	0.00	284
Construction	-52.39	95	-29.12	79	0.00	0
South of I-10	-154.10	7539	-6.71	1830	-19.54	2743
Total	1032.92	16447	-35.83	1909	-19.54	3479

*acres are the existing condition acres by habitat type

Within the environmental consequences section of the Supplemental Environmental Impact Statement being developed, the analysis of potential MSA-2 impacts takes place at multiple spatial scales. Each resource is examined on the following scales below (Figure 8):

1. Planning Area - Diverted Mississippi River water is eventually dispersed throughout the LPB).
2. Diversion Influence Area - Diverted Mississippi River water is modeled representing the extent of nutrients, velocities, and water levels.
3. Mitigation Area - United States Fish and Wildlife Service (USFWS) primary, secondary, and tertiary benefit areas.
4. Proposed Construction Area – delineates the extent of construction activity.

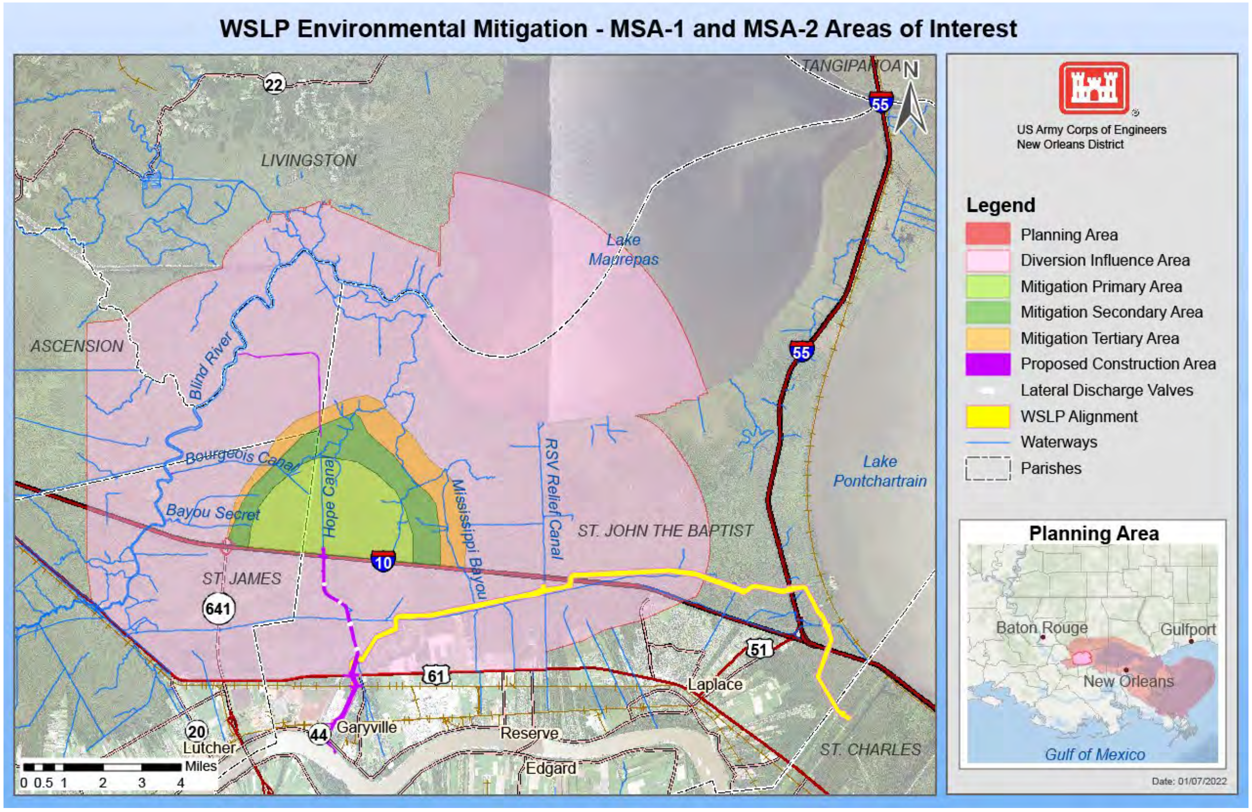


Figure 8. Maurepas Areas of Interest.

MSA-2 Mitigation Plan

Based on the most recent designs, WSLP Project would impact ~ 947 AAHUs of coastal zone (CZ) swamp habitat and ~ 293 AAHUs of CZ BLH habitat. Construction and operation of MSA-2 would result in impacts to ~ 206.5 AAHUs of CZ swamp, ~ 35.8 AAHUs of CZ BLH, and ~ 19.5 AAHUs of CZ marsh (Table 6). Swamp impacts resulting from both the WSLP Project and MSA-2 would be mitigated through construction and operation if MSA-2 as discussed throughout the Draft Supplemental Environmental Impact Statement (SEIS) to West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study Draft Mitigation Plan Update. BLH impacts resulting from both WSLP Project and MSA-2 would be mitigated per the approved plan discussed in EA #576 as summarized below (Table 7). Marsh impacts resulting from construction and operation of MSA-2 would be mitigated through construction of the Guste Island marsh creation project as discussed below or through the purchase of mitigation bank credits and construction the Guste Island marsh creation project (Table 8).

Both the St James and the Pine Island projects, approved in EA #576, were coordinated with DNR and have received Coastal Zone Consistency (C20190208) (see Attachments 1 and 2). Since the proposed St James and Guste Island projects discussed in this plan fall within the exact footprint of the previously approved projects, and are much smaller in size, the existing consistency should be applicable.

Table 6: Impacts Incurred by Both WSLP Project and MSA-2

Habitat Type Impacted	WSLP	MSA-2
Swamp	~ 947 AAHUs	~ 206.5 AAHUs
BLH	~ 293 AAHUs	~ 35.8 AAHUs
Marsh	0	~ 19.5 AAHUs

St. James BLH-Wet Restoration, St. James Parish, Louisiana

Table 7: Proposed BLH Mitigation Projects Approved in EA #576

Project	~ AAHUs	~ Acres
Mitigation Banks	TBD	TBD
St James	Up to ~ 36	Up to ~ 73.4

Table 8: Proposed Marsh Mitigation Projects

Project	~ AAHUs	~ Acres
Mitigation Banks	TBD	TBD
Guste Island	Up to ~19.5	Up to ~75

GENERAL SOW:

The proposed project involves restoration of up to ~ 74 acres of wet bottomland hardwoods (BLH-wet) as compensatory mitigation for coastal zone BLH impacts resulting from construction of the MSA-2. The BLH restoration area (mitigation area) would be located in existing agricultural fields at the previously approved St. James mitigation area as described in EA #576 (Figure 9). This site is located off the Mississippi River between the towns of Romeville and Union, LA around the Nucorp Plant in St. James Parish.

The main earthwork activities required prior to planting the mitigation areas would include degrading (scraping) portions of some mitigation areas (see degrading section), removal of undesirable drainage ditches and culverts, removal of undesirable earthen berms, establishing dirt access roads, establishing a project staging area, and tillage of areas to be planted. To maximize water flow into the site, any existing dikes/berms within the property boundary which prevent water flow into the site would be degraded as long as this effort does not harm or adversely affect outside properties/water sources. Any existing drainage features (drainage ditches, etc.) within or adjacent to the mitigation areas and within the property boundary would likely be removed to help assure appropriate site hydrology. The mitigation areas would then be planted with native canopy and midstory species typical of BLH-wet habitats.

A 10% contingency was added to the total acres needed to account for potential access roads and unanticipated impacts to the mitigation site during construction.

PROPOSED PLANTING:

Assumed total initial plantings required for the mitigation areas are:

BLH Canopy: ~ 40,330 seedlings. (545 seedlings per acre)

BLH Midstory: ~ 10,064 seedlings. (136 seedlings per acre)

Assume BLH canopy plants species would be installed on an 8ft by 10ft grid.

Assume BLH midstory plants species would be installed on a 16ft by 20ft grid.

Mowing poles (PVC pipes extending roughly 6 feet above grade) would be installed on each planted row every 50’ to 100’ to guide mowing operations. Mowing the areas between planted roles and within other buffer areas would be conducted occasionally to help suppress growth of other plants that may initially compete with the BLH plantings.

DEGRADE AREAS:

Portions of BLH mitigation Areas might need to be degraded (scraped down) to a depth of between ~ 0.5 feet to 1.0 feet below the existing soil surface to help ensure satisfactory hydrology/hydroperiod for BLH-wet habitat.

Degrade material would be hauled off site to a contractor-provided upland disposal area, assume a 15-mile one-way haul distance. Some of the degraded soil may be used on-site if such fill is required.

DEMOLITION:

No existing structures appear to be within the mitigation site. There is an existing underground pipeline that passes through mitigation area. It is currently unknown what type of pipe is in this location. Assume at least a 20-ft buffer around the route of the pipeline unless it is determined that the pipeline is abandoned. The location of the pipeline shown on the map is approximate.

DURATION:

Necessary earthwork and related activities would likely up to one year. Initial plantings would begin in the winter following completion of earthwork and continue through mid-March.

Monitoring to determine contractor success of the plantings would likely occur the October after plantings. Monitoring to determine initial success would likely occur two Octobers after initial plantings. If this monitoring shows initial success criteria had been satisfied, the monitoring responsibilities would be transferred to the Non-Federal Sponsor the following spring.

SITE ACCESS:

Access to the project work limits would be as follows:

From the north, access to the site to be made via route LA-3125 which leads to Helvetia Street and Wilton Road. Each of these roads run through the site north/south and would be preserved. From the south, access to the site can be made via route LA-44 which leads to Helvetia Street.

Dirt maintenance/access roads ~ 15 feet wide would be established around the perimeter of each of the mitigation areas shown on attached drawing. The Contractor may also establish other maintenance/access roads within the mitigation areas. Such roads would first have to be approved by the Government. If approved, such roads would slightly reduce the acreage of each mitigation area affected.

STAGING:

Staging area(s) would only be permitted within one of the mitigation areas. The Contractor would determine where, within a particular mitigation area, to place staging and laydown areas suitable for the Contractor's means and methods to meet the required project period of performance. The proposed staging area would first be submitted for Government approval. The Contractor would be permitted to place crush stone paving for parking and laydown areas along with a temporary construction trailers. No utilities would be provided by the Government, and the Contractor would have to obtain all permissions and permits for utilities. The trailer, crushed stone paving, and temporary utilities would have to be removed by the Contractor and the end of the project and the disturbed area would have to be planted with native grasses by the Contractor before leaving the project site.

MAINTENANCE/MANAGEMENT ACTIVITIES:

After completion of all excavation, grading, and soil preparation activities but prior to initial plantings, herbicides may be applied to the mitigation areas to help control invasive and nuisance plant species. Mowing may also be performed in the mitigation areas during this time period. After the mitigation areas are initially planted and before the success of these plantings is evaluated (monitored), herbicide applications and/or mowing may also occur to help suppress undesirable vegetation. Throughout this period, access/maintenance roads would be maintained as necessary as would be any new drainage features established.

The first monitoring event would occur in the fall of the year of the initial plantings. This report could show additional plantings are needed or it may not. Regardless, various mowing events and herbicide application events would take place during the period from the first monitoring event to the second monitoring event. It is assumed that the second monitoring event would show success criteria for the plantings had been achieved as were success criteria about control of invasive and nuisance plants. In this case, the Non-Federal Sponsor would take over the project including all management and maintenance work.

EQUIPMENT:

Equipment to be used for the respective work is assumed as follows:

Degrading: Up to D8 bulldozers, wheel tractor scrapers, front-end loaders, off-road and on-road dump trucks.

Demolition (if needed): Backhoes with grapple and hammer attachments, bulldozer, front loaders, and on/off road dump trucks.

Planting Preparation: Tractor with harrow and scarifier, bulldozers, and backhoe.

Planting: Pickup trucks, ATVs and/or UTVs, and 2,000-to-4,000-gallon water trucks.

Initial Maintenance: Tractors with brush-hog/mowers; ATVs and/or UTVs, back-pack sprayers and/or boom sprayers; bulldozers or backhoes.

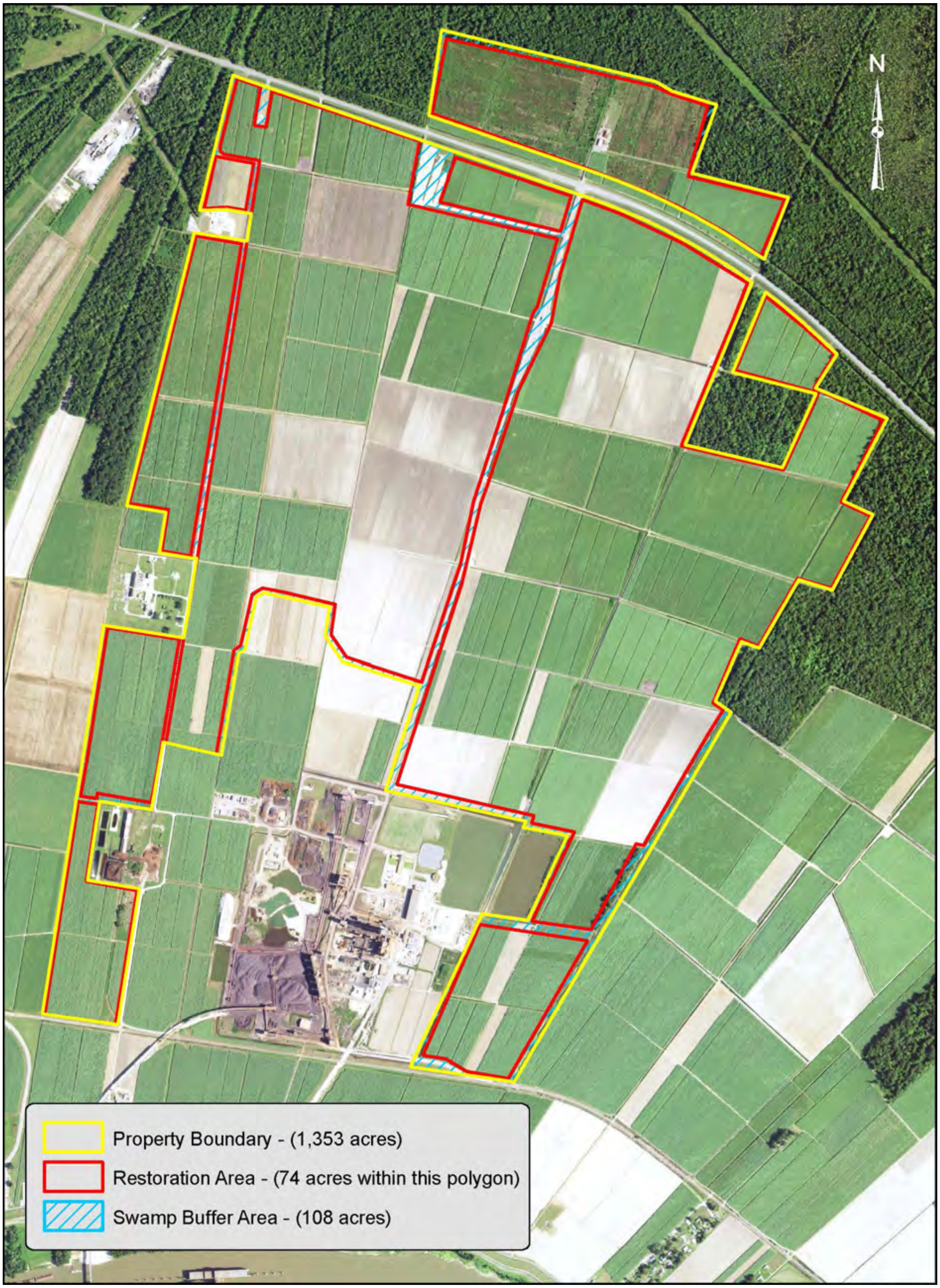


Figure 9. St. James BLH-Wet Restoration proposed project area.

Guste Island Intermediate Marsh Mitigation Project Description

GENERAL SCOPE:

The Guste Island intermediate marsh restoration project (Guste Island) is proposed as compensatory mitigation for the impacts to fresh marsh incurred by construction and operation of the proposed MSA-2. The Guste Island mitigation project was developed using two recent MVN projects, the constructed Milton Island Intermediate Marsh Restoration Project (Milton Project) (PIER 36 TIER 1) and the approved Pine Island project (EA #576). Both projects are located in the same geographic area as the Guste Island project therefore the designs and impact analysis of these two projects were considered to be similar and could appropriately be used for development and analysis of the Guste Island project.

The Guste Island intermediate marsh restoration project would be located near Madisonville, Louisiana on the north shore of Lake Pontchartrain, west of the Causeway Bridge (Figure 10). This project would consist of three major construction related features:

1. Marsh creation
2. Borrow
3. Access

The proposed marsh creation site would be ~ 75 acres within the previously identified and approved Pine Island swamp restoration area as described in EA #576. The borrow area would be the same as the borrow area identified for Pine Island. However, substantially less borrow material would be required therefore only ~ 100 acres within that previously identified area would be dredged. Access for pipeline(s), watercraft, and other construction related equipment would be similar to that described in EA #576.

PROJECT AREA SIZE ESTIMATION:

Information from the adjacent Milton Project, constructed in 2018, was used to size the Guste Island Project. Wetland value assessments (WVAs) performed for the Milton Project estimated a mitigation potential of 0.315 average annual habitat units/acres (AAHUs/acre) (Appendix G "Prior Reports"). Based on this mitigation potential and a 20 percent contingency ~ 75 acres for construction would be needed to mitigate ~ 19.5 AAHUs impacted by the MSA-2 alternative. Contingency was added to account for potential impacts resulting from construction of this project such as, but not limited to, potential impacts to existing marsh or SAV within the construction area, potential impacts associated with fill containment dike construction, and access.

MARSH CREATION PLAN:

The proposed intermediate marsh creation would be constructed within an ~ 75-acre area within the Pine Island Swamp Mitigation project area (which is ~ 1,965 acres). The proposed marsh creation area is primarily in shallow open water, but there is some existing emergent marsh and submerged aquatic vegetation present as well. The marsh creation area was sized to account for potential unavoidable adverse impacts to emergent marsh and submerged aquatic vegetation. Adverse impacts would be avoided and minimized to the extent practicable. The marsh creation area would consist of three features:

1. Marsh platform – area within containment dikes that would be constructed to an elevation expected to settle within the functional marsh elevation range of intermediate marshes within the Lake Pontchartrain Basin (~ -0.17 to +1.56 feet based on 2014 CRMS data; Jankowski et al., 2017). This would be ~ 67.5 acres and would be constructed to up to ~ +3.5 feet NAVD88.

2. Containment dikes – raised areas constructed and designed to contain pumped material that would create the marsh platform. These would be either gapped or completely degraded after the marsh platform settles as part of final construction of the Guste Island project (~ 1 year after creation of the marsh platform). Material resulting from gapping or degrading would be placed back into the areas dredged to construct the dikes. Existing high ground could be used to contain pumped material to the extent practicable. It is expected this would be ~ 10% of the project area (~ 7.5 acres) and would be constructed to ~ +4.5 feet NAVD88. However, the exact acreage would vary based on design details such as but not limited to shape (square or circle) and location (e.g., does it border any existing high ground?).

3. Containment dike borrow areas – Borrow obtained from within the marsh creation cell or open water adjacent to the dike alignment would be dredged down to an elevation of ~ -7.0 feet NAVD88 to construct the containment dikes.

In addition to these three features, deeper openings within the containment dikes and vicinity may be constructed as part of final construction of the Guste Island project (“fish dips”). Fish dips would facilitate exchange with surrounding waterways and allow for aquatic organisms to have better access to the newly created marsh. Close coordination with the NMFS and USFWS regarding if and how fish dips would be constructed would occur during further design.

BORROW PLAN:

Hydraulic cutterhead dredges would be used to excavate ~ 1,700,000 cubic yards of material from an ~ 100-acre area within the previously identified and approved 2,238-acre Pine Island borrow area described EA #576. Dredging of the borrow area would be limited to -19.0 feet NAVD88 plus a 1-foot allowable over depth. A minimum buffer of 800 feet would be required between the borrow site footprint and the transmission line alignment located in Lake Pontchartrain, north of the proposed borrow site. The hydraulically dredged material would be moved into the marsh creation area via pipeline according to the access plan.

DURATION:

Necessary dike construction and initial pumping of sediment into the marsh platform would take up to 1 year to complete. Following an approximate 1 yearlong settlement period after pumping of sediment into the marsh platform, degrading of dike would begin and would take up to one year.

SITE ACCESS:

The pipeline and access corridor designated in EA #576 from the borrow source to the shoreline would be used for access for pipeline(s), watercraft, and other construction related equipment. There would be no allowances for excavation within the corridor. The dredge pipeline would be floated and or submerged within this corridor to the shoreline. From the shoreline, the dredge pipeline could cross existing marsh wetland habitats causing negative impacts. These impacts would be avoided, reduced, and/or minimized to the extent practicable. Any remaining impacts would be rectified (i.e., repaired as or after the pipeline is being removed) or mitigated. The proposed marsh creation area was sized to account for some impacts of this nature.

STAGING:

Staging of equipment for initial dike construction activities would be via barge(s) on or near the Lake Pontchartrain shoreline as indicated on the attached drawing. The proposed staging areas would first be submitted for Government approval. Staging of materials for the initial planting event are anticipated to be within the mitigation areas themselves.

MAINTENANCE/MANAGEMENT ACTIVITIES:

After completion of all dike construction, dredge pumping, and soil preparation activities, herbicides may be applied to the mitigation areas to help control invasive and nuisance plant species. Throughout this period, access/maintenance roads would be maintained as necessary as would be any fish dips (if applicable) and any new drainage features established.

The first monitoring event would occur in late summer one year after the settlement of the marsh platform. Various herbicide application events could take place during this period, if necessary. It is assumed that this monitoring event would show that all vegetation and invasive/nuisance species success criteria had been achieved. It is also assumed this monitoring event would show the success criterion established for the final soil surface elevation in the mitigation areas had been achieved. In this case, the Non-Federal Sponsor would take over the project including all management and maintenance work.

EQUIPMENT:

Equipment to be used for the respective work is assumed as follows:

Dike Construction: Excavators, marsh buggies, airboats

Dredge Pumping: Cutterhead dredge, tugs, crew boats, pipeline (steel, and rubber), derricks, barges, up to D-8 dozers, excavators, front-end loaders, marsh buggies, airboats, marsh masters

Rip-rap Construction (if needed): Excavators, scows, barges, up to D-8 dozers, front-end wheel loaders, marsh buggies

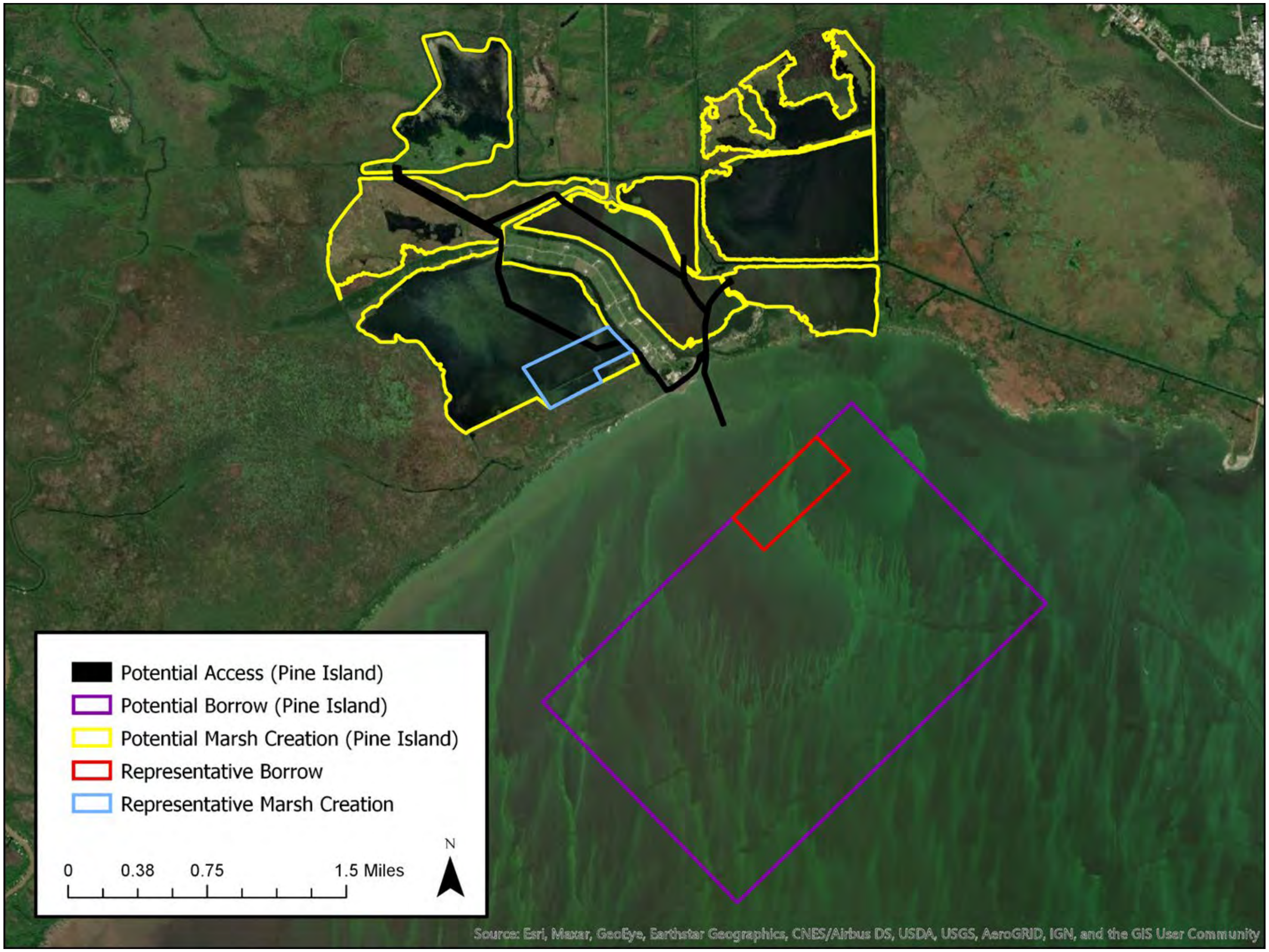


Figure 10: Potential areas show areas that would be considered for the Guste Island Mitigation Project. Representative Areas are included to indicate approximate sizing based on MSA-2's mitigation need, and are not intended to represent the precise location of project features.

GUIDELINES APPLICABLE TO ALL USES

Guidelines 1.1 – 1.6 The guidelines have been read in their entirety, and all applicable guidelines would be complied with. The proposed action would be in conformance with all applicable water and air quality laws, standards and regulations, and with those other laws, standards and regulations which have been incorporated into LCRP, and is deemed in conformance with the program except to the extent that these guidelines would impose additional requirements. The proposed activity would not be carried out or conducted in such a manner as to constitute a violation of the terms of a grant or donation of any lands or waterbottoms to the State or any subdivision thereof. Information regarding potential impacts of the proposed action is provided herein and would also be addressed in the forthcoming supplemental environmental impact statement.

Guideline 1.7 Potential short- and long-term effects resulting from the construction and operation of the proposed action include increased total suspended sediments, turbidity, and organic/nutrient enrichment of the water column; disturbance and release of possible contaminants; decrease in water temperatures; and the possible release of oxygen depleting substances as well as possibly increasing dissolved oxygen levels. Potential impacts would be minimized, as much as practicable, through the implementation of stormwater pollution prevention plans (SWPPPs) and other applicable best management practices (BMPs).

Generally, four water quality conditions could change with operation of the proposed action:
1) Freshwater would be moved throughout the entire diversion influence area;
2) Salinities could decrease throughout the entire diversion influence area;
3) Sediments in the mitigation area would increase, along with accompanying minor increases in trace metals associated with bed sediments; and
4) Nutrients in the diversion influence area could increase.

Potential construction impacts on water quality would occur within the immediate vicinity (within 0.5-mile) of all active construction areas. Direct impacts would also occur in the area downstream or down gradient of construction in both the Mississippi River and Lake Maurepas, respectively. Any increases in suspended solids and turbidity levels due to dredging related activities in the immediate proposed construction area would be minor, temporary, and highly localized. However, at this time, there is no proposed dredging in the Mississippi River, the work would take place in the batture. During operations, direct impacts would occur to water quality in the diversion influence area (Figure 8). No impacts are anticipated on water quality in the Mississippi River. Wetlands in coastal Louisiana have been shown to provide long-term nutrient loading benefits as "assimilation wetlands," that treat effluent and improve water quality (Day Jr. et al. 2019; Hunter et al. 2009).

As such, water quality impacts from the proposed action would be offset by the process of assimilation and nutrient loading. Lane et al. (2003) found that the Maurepas swamps are nitrogen limited compared to phosphorus, and dissolved inorganic nitrogen, especially nitrate, is the most important nutrient in the formation of phytoplankton blooms in Lake Maurepas. Nitrates in Mississippi River runoff from the proposed action would likely be removed via denitrification in the water column or uptake in wetland plants. Operating the diversion with

2,000 cfs outflow, majority of the introduced nutrients in the diversion influence area would be removed from the water column within ~ 3-4 miles from the diversion outflow north of Interstate 10 (i.e., they would likely be removed within the diversion influence area, see Figure 8). By the time the outflow reaches Lake Maurepas, any remaining nutrients would consist mostly of organic nitrogen, which is not available for algal uptake unless it is first converted back to inorganic nitrogen through the slow process of mineralization.

Indirect impacts from the proposed construction of the features could occur in a larger area of the basin or Mississippi River and would vary depending upon the nature of the impact. For example, runoff from the proposed construction area could impact water quality downstream depending on the amount of the release, what countermeasures are in place, the timeliness of the response action, and the weather conditions at the time of the release.

Indirect impacts during operations would likely occur within the diversion influence area. MSA-2 operation impacts on surface water and sediment quality may also indirectly impact other natural resources (e.g., wetlands; threatened, endangered and protected species; fisheries and aquatic resources; and recreational resources) within the diversion influence area.

Cumulatively, impacts with adjacent state-sponsored restoration projects and the Amite River Diversion Canal could coincide and result in localized short-term impacts within canals in the Maurepas Swamp and adjacent waterbodies. As stated above, these impacts would vary depending upon the nature of the impact. The process of assimilation and nutrient loading would reduce potential impacts from the diversion canal outflow while any additional releases of runoff (e.g. wastewater treatment facilities and agriculture) in the vicinity of the TSA could elevate nutrient levels. Short-term hydrologic impacts from hurricanes, wave fetch over lakes, etc. could further limit potential for algal blooms.

While there would be a slight alteration in water elevation along Bayou Secret and Bayou Bourgeois Canal there would be minimal impacts in Blind River, as a LA Scenic River, from algal blooms and other water quality changes. Increases in agricultural runoff upstream in the Mississippi River and tributaries could potentially elevate the impact to nutrients in Blind River, but current data and trends indicate a low risk. The TSA could route future commercial agricultural fertilizer, pesticides, and other constituents in river water into Maurepas Swamp and adjacent waterbodies, but nutrient loading and assimilation in existing swamp vegetation would result in a minimal impact. Such conditions that result in algal blooms would likely continue to occur in the northern planning area around northern Lake Maurepas and Lake Pontchartrain.

No adverse alteration or destruction of unique or valuable habitats, critical habitat for endangered species, important wildlife or fishery breeding or nursery areas, or forestlands is anticipated. No adverse cumulative or secondary impacts to the biological productivity of wetland ecosystems are anticipated, with exception to possible impacts to deer, nesting alligators, and pallid sturgeon, this is discussed in more detail below. Adverse disruptions of coastal wildlife and fishery migratory patterns are not anticipated, see possible exceptions related to deer, nesting alligators, and pallid sturgeon below. There is no designated critical habitat in the area of MSA-2.

During flooding events, the size of white-tailed deer populations may be affected by the mortality of smaller fawns and a reduced carrying capacity (due to less sub-areal land masses). Loss of forage and reduced lactation rates in adult females have also been reported. Impacts from operation and maintenance of the diversion would elevate water levels in the benefit area between approximately 1 to 2 feet within the Maurepas WMA, which could result in significant adverse impacts to terrestrial species, including nesting alligator and deer populations. In the past, the LDWF has modified deer seasons and harvest recommendations in specific areas due to the anticipated impacts to recruitment in response to late summer flooding. Further management measures by LDWF could potentially mitigate impacts to deer populations that could occur during diversion operation.

Impacts to alligator populations would be similar, but less intense for adults given their resilience to flood conditions. There can be much variation in alligator populations following tropical storm events, some which are more the effect of prey availability in lower salinity areas.

The endangered pallid sturgeon are adapted to living close to the bottom of large, silty rivers with a natural hydrograph. The U.S. Army Engineer Research and Development Center conducted sampling near the location of the proposed diversion intake and several pallid sturgeons were captured during this event. Adult and subadult pallid sturgeon are relatively abundant in the proposed construction area and could be directly affected by the proposed diversion due to noise, vibration, and presence of construction personnel and equipment. Pallid sturgeons would also be directly impacted by the operation of the diversion by way of entrainment. Since operation of the diversion is expected to occur every year, this impact would be reoccurring over the 50-year project life. Juvenile pallid sturgeons are assumed to have a "low" entrainment risk due to low likelihood of their occurrence in the vicinity of the diversion's intake. There is an assumed "medium" risk of entrainment by adults and subadults due to the likelihood of presence and their relatively low burst swimming speeds compared to intake velocities. Management recommendations would be followed to reduce or mitigate a chance of entrainment.

No adverse alteration or destruction of public parks, shoreline access points, public works, designated recreation areas, scenic rivers, or other areas of public use and concern is anticipated. No increases in the potential for flood, hurricane or other storm damage, or increases in the likelihood that damage would occur from such hazards are anticipated. During tropical storm events, the diversion would not operate. However, after a storm event the operation of the diversion could potentially ameliorate the effects of a storm event.

No significant economic impacts on the locality or adverse disruptions of existing social patterns would occur due to the proposed action. Activities associated with the proposed alternative have the potential to directly and indirectly impact existing and previously undocumented cultural resources that may exist within the proposed construction footprint, mitigation, and diversion influence areas. A review of the Louisiana Cultural Resources Map (on-line), existing cultural resources survey reports, and other available documentation identified eleven (11) previously recorded archaeological resources and three (3) previously recorded architectural resources within the proposed construction footprint, mitigation, and diversion influence areas. Much of the proposed construction footprint, mitigation, and diversion influence areas have not been previously surveyed for cultural resources and those areas would require cultural resources surveys prior to construction. The CEMVN would follow the steps as outlined in an existing programmatic agreement to identify and evaluate cultural resources and complete the Section 106 process. If significant historic properties are impacted or new historic properties are identified within the proposed construction footprint, mitigation, and diversion influence areas, strategies would be developed to avoid those resources or to minimize or mitigate for adverse effects, in accordance with the programmatic agreement. No proximal areas of special concern exist. No land loss, erosion, or subsidence would occur. The proposed action would not result in reduced long-term biological productivity of the coastal ecosystem.

Guidelines 1.8 – 1.10 Acknowledged. Potential adverse impacts listed above would clearly be outweighed by the human and environmental benefits the TSA would provide by strategically delivering nutrient-laden river water to restore a degraded Cypress-Tupelo swamp. Reconnecting the Mississippi River and the Maurepas Swamp, would also improve the swamp ecosystem health and function, the hydrologic distribution of freshwater, and topographic diversity.

GUIDELINES FOR LEVEES

Guidelines 2.1 – 2.6 Acknowledged The proposed action would involve the building of conveyance channel guide levees ~ 6 to 10 feet tall. Conveyance channel guide levee impacts to wetlands are accounted for and included in the SEIS. Up to approximately 32 LDVs would be constructed to allow for water exchange between the conveyance channel and the areas east and west of the channel. The LDVs would be actively operated and would be bidirectional to facilitate drainage of discharged water and precipitation to minimize potential impacts from increased inundation duration. The HET has specifically evaluated 7 days of discharge through the LDVs via Delft3D modeling; however, it may be necessary to operate the LDVs differently in practice as part of the adaptive management approach to MSA-2

GUIDELINES FOR LINEAR FACILITIES

Guideline 3.1 – 3.16 Acknowledged. Portions of the proposed diversion's conveyance channel would utilize a currently existing canal (i.e., Hope Canal), which would reduce the length of newly constructed linear channel needed for the proposed diversion and minimize adverse impacts to wetlands associated with channel excavation. Required earthwork would consist of clearing, grubbing, excavation, and removal of ~ 1,279,232 CY of earthen material for the proposed diversion's conveyance channel and disposal at an approved disposal site. If a borrow study in subsequent design phases indicates sufficient suitability within the excavated material, the Contractor may elect to use that material on-site. Any material used on site would stay within the ROW and would be used to construct features as described in the Plans and Specs. The majority of fill material used throughout the proposed construction area would be imported from an USACE approved borrow sources as described in SEA 571.

The proposed main outfall channel would improve natural hydrologic and nutrient transport patterns, sheet flow, and water quality, and would positively benefit the receiving wetlands and associated fish and wildlife habitat primarily in the mitigation area and diversion influence area.

LDVs were designed and located using the best practical techniques to minimize disruption of natural hydrologic and sediment transport patterns, sheet flow, and water quality, and to minimize adverse impacts on wetlands. The LDVs would be actively operated and would be bidirectional to facilitate drainage of discharged water and precipitation to minimize potential impacts from increased inundation duration.

GUIDELINES FOR DREDGED MATERIAL DEPOSITION

Guideline 4.1 At the time of this submittal, the intent is not to dredge any material in the Mississippi River. Excavated materials removed during excavation and enlargement of the proposed diversion's intake and outfall channels and the main conveyance channel would be deposited in a manner that would avoid disruptions of water movement, flow, circulation and quality. Excavated material deposition is not expected to result in significant or persistent water quality impacts in the vicinity of construction activities. Any minor increases in suspended sediment and turbidity levels during the placement of excavated spoil would be temporary and highly localized. Minor reductions in dissolved oxygen levels associated with excavated material deposition would be temporary.

Guideline 4.2 Earthwork would consist of clearing, grubbing, excavation, and removal of ~ 1,279,232 CY of earthen material for the proposed diversion's conveyance channel and disposal at an approved disposal site. If a borrow study in subsequent design phases indicates sufficient suitability within the excavated material, the Contractor may elect to use that material on-site. Any material used on site would stay within the ROW and would be used to construct features as described in the Plans and Specs. Embankment cuts would be established north of the conveyance channel in the northern part of the swamp. The cuts would occur along the existing ridge of an old railroad embankment. Water must be circulated throughout the swamp to reestablish the vitality of the wetland vegetation. Water movement into the northwest corner of the swamp is restricted by an embankment that was constructed decades ago to support a defunct Cypress logging railroad spur. To establish the cuts, 7.51 acres along the old railroad embankment would be cleared for equipment access, 5 individual areas along the embankment would be excavated to existing grade to allow for water flow while all spoil would be placed in 20 individual areas along the embankment. It is anticipated that no material would be removed from the proposed construction area and placed in a new disposal area.

Guideline 4.3 If material is dredged, it would not be disposed of in a manner which could result in the impounding or draining of wetlands or the creation of development sites.

Guidelines 4.4 – 4.7 Acknowledged.

GUIDELINES FOR SHORELINE MODIFICATION

Guideline 5.1 – 5.9 Not applicable.

GUIDELINES FOR SURFACE ALTERATIONS

Guidelines 6.1 – 6.14 Acknowledged. Surface alterations in the proposed construction area (the overall proposed construction area is 288.30 acres; temporary impacts are 26.48 acres and permanent impacts are 261.82 acres.) would mainly entail the excavation of a new intake channel, excavation of a conveyance channel (a portion of which is an existing canal), and excavation of a new outfall channel. Required earthwork would consist of clearing, grubbing, excavation, and removal of ~ 1,279,232 CY of earthen material for the proposed diversion's conveyance channel and disposal at an approved disposal site. If a borrow study in subsequent design phases indicates sufficient suitability within the excavated material, the Contractor may elect to use that material on-site. Any material used on site would stay within the ROW and would be used to construct features as described in the Plans and Specs. The majority of fill material used throughout the proposed construction area would be imported from USACE approved borrow sources as described in SEA 571.

Impacts from construction would occur within, and in close proximity to, the footprint of each individual construction component, such as river-side features (e.g. automated gate structure, cofferdam, levee tie-in), access roads, and embankment features for excavated spoil placement. The anticipated impact associated with land clearing is expected to be slight and would not have a long-term negative impact on any wildlife that may be present in the construction area.

Impacts from the operation and maintenance of the diversion would elevate water levels in the diversion influence area and approximately between approximately 1 to 2 feet within the Maurepas Wildlife Management Area (WMA). While there is an anticipated increase in water surface elevation from the diversion operations, this is primarily confined to the diversion influence area, with the greatest water surface elevations occurring near the outfall and gradually falling as one moves away from the outfall (i.e. as one moves closer to the extent of the diversion influence area). The LDWF has concerns about the effects of water level increases on the Wildlife Management Area. Increased water levels could result in significant adverse impacts to terrestrial species, including nesting alligator and deer populations. Specific to deer, reduced lactation rates in does (Jones et al. 2019) along with reduced forage quality and increased vulnerability to predators within the WMA could result in further mortality during operation. In personal communication with LDWF's Deer Program Manager, John Bordelon on September 1, 2021, there is not a large enough sample size of monitored deer in the Maurepas WMA to provide a representative impact analysis for FWP conditions at this time. In the past, LDWF has modified deer seasons and harvest recommendations in specific areas due to the anticipated impacts to recruitment in response to late summer flooding. Further management measures by LDWF could potentially mitigate impacts to deer that would occur during diversion operation. The WMA closes to deer hunting when the U.S. Geological Survey water level gauge CRMS 5373 is at or above 3.0 msl feet and reopens when water levels recede to 2.5 msl feet following a closure.

The proposed action would minimally affect water quality and flows in the Mississippi River and conveyance channel, benefits would occur to the mitigation area and diversion influence area by strategically delivering nutrient-laden river water to improve a Cypress-Tupelo swamp. The proposed weirs would be constructed to ensure fish passage and allow for boat travel for low draft vessels.

Most of the fill material used throughout the proposed construction area would be imported from an USACE approved borrow sources as described in SEA 571. Thus the fill would be free of contaminants and compatible with the existing environmental setting.

GUIDELINES FOR HYDROLOGIC AND SEDIMENT TRANSPORT MODIFICATIONS

Guidelines 7.1 – 7.9 Acknowledged. The proposed freshwater diversion would reconnect the Mississippi River to the Maurepas Swamp, strategically delivering nutrient-laden river water to restore a degraded Cypress-Tupelo swamp. The proposed diversion has a 2,000 cubic foot per second (cfs) design flow. The Recommended Plan would also serve to compensate for the WSLP Project construction impacts of ~ 947 AAHU of CZ swamp. The expected annual operational period for the proposed diversion would be between January 1 and July 1. The precise timing, discharge rate, and duration of the pulses would be modified to maximize benefit to the swamp. The first 3 years of operation consist of gradually increasing flow duration and magnitude (i.e., a "ramp-up" period). This ramp-up period is intended to reduce the initial shock to the system and enable adaptive management based upon observed water flow and environmental responses. The operating plan for years 4-50 would start operations at 2,000-cfs or maximum operating capacity based on river conditions on January 1, let it run until April 1, and then shut it off. Restart operations at 2,000-cfs on May 13, let it run until June 30 and then shut it off. The goal of operations is to deliver river water to the swamp each year during the growing season, but the timing and duration of the pulses may be adaptively managed based on river hydrographs and swamp conditions and timing. Project monitoring data, as well as assessments of river stage and discharge, would collectively guide future operations through the project life. This Operations Plan is a living document and would be adjusted based on site conditions, a review of project monitoring data, and an adaptive management approach.

The proposed diversion's gated intake structure would be linked to sensors in the Mississippi River established to detect chemical spills from the adjacent Pin Oak oil and gas terminal. These sensors trigger an alarm which would alert the project operator to immediately close the gated intake structure to prevent chemicals from being drawn into the conveyance channel. A supervisory control and data acquisition system would be used allow for real-time monitoring and management of project operations and rapid intake closure in emergency situations. Operations of the proposed diversion's gated intake structure are not expected to significantly impact navigation in the Mississippi River. A FLOW-3D modeling study (Meselhe et al., 2015) indicates that under high as well as low river flow conditions, the flow approaches the intake channel entrance along the shoreline of the Mississippi River without significantly affecting flow in the Mississippi River navigation channel. High water conditions in the Mississippi River are not likely to affect proposed diversion's structural components. The headworks and rebuilt Mississippi River levee would be constructed to meet the USACE standards for mainline flood protection.

Adult and subadult pallid sturgeon are relatively abundant in the lower MS and could be directly affected by the construction of the proposed diversion due to construction activities including noise, vibration, and presence of construction personnel and equipment. Pallid sturgeon would also be directly impacted by the operation of the diversion by way of entrainment. This impact would be reoccurring over the 50-year project life. Juvenile pallid sturgeon are assumed to have a "low" entrainment risk due to low likelihood of their occurrence in the project area. There is an assumed "medium" risk of entrainment by adults and subadults due to the likelihood of presence and their relatively low burst swimming speeds compared to intake velocities (Kirk et al., 2008). USFWS management recommendations would be followed to reduce or mitigate chance of entrainment. A Biological Assessment with detailed impacts will be included in the final SEIS.

GUIDELINES FOR DISPOSAL OF WASTES

Guidelines 8.1 – 8.9 The proposed action would not involve the disposal of wastes; therefore, these guidelines are not applicable.

GUIDELINES FOR USES THAT RESULT IN THE ALTERATION OF WATERS DRAINING INTO COASTAL WATERS

Guideline 9.1 The proposed action would minimally affect water quality and flows in the Mississippi River, while providing benefits to the mitigation area and diversion influence area by strategically delivering nutrient-laden river water to improve a Cypress-Tupelo swamp. During operations, direct impacts would occur to water quality in the diversion influence area (Figure 8). No impacts are anticipated on water quality in the Mississippi River. Wetlands in coastal Louisiana have been shown to provide long-term nutrient loading benefits as "assimilation wetlands," that treat effluent and improve water quality (Day Jr. et al. 2019; Hunter et al. 2009). Water quality impacts from the proposed action would be offset by the process of assimilation and nutrient loading. Lane et al. (2003) found that the Maurepas swamps are nitrogen limited compared to phosphorus, and dissolved inorganic nitrogen, especially nitrate, is the most important nutrient in the formation of phytoplankton blooms in Lake Maurepas. Nitrates in Mississippi River runoff from the proposed action would likely be removed via denitrification in the water column or uptake in wetland plants.

Guidelines 9.2 – 9.3 Not applicable.

GUIDELINES FOR OIL, GAS, AND OTHER MINERAL ACTIVITIES

Guidelines 10.1 – 10.14 The proposed action would not involve oil, gas, and other mineral activities; therefore, these guidelines are not applicable.

GUIDELINE DEFINITIONS

Levees - any use or activity which creates an embankment to control or prevent water movement, to retain water or other material, or to raise a road or other lineal use above normal or flood water levels. Examples include levees, dikes and embankments of any sort.

Linear Facilities - those uses and activities which result in creation of structures or works which are primarily linear in nature. Examples include pipelines, roads, canals, channels, and powerlines.

Shoreline Modifications - those uses and activities planned or constructed with the intention of directly or indirectly changing or preventing change of a shoreline. Examples include bulkheading, piers, docks, wharves, slips and short canals, and jetties.

Spoil Deposition - the deposition of any excavated or dredged material.

Surface Alterations - those uses and activities which change the surface or usability of a land area or water bottom. Examples include fill deposition, land reclamation, beach nourishment, dredging (primarily areal), clearing, draining, surface mining, construction and operation of transportation, mineral, energy and industrial facilities, and industrial, commercial and urban developments.

Hydrologic and Sediment Transport Modifications - those uses and activities intended to change water circulation, direction of flow, velocity, level, or quality or quantity of transported sediment. Examples include locks, water gates, impoundments, jetties, groins, fixed and variable weirs, dams, diversion pipes, siphons, canals, and surface and groundwater withdrawals.

Waste Disposal - those uses and activities which involve the collections, storage and discarding or disposing of any solid or liquid material. Examples include littering; landfill; open dumping; incineration; industrial waste treatment facilities; sewerage treatment; storage in pits, ponds or lagoons; ocean dumping and subsurface disposal.

Alterations of Waters Draining in Coastal Waters - those uses or activities that would alter, change, or introduce polluting substances into runoff and thereby modify the quality of coastal waters. Examples include water control impoundments, upland and water management programs, and drainage projects from urban, agricultural and industrial developments.

Oil, Gas and Other Mineral Activities - those uses and activities which are directly involved in the exploration, production, and refining of oil, gas and other minerals. Examples include geophysical surveying, establishment of drill sites and access to them, drilling, on site storage of supplies, products and waste materials, production, refining, and spill cleanup.

Coastal Water Dependent Uses - those which must be carried out on, in or adjacent to coastal water areas or wetlands because the use requires access to the water body or wetland or requires the consumption, harvesting or other direct use of coastal resources, or requires the use of coastal water in the manufacturing or transportation of goods. Examples include surface and subsurface mineral extraction, fishing, ports and necessary supporting commercial and industrial facilities, facilities for the construction, repair and maintenance of vessels, navigation projects, and fishery processing plants.

Best Practical Techniques - best practical techniques shall mean those methods or techniques which would result in the greatest possible minimization of the adverse impacts listed in Guideline 1.7 and in specific guidelines applicable to the proposed use. Those methods or techniques shall be the best methods or techniques which are in use in the industry or trade or among practitioners of the use, and which are feasible and practical for utilization.

Water or Marsh Management Plan - a systematic development and control plan to improve and increase biological productivity, or to minimize land loss, saltwater intrusion, erosion or other such environmental problems, or to enhance recreation.

Impoundment Levees - those levees and associated water control structures whose primary purpose is to contain water within the levee system either for the prevention of the release of pollutants, to create fresh water reservoirs, or for management of fish or wildlife resources.

Hurricane or Flood Protection Levees - those levees and associated water control structures whose primary purpose is to prevent occasional surges of flood or storm generated high water. Such levee systems do not include those built to permit drainage or development of enclosed wetland areas.

Development Levees - those levees and associated water control structures whose purpose is to allow control of water levels within the area enclosed by the levees to facilitate drainage or development within the leveed areas. Such levee systems also commonly serve for hurricane or flood protection, but are not so defined for purposes of these guidelines.

Feasible and Practical - those locations, methods and/or practices which are of established usefulness and efficiency and allow the use or activity to be carried out successfully.

Minerals - oil, gas, sulfur, geothermal, geopressured, salt, or other naturally occurring energy or chemical resources which are produced from below the surface in the coastal zone. Not included are such surface resources as clam or oyster shells, dirt, sand, or gravel.

Sediment Deposition Systems - controlled diversions of sediment-laden water in order to initiate land building or sediment nourishment or to minimize undesirable deposition of sediment in navigation channels or habitat areas. Typical activities include diversion channels, jetties, groins or sediment pumps.

Radioactive Wastes - Wastes containing source, special nuclear, or by-product material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923).

OTHER STATE POLICIES INCORPORATED INTO THE PROGRAM

Section 213.8A of Act 361 directs the Secretary of DOTD, in developing the LCRP, to include all applicable legal and management provisions that affect the coastal zone or are necessary to achieve the purposes of Act 361 or to implement the guidelines effectively. It states:

The Secretary shall develop the overall state coastal management program consisting of all applicable constitutional provisions, laws and regulations of this state which affect the coastal zone in accordance with the provisions of this Part and shall include within the program such other applicable constitutional or statutory provisions, or other regulatory or management programs or activities as may be necessary to achieve the purposes of this Part or necessary to implement the guidelines hereinafter set forth.

The constitutional provisions and other statutory provisions, regulations, and management and regulatory programs incorporated into the LCRP are identified and described in Appendix 1. A description of how these other authorities are integrated into the LCRP and coordinated during program implementation is presented in Chapter IV. Since all of these policies are incorporated into the LCRP, federal agencies must ensure that their proposed actions are consistent with these policies as well as the coastal use guidelines. (CZMA, Section 307)

CONSISTENCY DETERMINATION

The goal of the proposed diversion is to create ~ 947 AAHUs of swamp habitat by reintroducing Mississippi River derived fresh water, nutrients, and sediments that are expected to improve the health, and essential functions and values of the existing swamp. The proposed diversion would provide additional freshwater, nutrients, and fine sediments to the diversion influence area. The proposed action will restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them by reversing the trend of degradation and deterioration in the diversion influence area, so as to contribute towards achieving and sustaining a larger coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana and thus contribute to the economy and well-being of the Nation.. Based on this evaluation, the U. S. Army Corps of Engineers, New Orleans District, has determined that the proposed action is consistent, to the maximum extent practicable, with the State of Louisiana's Coastal Resources Program..

REFERENCES

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Meselhe, E., Richardson, J., Lagumbay, R., Allison, M., Jung, H. (2015). Simulation of Flow near Proposed Dock Facility and Freshwater Diversion Reserve, Louisiana at River Mile 144.2. Prepared for and funded by the Coastal Protection and Restoration Authority. Baton Rouge, LA.

ATTACHMENTS

JOHN BEL EDWARDS
GOVERNOR

THOMAS F. HARRIS
SECRETARY

State of Louisiana

DEPARTMENT OF NATURAL RESOURCES

OFFICE OF COASTAL MANAGEMENT

March 4, 2020

Marshall K. Harper
Chief, Environmental Planning Branch
Corps of Engineers- New Orleans District
7400 Leake Avenue
New Orleans, LA 70118
Via email: marshall.k.harper@usace.army.mil

RE: **C20190208,** Coastal Zone Consistency
U.S. Army Corps of Engineers
Direct Federal Action
Bipartisan Budget Act 18 Mitigation for Construction Projects: West Shore Lake Pontchartrain Flood Risk Management
St. Mary, St. John the Bapist, St. Tammany and Tangipahoa Parishes, **Louisiana**

Dear Mr. Harper:

The above referenced project has been reviewed for consistency with the Louisiana Coastal Resources Program in accordance with Section 307 (c) of the Coastal Zone Management Act of 1972, as amended. The project, as proposed in this application, is consistent with the LCRP.

If you have any questions on this matter please contact Jeff Harris of the Consistency Section at (225) 342-7949 or jeff.harris@la.gov.

Sincerely,

/S/ Charles Reulet
Administrator
Interagency Affairs/Field Services Division

CR/MH/jdh

cc: Libby Behrens, Corps of Engineers
Tammy Gilmore, Corps of Engineers
Dave Butler, LDWF
Kyle Balkum, LDWF
Craig LeBlanc, OCM/FI
Sabrina Schenk, St. Tammany Parish
René C. Pastorek, St. John the Baptist Parish

From: Jeff Harris <Jeff.Harris@LA.GOV>
Sent: Friday, February 21, 2020 2:46 PM
To: Behrens, Elizabeth H CIV USARMY CEMVN (USA) <Elizabeth.H.Behrens@usace.army.mil>; Gilmore, Tammy F CIV USARMY CEMVN (USA) <Tammy.F.Gilmore@usace.army.mil>
Cc: Sara Krupa <Sara.Krupa@LA.GOV>; Mark Hogan <Mark.Hogan@LA.GOV>
Subject: [Non-DoD Source] C20190208 BBA 18 WSLP

Tammy, Libby—

Here are Kelley's comments regarding the mitigation sites for the WSLP portion of the BBA 18 project, for your review (note that her statements about OCM being in agreement reflects our Mitigation Section's position, not OCM's concurrence with the consistency determination). It appears to me that the gap between what you need to do and what meets our program requirements isn't insurmountable. I think LDWF's concerns will be the more difficult obstacle to clear; I hope you were able to start the dialog with Kyle earlier today.

Have a good weekend, and I'm sure we'll be talking next week.

--Jeff

1. OCM is in agreement with the proposed mitigation alternatives specified in the Coastal Zone Consistency Determination document EA#576. However, it should be noted that although the Albania North, Albania South, and Cote Blanche projects are located in the Coastal Zone, they are located in the Vermilion/Teche Hydrologic Basin which is four basins over from the hydrologic basin of impact (Pontchartrain) and OCM would not be agreeable to using them as mitigation options. In addition, some of those banks listed that are in the coastal zone have acreage above the 5 foot contour and those acres would not be able to be utilized for mitigation. St. James mitigation site project is listed in the table as Out of the Coastal Zone when in fact, it is located in the Coastal Zone and could be utilized for mitigation.

2. Mitigation banks are listed as an alternative as well which OCM highly supports. Should credits be purchased from a mitigation bank, the bank would have to be located in the Coastal Zone, within the same or an adjacent hydrologic basin where the impacts occurred and must be approved by OCM.

3. If Mitigation bank credits are not available, OCM supports a combination of projects in addition to the purchase of mitigation bank credits as well.

4. Based on the WVAs provided in Appendix A of the West Shore Lake Pontchartrain EIS, the impacts required to be offset by mitigation are:
   Swamp: 1,090 AAHU
   BLH: 99 AAHU

   Information provided in Coastal Zone Consistency Determination document EA#576, it appears under the alternative projects that only Pine Island and Joyce are projects that would meet OCM mitigation requirements for swamp and both project AAHU totals are: 969.8 AAHUs a shortage of 120.2 AAHUs (1,090-969.8= 120.2 AAHUs)

St John and St. James are both in the coastal zone however it appears that most of St. John is > 5 foot contour. Since the St. James BLH project will create 676.2 AAHUs there should be amble BLH to offset 99 AAHUs of impact.

USFWS Coordination

United States Department of the Interior

FISH AND WILDLIFE SERVICE
200 Dulles Drive
Lafayette, Louisiana 70506

July 2, 2020

Colonel Stephen Murphy
District Commander
U.S. Army Corps of Engineers
7400 Leake Avenue
New Orleans, LA 701118-3651

Dear Colonel Murphy:

The Coastal Planning Protection and Restoration Authority (CPRA) has requested that environmental benefits resulting from operation of the Maurepas Freshwater Diversion Project, be used to mitigate environmental impacts associated with the construction of the authorized West Shore Lake Pontchartrain Flood Risk Management Project (WSLP). The Maurepas Freshwater Diversion Project is currently being engineered by CPRA and would be constructed by the CPRA as a State coastal swamp restoration project. The Corps has requested input from the Fish and Wildlife Service (Service) regarding the benefits that might be obtained from this diversion project.

The following comments are provided on a planning-aid basis to address the extent to which the CPRA's request is consistent with the Service's Mitigation Policy and provide a preliminary quantification of Maurepas Diversion benefits available to compensate for WSLP impacts. These comments and recommendations are submitted in accordance with the FWCA (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), and the National Environmental Policy Act of 1969 (as amended). This letter does not constitute the final report of the Secretary of Interior as required by Section 2(b) of the FWCA.

The swamps surrounding Lake Maurepas are dominated by bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatic*). Degradation of those swamps due to salinity encroachment and other causes has been well documented (Shafer et al. 2009, Shafer et al. 2016, and Myers et al. 1995, and others). The Louisiana Coastal Wetlands Master Plan and other restoration plans and studies have proposed the re-introduction of Mississippi River water, nutrient, and sediments into those swamps to conserve and restore those swamps (Coastal Protection and Restoration Authority 2017, Shafer et al. 2016, and others). Because the Maurepas Diversion is recognized for its potential to benefit the degrading Maurepas swamps, it has received Restore Act funding for both engineering, design, and construction.

A substantial amount of engineering and design has been conducted to date. Until final designs and a final operational schedule are completed, uncertainly exists regarding the benefits that might be achieved through operation of this diversion project. Additionally, hydrologic modeling work to date has been limited to basic feasibility level assessments. Additional modeling work is needed to better inform a robust environmental benefits assessment, including modeling under future sea level rise

(SLR) and salinity conditions. Given these unknowns and uncertainties, it is difficult to estimate environmental benefits the diversion may provide.

The Service' Mitigation Policy requires that a mitigation project must provide benefits for the life of the project that is being mitigated. As the WSLP has a 50-year period of analysis, the Maurepas Diversion would have to provide benefits for the same 50-year period of analysis. Given that SLR is expected to reduce future diversion benefits, especially in swamps closest to Lake Maurepas, the Maurepas Diversion benefit area previously determined by the CPRA would have to be reduced to a more strongly influenced area closer to the outfall where future benefits are more certain. This smaller benefit area would be justifiable under the Service's Mitigation Policy.

The Interstate 10 road embankment would likely impede flow of introduced Mississippi River water into and through the swamps south of the interstate despite the proposed installation of culverts beneath the interstate. Consequently, diversion benefits to those swamps are highly uncertain and not included within the reduced benefit areas.

A reduced primary benefit area was drawn north of I-10 to include the zone receiving highest nutrient inputs accordingly to initial hydrologic modeling outputs (Figures 1 and 2). A smaller secondary benefit polygon was drawn around the primary benefit area to capture a lesser degree of nutrient input benefits. These benefits polygons were drawn conservatively to reduce uncertainties especially in the later years of the project life.

Figure 1. Map showing the vicinity of Maurepas Diversion primary and second mitigation benefit areas.

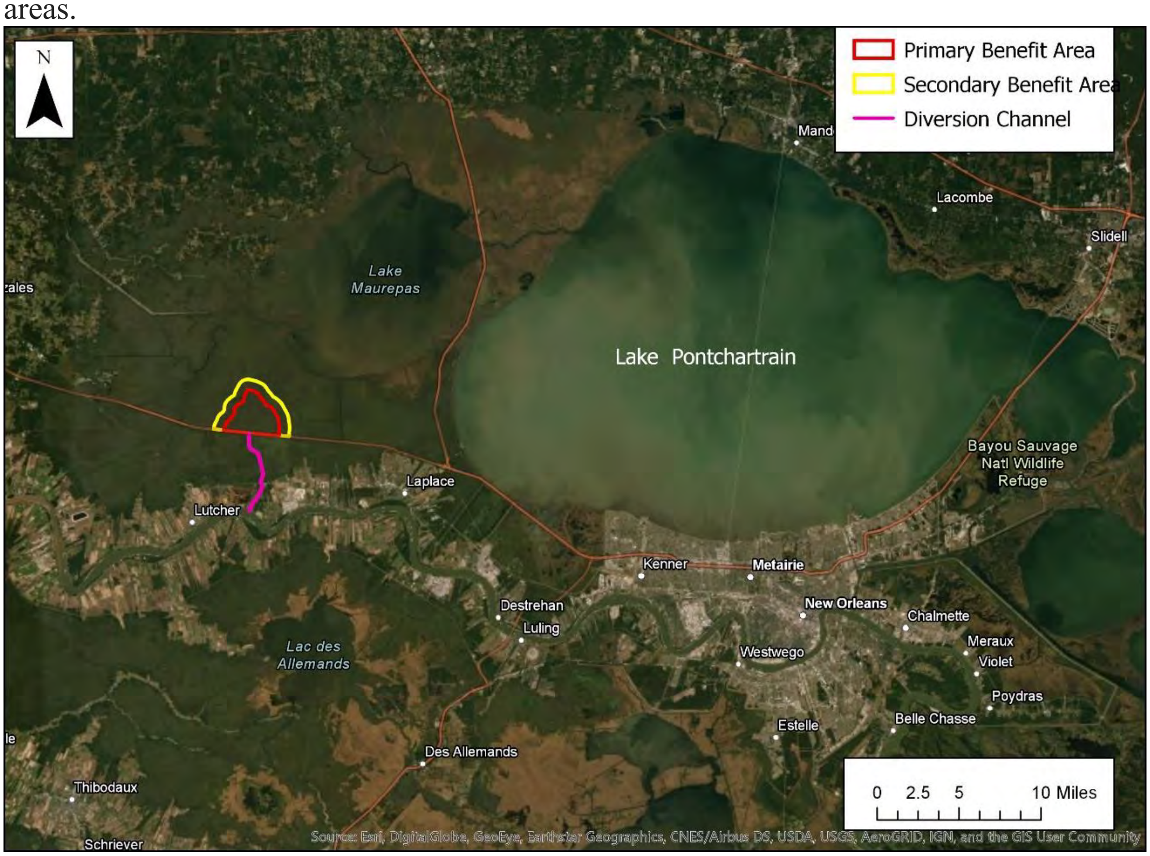
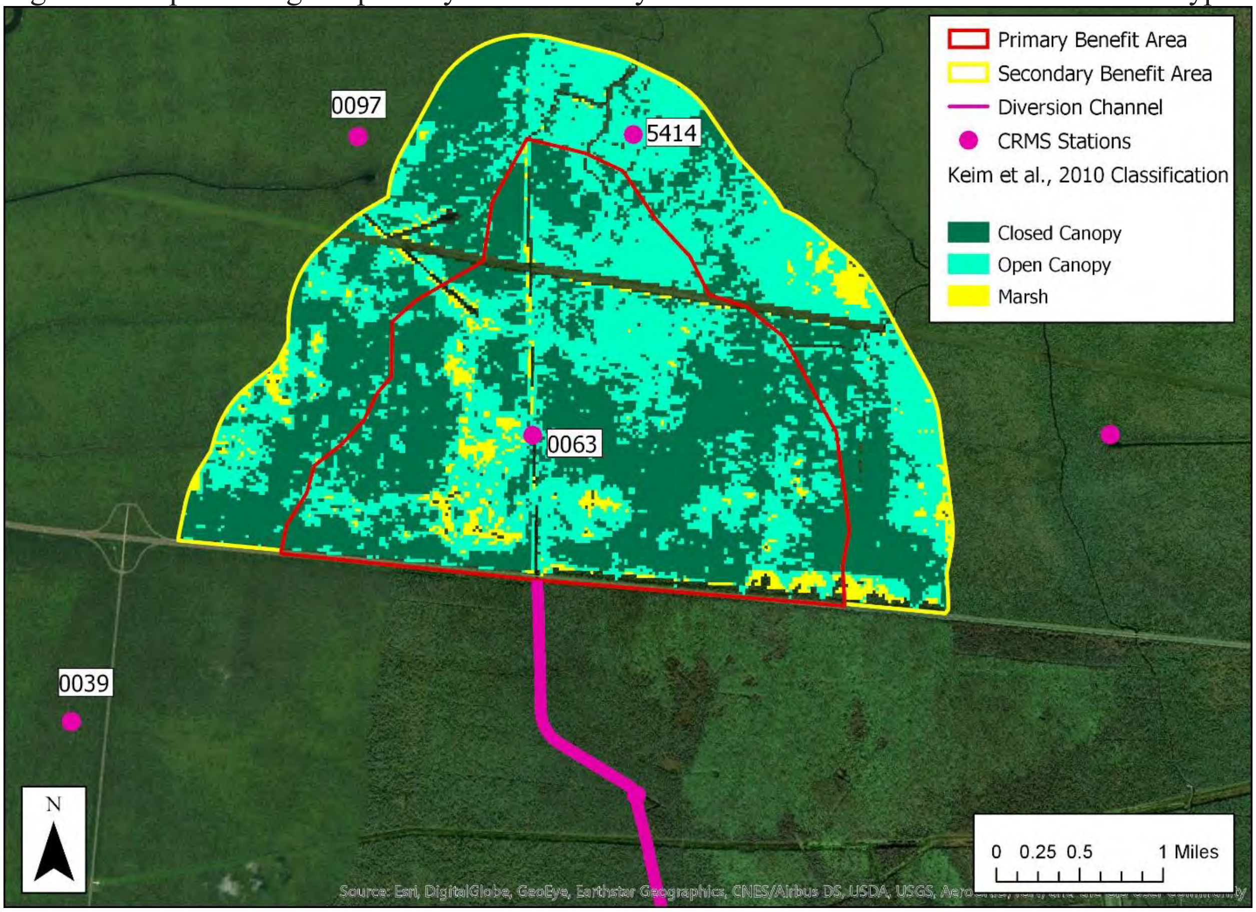


Figure 2. Map showing the primary and secondary area benefit areas and associated habitat types.



Within the primary and secondary benefit areas, a habitat classification (Kiem et al. 2010) was utilized to determine the acreage of closed canopy forest and transitional canopy forest used in the WVA. A separate WVA was run for each of these canopy conditions. Acreage for each of the forest types and benefit areas are presented in Table 1.

Table 1. Project area forest type acreage from Keim et al. 2010.

Benefit Area	Transitional Canopy (acres)	Closed Canopy (acres)	Marsh (acres)
Primary Area	1458.2	1861.4	178.1
Secondary Area	1422.7	1359.9	129.4
Totals	2880.9	3221.3	307.5

According to the draft WVA, the Transitional Canopy area gains 302.94 AAHUs and the Closed Canopy area gains 354.04 AAHUs (Table 2). Secondary Benefit areas were assumed to provide 75% of the benefits (AAHUs) provided by their Primary Benefit Area counterparts. Because the Secondary

Benefit areas are smaller than the Primary areas, the benefits were further reduced in proportion to the acreage decrease (97.57% for the Transitional area, and 73.06% for the Closed Canopy area). When these reductions are applied, the total benefit for both Primary and Secondary areas (for both canopy types) is 1,072.6 AAHUs. When Maurepas Diversion draft construction impacts to swamp are considered, the total net benefit becomes 1,047.4 AAHUs. This data is summarized in the Table 2. The Mitigation Potentials for each evaluated subarea are provided in Table 3.

Table 2. Results of the draft WVA.

Maurepas Diversion Benefits	Net AAHUs	
	Transitional Canopy	Closed Canopy
Primary Benefit Area	299.2	343.6
Secondary Benefit Area	218.9	188.3
Direct Impacts		-25.2
Subtotals	518.1	506.7
TOTAL		**1,024.8**

Figure 3. Mitigation Potentials for evaluated subareas.

Maurepas Diversion Benefits	Mitigation Potentials (AAHUs/ac)	
	Transitional Canopy	Closed Canopy
Primary Benefit Area	0.205	0.185
Secondary Benefit Area	0.154	0.138

Based upon the draft results provided above, the Maurepas Diversion appears to provide sufficient benefits to compensate for WSLP impacts. The Service is therefore not opposed to considering the Maurepas Diversion as one of the mitigation options available. When the diversion operation plan has been developed and additional hydrologic modeling is available, revisions to the Maurepas Diversion benefit area size and location as well as benefits associated with diversion operations can be made. Those results along with a detailed WVA Project Information Sheet will be provided once the final WVA has been completed.

We appreciate the opportunity to provide comments on the proposed mitigation project, as well as the USACE's continued cooperation during the mitigation alternatives review process. If you have any questions or require additional information, please contact Mr. Ronny Paille (337-291-3117) of this office.

Sincerely,

Joseph A. Ranson
Field Supervisor
Louisiana Ecological Services Office

cc: NMFS, Baton Rouge, LA
EPA, Dallas, TX
CPRA, Baton Rouge, LA
DNR, Baton Rouge, LA
LDWF, Baton Rouge, LA

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Coordination Act Report

United States Department of the Interior

FISH AND WILDLIFE SERVICE
200 Dulles Drive
Lafayette, Louisiana 70506

February 3, 2022

Colonel Murphy
District Engineer
U.S. Army Corps of Engineers
Post Office Box 60267
New Orleans, Louisiana 70160-0267

Dear Colonel Murphy:

We are providing the enclosed draft Fish and Wildlife Coordination Act (FWCA) Report on the Maurepas Swamp Project Mitigation Alternative. Our draft FWCA Report was prepared under the authority of the FWCA (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), but does not entirely fulfill the final reporting requirements of Section (2)b of that Act. A copy of this report is being provided to the Louisiana Department of Wildlife and Fisheries and the National Marine Fisheries Service for review. Comments received from those agencies will be included in the final report.

We appreciate the cooperation of your staff on this project and look forward to our continued coordination with you to further protect and enhance fish and wildlife resources. If you need additional assistance or have questions regarding this report, please contact Ronny Paille (337/291-3117) of this office.

Sincerely,

Brigette D Firmin

Brigette D. Firmin
Acting Field Supervisor
Louisiana Ecological Services Office

cc: Environmental Protection Agency, Dallas, TX
National Marine Fisheries Service, Baton Rouge, LA
LA Dept. of Wildlife and Fisheries, Baton Rouge, LA
LA Dept. of Natural Resources (CMD), Baton Rouge, LA
Coastal Protection and Restoration Authority (CPRA), Baton Rouge, La
Natural Resources Conservation Service, Alexandria, LA

MAUREPAS SWAMP PROJECT

DRAFT
FISH AND WILDLIFE COORDINATION ACT REPORT

SUBMITTED TO
NEW ORLEANS DISTRICT
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

PREPARED BY

RONNY PAILLE
FISH AND WILDLIFE FIELD BIOLOGIST

U.S. FISH AND WILDLIFE SERVICE

ECOLOGICAL SERVICES

LAFAYETTE, LOUISIANA

February 2022

Executive Summary

The Maurepas Swamp Project is designed to seasonally introduce Mississippi River water, nutrients, and sediments into the degrading swamps south of Lake Maurepas. The Louisiana Coastal Protection and Restoration Authority (CPRA) has requested that Maurepas Swamp Project induced swamp benefits be used to compensate for impacts to swamp associated with the West Shore Lake Pontchartrain Flood Risk Management Project (WSLP), a project where CPRA is the local sponsor.

The Maurepas Swamp Project would provide benefits to swamps located north of Interstate 10 due to introduction of beneficial freshwater, nutrients, and suspended sediment. Swamps located south of Interstate 10 would experience indirect impacts due to impaired drainage associated with construction of conveyance channel guide levees. Swamps would also be directly impacted by construction of project features. Under the intermediate sea level rise scenario, the Maurepas Swamp Project net effect on public owned swamp and on public plus privately owned swamps is 1,033 and 1,275 Average Annual Habitat Units (AAHUs), respectively. Either of these AAHU values are more than sufficient to compensate for the WSLP swamp impacts of -947.2 AAHUs.

Despite the net swamp benefits, the Maurepas Swamp Project would result in direct construction impacts, and drainage impairment impacts to bottomland hardwood forests (BLH). The total BLH impact under the intermediate sea level rise scenario is -35.83 AAHUs. The Maurepas Swamp Project would also result in net impacts to marshes located south of Interstate 10 due to impaired drainage and loss of fishery access associated with the construction of conveyance channel guide levees. That marsh impact is -19.54 AAHUs.

The Maurepas Swamp Project would correct freshwater, nutrient, and suspended sediment deprivation resulting from construction of flood protection levees along the Mississippi River. The planned re-introduction of those Mississippi River water inputs will also serve to improve the sustainability of the Maurepas swamp ecosystem. Given these anticipated system level benefits, the Fish and Wildlife Service (Service) does not object to the selection of the Maurepas Swamp Project to mitigate WSLP swamp impacts, provided that the following recommendations are enacted to ensure that the envisioned swamp benefits are achieved, unnecessary impacts are avoided and/or minimized, and that unavoidable impacts to fish and wildlife resources are mitigated.

1. The U.S. Army Corps of Engineers (USACE) should coordinate closely with the Service and other fish and wildlife conservation agencies throughout the planning, engineering and design of project features to ensure that those features are located and designed to avoid and minimize wetland impacts and associated fish and wildlife resources.

2. Project impacts to BLH and marsh should be minimized to the greatest degree possible, and unavoidable impacts should be mitigated in a manner approved by the Service and other natural resource agencies.

3. Surplus Maurepas Swamp Project compensation should not be considered available as potential compensation for swamp impacts resulting from projects other than WSLP.

4. The USACE should coordinate with the Louisiana Department of Wildlife and Fisheries (LDWF) regarding work conducted on the Maurepas Swamp WMA and should make monitoring results and operations information available to LDWF Point of Contact Kyle Balkum, Phone # 225-765-2819.

5. Monitoring of the Davis Pond and Caernarvon Diversions indicated that some contaminants were being introduced into the receiving areas from the Mississippi River. To address potential impacts of future contaminants on fish and wildlife resources, the Service recommends that pre- and post-operation sampling of wildlife, fish, and/or shellfish, from the outfall area and the Mississippi River be undertaken. Preferably, sampled species from the outfall area should forage exclusively within the diversion outfall area. The Service recommends that USACE, in coordination with the Service, develop a list of contaminants to be analyzed. The list of contaminants to be analyzed would be taken from the most recent EPA Priority Pollutants and Contaminants of Concern (COC) list. Periodic post-operational sampling should start after sufficient time for potential contaminants to accumulate (i.e., 3 to 5 years) and the frequency of subsequent periodic sampling (e.g., 3 to 5 years) would be predicated upon levels of contaminants detected. Expansion of sampling to local nesting bald eagles, (e.g., fecal and blood samples analyzed for the same contaminants) would also be predicated upon the type and level of contaminants detected. If high levels of contaminants are found, the Service and other resource agencies should be consulted. This adaptive sampling plan should be developed in cooperation with the Service and other natural resource agencies and implemented prior to operation.

6. The Service recommends that consideration be given to operating the diversion in a manner that would prevent or minimize adverse impacts to wetlands due to prolonged inundation and focus on the overall enhancement of the entire project area to the greatest extent possible.

7. The Service recommends development of a detailed Monitoring and Adaptive Management (MAM) Plan to inform operational decisions in order to minimize adverse impacts where possible. The MAM plan should be developed through coordination with the Service, the National Marine Fisheries Service (NMFS), and other resource agencies. At a minimum, the MAM Plan should conduct the monitoring described in the U.S. Army Engineering and Research Development Center's (ERDC) "Success Criteria for Mississippi River Reintroduction into Maurepas Swamp: Ten Year Targets."

8. A report documenting the status of implementation, operation, maintenance and adaptive management measures should be prepared every three years by the managing agency and provided to the USACE, the Service, NMFS, U.S. Environmental Protection Agency, Louisiana Department of Natural Resources, Louisiana Coastal Protection and Restoration Authority, and the LDWF. That report should also describe future management activities, and identify any proposed changes to the existing management plan.

9. Further detailed planning of project features and any adaptive management and monitoring plans should be developed in coordination with the Service and other State and Federal natural resource agencies so that those agencies have an opportunity to review and submit recommendations on work addressed in those reports and plans.

10. Avoid adverse impacts to bald eagle nesting locations and wading bird colonies through careful design of project features and timing of construction. During project construction a qualified biologist should inspect the proposed construction site for the presence of documented and undocumented wading bird nesting colonies and bald eagles.

    a. All construction activity during the wading bird nesting season (February through October 31 for wading bird nesting colonies, exact dates may vary) should be restricted within 1,000 feet of a wading bird colony. If restricting construction activity within 1,000 feet of a wading bird colony is not feasible, the USACE should coordinate with FWS to identify and implement alternative best management practices to protect wading bird nesting colonies.
    b. During construction activities, if a bald eagle nest is within or adjacent to the proposed project area, then an evaluation must be performed to determine whether the project is likely to disturb nesting bald eagles. That evaluation may be conducted on-line at: http://www.fws.gov/southeast/es/baldeagle. Following completion of the evaluation, that website will provide a determination of whether additional consultation is necessary and those results should be forwarded to this office.

11. The Service recommends that the USACE contact the Service and LDWF for additional consultation if: 1) the scope or location of the proposed project is changed significantly, 2) new information reveals that the action may affect listed species or designated critical habitat, 3) the action is modified in a manner that causes effects to listed species or designated critical habitat, or 4) a new species is listed or critical habitat designated. Additional consultation as a result of any of the above conditions or for changes not covered in this consultation should occur before changes are made or finalized.

12. The Service recommends that to the extent feasible, all dredged material removed from the settling basin should be used beneficially to enhance nearby coastal habitats that are in decline or to augment coastal restoration projects/features.

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INTRODUCTION

The Maurepas Swamp Project, is a coastal wetland restoration project designed by the Louisiana Coastal Protection and Restoration Authority (CPRA). Recently, the CPRA has sought to use the Maurepas project as mitigation for construction impacts of the U.S. Army Corps of Engineers' (USACE) West Shore Lake Pontchartrain Flood Risk Management Project (WSLP), a project where CPRA is the local sponsor. If the Maurepas Swamp Project is selected to mitigate WLSP impacts to swamp, the Maurepas Swamp Project will become a USACE mitigation project.

The Maurepas Swamp Project (MSP) would seasonally discharge up to 2,000 cubic feet per second (cfs) of Mississippi River water into the degraded Maurepas swamps located in St. James and St. John the Baptist Parishes. A conveyance channel would be constructed to carry river water to the Hope Canal, and Hope Canal would be enlarged to a point just north of Interstate 10, at which point diverted river water would spread out into the receiving area swamps and marshes north of Interstate 10.

This draft Fish and Wildlife Coordination Act (FWCA) Report provides an analysis of fish and wildlife resource impacts associated with construction and operation of the Maurepas Swamp Project. This draft FWCA Report does not fulfill the requirements of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) but when finalized would constitute the final report of the Secretary of the Interior as required by Section 2(b) of that Act. This draft report has been provided to the Louisiana Department of Wildlife and Fisheries (LDWF) and the National Marine Fisheries Service (NMFS) for their review and comment. Their comments will be incorporated into our final report.

DESCRIPTION OF STUDY AREA

The Maurepas swamps are located west and south of Lake Maurepas. Historically, these swamps received floodwaters from the Mississippi River through crevasses and overbank flows. Construction of flood control levees along the Mississippi River in the 1920s eliminated those water, nutrient, and suspended sediment inputs. Loss of those inputs together with sea level rise (SLR) and subsidence, has resulted in the gradual sinking of the swamp surface and increased inundation. Saltwater intrusion via the Mississippi River Gulf Outlet (MRGO), a deep-draft navigation channel, increased the frequency and magnitude of salinity spikes. However, closure of the MRGO in 2009 has since reduced and stabilized salinities, but submergence and stagnation remain problematic and the swamp ecosystem is continuing to degrade. Although the project area is dominated by cypress-tupelo swamp, there are locations where marshes exist interspersed amidst the swamp, especially in areas closer to Lake Maurepas where the forest has suffered die-back due to saltwater events.

EXISTING FISH AND WILDLIFE RESOURCES

Swamps

The Maurepas swamps consist primarily of bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*). Other water tolerant tree species such as red maple (*Acer rubrum*), Carolina ash (*Fraxinus caroliniana*) and swamp tupelo (*Nyssa biflora*) occur in lesser numbers.

Herbaceous vegetation includes green arrow arum (*Peltandra virginica*), alligatorweed (*Alternanthera philoxeroides*), smartweeds (*Polygonum* sp.), spikerushes (*Eleocharis* sp.), giant cutgrass (*Zizaniopsis miliacea*), American cupscale (*Sacciolepis striata*), smooth beggartick (*Bidens laevis*), and others. In bayous and ponds, submerged and floating-leaved aquatic vegetation such as duckweed (*Lemna* sp.), common Salvinia (*Salvinia minima*), water hyacinth (*Eichhornia crassipes)*, parrots feather (*Myriophyllum aquaticum*), and other species may occur.

Fresh Marsh

Some areas in the swamp and especially areas closer to Lake Maurepas have experienced tree mortality and have converted to fresh marsh. In places marsh vegetation is rooted in the substrate, but in other areas, the marshes may be characterized by floating or semi-floating vegetated mats. Vegetation may include bulltongue (*Sagittaria lancifolia*), cattail (*Phyla* sp.), American cupscale (*Sacciolepis striata)*, pennywort (*Hydrocotyle* sp.), giant cutgrass (*Zizaniopsis miliacea),* smooth beggartick (*Bidens laevis)*, spikerushes (*Eleocharis* sp.*)*, alligatorweed (*Alternanthera philoxeroides),* and others. Along the edges of bayous and canals one may find submerged aquatic vegetation and floating-leaved vegetation as listed above for swamps.

Wildlife Resources

Wildlife such as white-tailed deer, raccoon, mink, river otter, nutria, and others occur in the Maurepas swamps and marshes. These areas are also used by a variety of wintering migratory waterfowl such as mallards, blue-winged teal, gray duck, and by summer migrants such as the black-bellied whistling duck, and by non-migratory wood ducks. Wading birds such as great blue heron, common egret, snowy egret, white ibis, and yellow crowned night herons forage and nest in these swamps and marshes. Waterbirds include king rail, sora, purple moorhen, and common moorhen. Other nongame birds such as boat-tailed grackle, red-winged blackbird, northern harrier, bald eagle, belted kingfisher, and sedge wren also utilize project area swamps and marshes.

Forested wetlands and scrub-shrub areas provide habitats for songbirds such as the northern parula, yellow-rumped warbler, prothonotary warbler, white-eyed vireo, Carolina chickadee, and tufted titmouse. Additionally, these areas also provide important resting and feeding areas for songbirds migrating across the Gulf of Mexico. Other avian species found in forested wetlands include the common flicker, white-eyed vireo, belted kingfisher, pileated woodpecker, downy woodpecker, common grackle, and common crow. Forested habitats and associated waterbodies also support raptors such as the red-tailed hawk, red-shouldered hawk, Mississippi kite, northern harrier, screech owl, great horned owl, and barred owl. Numerous other bird species use forested wetlands throughout the study area.

Project area swamps and marshes provide habitat for American alligator, alligator snapping turtle, softshell turtles, and various snake species such as water snakes, water moccasin, ribbon snakes, and speckled king snakes. Area wetlands support numerous amphibians such as tree frogs, bullfrogs, leopard frogs, cricket frogs, and others.

Bayous and Canals

Mississippi Bayou is a natural waterway with tributaries which drains interior swamps and marshes. Given its sluggish flow and the biological oxygen demand from highly organic adjoining wetlands, dissolved oxygen levels may occasionally become low during warm months. Hope Canal has a larger drainage area and perhaps more water exchange, but it too can occasionally develop low dissolved oxygen concentrations. Dead-end oil and gas exploration canals may experience reduced water exchange causing them to be stagnant and increase the likelihood of having low dissolved oxygen content. Blind River, located west of the project area, may receive input of introduced river water via sheet-flow and carry that introduced river water to Lake Maurepas.

Fishery Resources

Bayous and canals also provide habitat for fishes such as largemouth bass, bluegill, red-ear sunfish, crappie, blue catfish, buffalo, bowfin, gar, and others. Freshwater tolerant estuarine-dependent species such as blue crab, striped mullet, Gulf menhaden, and Atlantic croaker may occur seasonally with project area bayous and canals. Given the lack of channels within the interior swamps, water exchange is poor, and low dissolved oxygen conditions common. Therefore, it is unlikely that any fishes other than a few small hardy resident fishes such as mosquitofish, least killifish, and sailfin mollies occur within the deep swamp.

Essential Fish Habitat

The project area swamps and marshes are located in an area that has been identified as essential fish habitat (EFH) for various life stages of federally managed species, including juvenile life stages of white shrimp and red drum. Categories of EFH in the project area include mud and shell substrates, submerged aquatic vegetation, estuarine water column, and estuarine emergent wetlands. Detailed information on federally managed fisheries and their EFH is provided in the 2005 generic amendment of the Fishery Management Plans for the Gulf of Mexico prepared by the Gulf of Mexico Fishery Management Council. The generic amendment was prepared as required by the Magnuson-Stevens Fishery Conservation and Management Act (P.L. 104-297).

In addition to being designated as EFH for white shrimp, and red drum, wetlands in the project area provide nursery and foraging habitats supportive of a variety of economically important marine fishery species, including striped mullet, Gulf menhaden, and blue crab. Some of these species serve as prey for other species managed under the Magnuson-Stevens Act by the Gulf of Mexico Fishery Management Council (e.g. mackerels, snappers, and groupers) and highly migratory species managed by NMFS (e.g. billfishes and sharks). These wetlands also produce nutrients and detritus, important components of the aquatic food web, which contribute to the overall productivity of Louisiana estuaries.

Threatened and Endangered Species

Current Federally listed threatened and endangered species and their critical habitat that may be found in or near the study area include the Eastern Black Rail (*Laterallus jamaicensis ssp*), the West Indian manatee (*Trichechus manatus*), and the pallid sturgeon (*Scaphirhynchus albus*).

The eastern black rail is a wetland-dependent bird requiring dense emergent cover and extremely shallow water depths (< 6 cm) over a portion of the wetland-upland interface to support its resource needs. Birds are found in a variety of salt, brackish, and freshwater marsh habitats that can be tidally or non-tidally influenced. Plant structure is considered more important than plant species composition in predicting habitat suitability (Flores and Eddleman 1995). In Louisiana, occurrences have been documented in high brackish marsh vegetated with Gulf cordgrass (*Spartina spartinae*), saltgrass (*Distichlis spicata),* sea oxeye *(Borrichia frutescens)*, and saltmeadow cordgrass (*Spartina patens)* and often interspersed with shrubs such as marsh elder (*Iva frutescens*) or saltbush (*Baccharis hamilifolia*). The high marsh is only inundated during extreme high tide events. In general, the character of the high marsh is a short grassy savannah. It may also occur in working wetland habitats such as rice fields. Recent surveys conducted within southwestern Louisiana have revealed that the eastern black rail occurs along the Cameron and Vermilion Parish coastlines in both the breeding and non-breeding season.

West Indian manatees occasionally enter Louisiana coastal waters and streams during the warmer months (i.e., June through September). During in-water work in areas that potentially support manatees all personnel associated with the project should be instructed about the potential presence of manatees, manatee speed zones, and the need to avoid collisions with and injury to manatees. All personnel should be advised that there are civil and criminal penalties for harming, harassing, or killing manatees which are protected under the Marine Mammal Protection Act of 1972, the Endangered Species Act of 1973, and state law. Additionally, personnel should be instructed not to attempt to feed or otherwise interact with manatees, although passively taking pictures or video would be acceptable. For more detail on avoiding contact with manatees refer to the enclosed conservation measures (Appendix B) and contact this office. Should a proposed action directly or indirectly affect the West Indian manatee, further consultation with this office will be necessary.

The pallid sturgeon is found in the Mississippi River and is adapted to large, free-flowing, turbid rivers with a diverse assemblage of physical characteristics that are in a constant state of change. Entrainment associated with the diversion of river water to coastal wetlands is a potential effect that should be addressed in coordination with the Service.

In accordance with Section 7(c) of the Endangered Species Act, the USACE submitted a Biological Assessment (BA) dated December 22, 2021, providing anticipated project effects on the above-mentioned species. Via that BA, the USACE also initiated formal consultation on the pallid sturgeon. In keeping with the consultation requirements of the Endangered Species Act (ESA), informal and formal consultation must be completed before the Record of Decision for the project can be signed.

At-Risk species

For the purposes of a conservation strategy, the Service's Southeast Region has defined "at-risk species" as those that are proposed for listing as threatened or endangered under the Endangered Species Act, a candidate for listing, or it has been petitioned by a third party for listing. The Service's goal is to work with private and public entities on proactive conservation to conserve these species, thereby precluding the need to federally list as many at-risk species as possible.

Alligator Snapping Turtle

The alligator snapping turtle (*Macrochelys temminckii*) was proposed for listing as threatened on November 9, 2021. The alligator snapping turtle occurs in waterways that drain into the Gulf of Mexico. Although the species range is large, population densities are likely low throughout the range. They occur in various habitats including rivers, oxbows, lakes, and backwater swamps adjacent to large rivers. It is most common in freshwater lakes and bayous, but also found in coastal marshes and sometimes in brackish waters near river mouths. Typical habitat is mud-bottomed waterbodies having some aquatic vegetation. The alligator snapping turtle is slow growing and long lived. Sexual maturity is reached at 11 to 13 year of age. Because of this and its low fecundity, loss of breeding females is thought to be the primary threat to the species. Extensive commercial and recreational harvesting in the last century resulted in significant declines to many alligator snapping turtle populations. Commercial harvesting is now prohibited in all states within its range and recreational harvest is prohibited in every state except for Mississippi and Louisiana. Currently, the primary threats to the species are legal and illegal intentional harvest, bycatch associated with commercial fishing of catfish and buffalo, nest predation and habitat alteration.

Golden-Winged Warbler

The golden-winged warbler (*Vermivora chrysoptera*) breeds in higher elevations of the Appalachian Mountains and northeastern and north-central U.S. with a disjunct population occurring from southeastern Ontario and adjacent Quebec northwest to Minnesota and Manitoba. Wintering populations occur in Central and South America. The loss of wintering habitat in Central and South America and migratory habitat may also contribute to its decline. The golden-winged warbler is also known to hybridize with the blue-winged warbler (*Vermivora cyanoptera*).

This species may be found in forested habitats throughout Louisiana during spring and fall migrations. This imperiled songbird is dependent on forested habitats along the Gulf, including coastal Louisiana, to provide food and water resources before and after trans-Gulf and circum-Gulf migration. Population declines correlate with both loss of habitat owing to succession and reforestation and with expansion of the blue-winged warbler into the breeding range of the golden-winged warbler.

Monarch Butterfly

Recent research has shown dramatic declines of the monarch butterfly (*Danaus plexippus plexippus*) and their habitats leading conservation groups to petition the Service to list the species under Endangered Species Act (ESA). Ensuring adequate and sustainable habitats, meeting all the life history needs of these species is of paramount importance. The Service and its partners are taking immediate actions to replace and restore monarch and pollinator habitat on both public and private lands through revegetation of disturbed areas with native plant species, including species of nectar-producing plants and milkweed endemic to the area.

Migratory Birds and Other Trust Resources

Bald Eagle

The proposed project area may provide nesting habitat for the bald eagle (*Haliaeetus leucocephalus*), which was officially removed from the List of Endangered and Threatened Species as of August 8, 2007. However, the bald eagle remains protected under the Migratory Bird Treaty Act of 1918 (as amended) (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA). Comprehensive bald eagle survey data have not been collected by the LDWF since

2008, and new active, inactive, or alternate nests may have been constructed within the proposed project area since that time.

Bald eagles typically nest in large trees located near coastlines, rivers, or lakes that support adequate foraging from October through mid-May. In southeastern Louisiana parishes, eagles typically nest in mature trees (e.g., bald cypress, sycamore, willow, etc.) near fresh to intermediate marshes or open water. Major threats to this species include habitat alteration, human disturbance, and environmental contaminants. Furthermore, bald eagles are vulnerable to disturbance during courtship, nest building, egg laying, incubation, and brooding. Disturbance during these periods may lead to nest abandonment, cracked and chilled eggs, and exposure of small young to the elements. Human activity near a nest late in the nesting cycle may also cause flightless birds to jump from the nest tree, thus reducing their chance of survival.

The Service developed the National Bald Eagle Management (NBEM) Guidelines to provide landowners, land managers, and others with information and recommendations to minimize potential project impacts to bald eagles, particularly where such impacts may constitute "disturbance," which is prohibited by the BGEPA. A copy of the NBEM Guidelines is available at:https://www.fws.gov/migratorybirds/pdf/management/nationalbaldeaglenanagementguidelines.pdf. Those Guidelines recommend: (1) maintaining a specified distance between the activity and the nest (buffer area); (2) maintaining natural areas (preferably forested) between the activity and nest trees (landscape buffers); and (3) avoiding certain activities during the breeding season. During any project construction, on-site personnel should be informed of the possible presence of nesting bald eagles in the vicinity of the project boundary, and should identify, avoid, and immediately report any such nests to this office. If a bald eagle nest occurs or is discovered within 660 feet of the proposed project area, then an evaluation must be performed to determine whether the project is likely to disturb nesting bald eagles. That evaluation may be conducted on-line at: http://www.fws.gov/southeast/es/baldeagle. Following completion of the evaluation, that website will provide a determination of whether additional consultation is necessary.

On September 11, 2009, the Service published two federal regulations establishing the authority to issue permits for non-purposeful bald eagle take (typically disturbance) and eagle nest take when recommendations of the NBEM Guidelines cannot be achieved. Permits may be issued for nest take only under the following circumstances where: 1) necessary to alleviate a safety emergency to people or eagles, 2) necessary to ensure public health and safety, 3) the nest prevents the use of a human-engineered structure, or 4) the activity or mitigation for the activity will provide a net benefit to eagles. Except in emergencies, only inactive nests may be permitted to be taken. The Division of Migratory Birds for the Southeast Region of the Service (phone: 404/679-7051, e-mail: SEmigratorybirds@fws.gov) has the lead role in conducting consultations and issuance of permits. Should you need further assistance interpreting the guidelines, avoidance measures, or performing an on-line project evaluation, please contact Ulgonda Kirkpatrick (phone: 321/972-9089, e-mail: ulgonda_kirkpatrick@fws.gov).

Coastal forest & neotropical migrating songbirds
Project area swamps provide stopover habitat needed by trans-Gulf migrating songbirds. The construction of project features may result in temporary and/or permanent impacts to migratory birds and the habitats upon which they depend for various life requisites. Project impacts, in

combination with regional and unrelated forest clearing, are a Service concern relative to breeding migratory birds of conservation concern within the Mississippi Alluvial Valley Bird Conservation Region (https://www.fws.gov/migratorybirds/pdf/management/birds-of-conservation-concern-2021.pdf). Many migratory birds of conservation concern require large blocks of contiguous habitat to successfully reproduce and survive.

In Louisiana, the primary nesting period for forest-breeding migratory birds occurs between April 15 and August 1. Some species or individuals may begin nesting prior to April 15 or complete their nesting cycle after August 1, but the vast majority nest during this period. Construction of the proposed project may directly impact migratory birds of conservation concern because habitat clearing that occurs during the aforementioned primary nesting period may result in unintentional take of active nests (i.e., eggs and young) in spite of all reasonable efforts to avoid such take. The MBTA prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. While the MBTA has no provision for allowing incidental take, the Service recognizes that some birds may be taken during project construction/operation even if all reasonable measures to avoid take are implemented.

In addition to the direct loss of forested habitat, the proposed project may indirectly impact migratory birds of conservation concern because project construction may result in habitat fragmentation. Forest fragmentation may contribute to population declines in some avian species because fragmentation reduces avian reproductive success (Robinson et al. 1995). Fragmentation can alter the species composition in a given community because biophysical conditions near the forest edge can significantly differ from those found in the center or core of the forest. As a result, edge species could recruit to the fragmented area and species that occupy interior habitats could be displaced.

Given that the Maurepas Swamp Project provides substantial net benefits to area swamps and slows the degradation/fragmentation of those swamps, the Maurepas Swamp Project should provide net benefits to migratory birds which use those swamps and to resident bird species.

Colonial Nesting Birds

In accordance with the MBTA and the FWCA, please be advised that the project area include habitats which are commonly inhabited by colonial nesting waterbirds and/or seabirds.

Colonies may be present that are not currently listed in the database maintained by the LDWF. That database is updated primarily by (1) monitoring previously known colony sites and (2) augmenting point-to-point surveys with flyovers of adjacent suitable habitat. Although several comprehensive coast-wide surveys have been recently conducted to determine the location of newly-established nesting colonies, we recommend that a qualified biologist inspect the proposed work site for the presence of undocumented nesting colonies during the nesting season because some waterbird colonies may change locations year-to-year. To minimize disturbance to colonial nesting birds, the following restriction on activity should be observed:

> For colonies containing nesting wading birds (i.e., herons, egrets, night-herons, ibis, and roseate spoonbills), anhingas, and/or cormorants, all activity occurring within 1,000 feet

of a rookery should be restricted to the non-nesting period (i.e., September 1 through February 15, exact dates may vary within this window depending on species present).

In addition, we recommend that on-site contract personnel be informed of the need to identify colonial nesting birds and their nests, and should avoid affecting them during the breeding season. Should on-site contractors and inspectors observe potential nesting activity, coordination with the LDWF and the Service should occur.

Refuges and Wildlife Management Areas

The Maurepas Swamp Wildlife Management Area occupies a large portion of the project area and is operated by the LDWF.

FISH AND WILDLIFE CONCERNS IN THE STUDY AREA

Following construction of flood control levees along the Mississippi River, and the associated loss of external suspended sediment inputs, the Maurepas swamps are no longer considered to be sustainable and are in the process of gradually transitioning to floating and rooted emergent marsh (Glick et al. 2013, Shaffer et al. 2009). The degradation of these swamps due to loss of riverine freshwater and sediment inputs have been well documented by academia as has the restoration solution of re-introduction of riverine freshwater and sediment (Shaffer et al. 2016, Keddy et al. 2007, Hoeppner et al. 2008).

The Coastal Wetlands Planning Protection and Restoration Act's (CWPPRA) 1993 Plan for the Pontchartrain Basin identified the Blind River Diversion as a long-term restoration project (Louisiana Coastal Wetlands Conservation and Restoration Task Force 1993).

The 2004 Louisiana Coastal Area Ecosystem Restoration Study (LCA) study identified the Maurepas Diversion (Small Diversion at Hope Canal) as a critical near-term restoration project that would address "the most critical ecological needs of the Louisiana coastal area" (USACE 2004). In 2010, the Final Environmental Impact Statement was released for the Hope Canal Project. That study also identified another diversion into the Maurepas swamps, the Small Diversion at Convent Blind River, as one of 10 additional near-term critical restoration features to be studied and subject to Congressional approval.

The 2017 Louisiana Comprehensive Master Plan for a Sustainable Coast includes measure 001.DI.21, which is a 2,000 cfs maximum discharge diversion into the eastern Maurepas swamp, at a location that appears to be the same as the subject Maurepas Swamp Project (Louisiana Coastal Protection and Restoration Authority 2017). The 2012 Master Plan also included a small diversion into the western Maurepas swamps (at Blind River). The inclusion of these diversions in the above mentioned wetland restoration plans illustrates the federal and state consensus on the need and value of such diversions to restore and sustain the degrading Maurepas swamps.

The Maurepas Swamp Project as Mitigation

Although conceived and promoted as a swamp restoration measure, the Maurepas Swamp Project is herein being evaluated as a mitigation project to compensate for construction impacts to swamp associated with the West Shore Lake Pontchartrain (WSLP) Hurricane and Storm

Damage Risk Reduction Project. Because engineering and design of the WSLP has been completed, the construction impacts are highly certain. Compensatory benefits of alternative mitigation projects should likewise be highly certain in order to fully compensate for WSLP impacts. Unlike typical tree planting mitigation projects, benefits obtained via river diversions are less certain. Hence, this assessment of benefits was conducted using a small project area where diversion influences would be more certain, would persist throughout the 50-year project life, and did not include far-field areas receiving lesser amounts of river water and having less certain benefits. Diversion benefits were assumed to decrease with distance from the primary discharge point (Hope Canal north of Interstate 10). Those benefits were estimated for Primary, Secondary, and Tertiary Benefit Areas. Construction impacts plus negative impacts in swamp habitat south of I-10 were also assessed. To fully compensate for WSLP swamp impacts, the total net benefits of the Maurepas Swamp Project must equal or exceed the WSLP impact measured in swamp habitat Average Annual Habitat Units (AAHUs).

FUTURE WITHOUT-PROJECT FISH AND WILDLIFE RESOURCES

Because the Maurepas swamps have been disconnected from Mississippi River freshwater, nutrient, and sediment inputs, those swamps are no longer sustainable and are suffering from gradual degradation and submergence. Although the degradation has slowed since the closure of the MRGO in 2009, the trend is still that of continual decline. The rate of degradation will depend upon the frequency of major droughts and hurricanes, all of which can introduce damaging levels of salinity to this salt-sensitive ecosystem. Wildlife species dependent upon those forested wetlands may be displaced as the forest converts to emergent marsh and open water.

EVALUATION METHODOLOGY

The Wetland Value Assessment (WVA) methodology measures baseline habitat quality and quantity and then projects habitat quality and quantity forward under future without project (FWOP) and future with project (FWP) conditions. The WVA methodology is a community model that uses an assemblage of variables considered important to the suitability of a given habitat type for supporting a diversity of fish and wildlife species. The WVA allows a numeric comparison of each future condition and provides a combined quantitative and qualitative estimate of project-related impacts to fish and wildlife resources.

WVA models operate under the assumption that optimal conditions for fish and wildlife habitat within a given coastal wetland type can be characterized, and that existing or predicted conditions can be compared to that optimum to provide an index of habitat quality. Habitat quality is estimated and expressed through the use of a mathematical model developed specifically for each habitat type. Each model consists of ecological variables that characterize fish and wildlife habitat quality, a Suitability Index graph for each variable to score the quality of each variable, and a mathematical formula to combine the Suitability Indices for each variable into a single value for wetland habitat quality, termed the Habitat Suitability Index (HSI).

The product of an HSI and the acreage of available habitat for a given target year is known as the Habitat Unit (HU). The HU is the basic unit for measuring project effects on fish and wildlife habitat. Future HUs change according to changes in habitat quality and/or quantity. Results are annualized over the period of analysis (i.e., 50 years) to determine the Average Annual Habitat Units (AAHUs) available for each habitat type.

The change in AAHUs for each FWP scenario, compared to FWOP project conditions, provides a measure of anticipated impacts. A net gain in AAHUs indicates that the project is beneficial to the habitat being evaluated; a net loss of AAHUs indicates that the project is damaging to that habitat type. Information on the WVA models, WVA variables, supporting information/spreadsheets are too voluminous to include in this report, but may be obtained upon request to the Service's Lafayette Ecological Services Field Office.

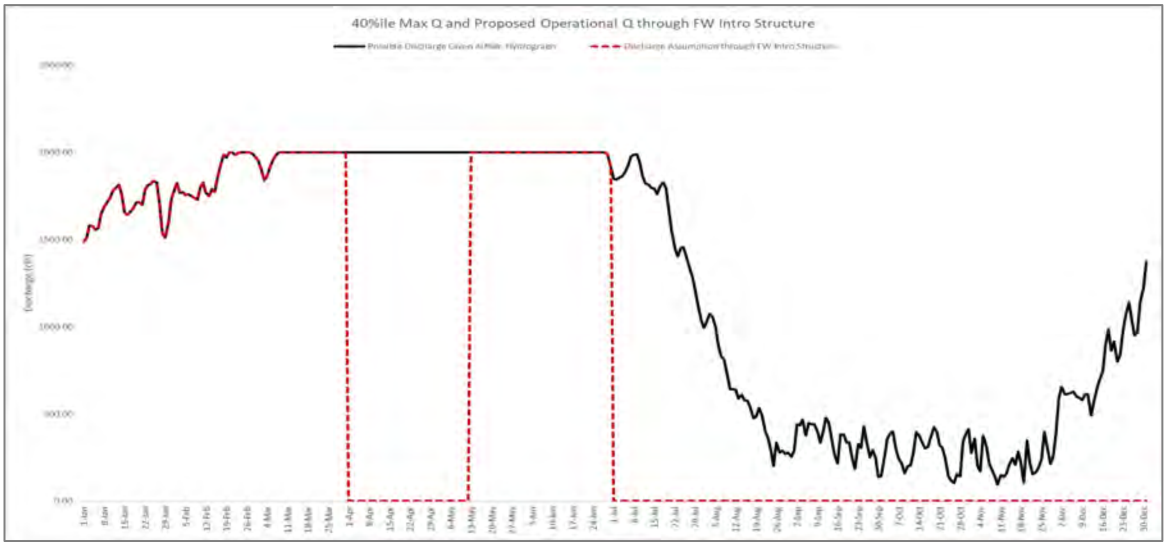
Target years are established when significant changes in habitat quality or quantity are expected during the project life, under FWP and FWOP conditions. Construction of the project would begin in 2026. It is assumed that all construction impacts would occur at the beginning of that year. WVA values quantify conditions at the end of the specified target year. Target years (TYs) used in WVAs for this study are identified in Appendix A. Methods and assumptions used to determine the project benefits and impacts are summarized in the WVA Project Information Sheets (PIS) which are available online at:
https://ecos.fws.gov/ServCat/Reference/Profile/142716.

DESCRIPTION OF ALTERNATIVE PLANS

Although there are no specific Maurepas Swamp Project alternatives, adaptive management of the Mississippi River water introduction may result in different outcomes. Based on information supplied by the CPRA who has designed the project, the project evaluated in this report is the most likely operational plan. This plan includes a three-year initial operation period during which the magnitude and duration of discharge will be incrementally increased. The anticipated typical operation hydrograph is illustrated in Figure 1 (see the red dashed line). The solid black line represents the possible diversion discharge as provided by slightly less than average Mississippi River stages.

The Maurepas Swamp Project is comprised of the following elements: an intake channel from the Mississippi River to the control structure, an automated gate structure in the river levee; a sedimentation basin located immediately downstream of the control structure; a 28,000±-foot-long conveyance channel; submerged weirs in Bayou Secret and Bourgeois Canal; box culverts under River Road, CN Railroad, and Airline Highway; a bridge over the channel at the KCS Railroad; cuts through the abandoned railroad embankment in the receiving area swamp; and reshaping the geometry of the existing Hope Canal channel under I-10.

Figure 1. Proposed diversion discharge and possible diversion discharge.



EVALUATION OF THE MAUREPAS SWAMP PROJECT

Natural Analogs and Ecosystem Response

Given the uncertainties regarding effects of Mississippi River water re-introduction into marshes and swamps, a review of natural or man-made analogs is useful to confirm how the Maurepas swamps may respond. The nearest example is that of the Bonnet Carre Spillway swamps located just downriver of the proposed Maurepas Swamp Project. That Spillway operates approximately once every 8 years at discharges much greater than the proposed diversion. But during high river stages, the Spillway may leak up to 10,000 cfs for several weeks each year depending on river stage (https://www.mvn.usace.army.mil/Missions/Mississippi-River-Flood-Control/Bonnet-Carre-Spillway-Overview/Spillway-Operation-Information/). A study comparing swamps in the Spillway versus those of the adjoining Labranche Wetlands revealed that Spillway substrates are of higher elevation than adjoining Labranche swamps, Spillway sediment accretion rates were greater, and the Spillway bald cypress trees exhibit more rapid growth rates (Day et al. 2012).

In 1993, the Naomi Siphon project began discharging up to 2,000 cfs of Mississippi River water into Barataria Basin fresh/intermediate marshes. A small amount of bald cypress swamp was also located behind the back levee immediately north of the discharge point. Operation of the siphon has been limited in the last several decades. However, prior to that, it was operated more frequently. Despite the minimal operations, an analysis of imagery reveals that forest/woody vegetation has expanded outward into the marsh. Although, the colonizing species are not likely bald cypress, the trend here is opposite that of most coastal swamp forests which are deteriorating and converting to marshes. Similar forest and/or tree appearance is occurring within the immediate outfall areas of the Davis Pond Freshwater Diversion and the Caernarvon Freshwater Diversion.

Observations also show that storm water discharge from the E.J. Gore and Meraux Pumping Stations (located in St. Bernard Parish) have preserved cypress swamp in the immediate vicinity of the outfall whereas more distant swamps died due to MRGO saltwater intrusion. These storm water discharges are fresh and likely nutrient rich, but not rich in suspended sediments.

Coastal Reference and Monitoring System (CRMS) data from the southern Atchafalaya River Basin show both high magnitude and long duration annual flooding occur. However, those sites also exhibit the highest tree growth rates across all of the coastal Louisiana CRMS sites. It is assumed that these CRMS stations may reflect trends to be expected once seasonal river water inputs are restored to the degraded Maurepas swamps. See Appendix A for a list of assumptions regarding the ecological effects of river water re-introduction into receiving area swamps.

Project Effects North of Interstate 10

Benefits similar to that described above for the lower Atchafalaya Basin would be expected in the receiving area swamps north of Interstate 10. The flushing with fresh oxygenated and nutrient rich water is expected to increase tree health and growth rates. The increased organic matter production plus deposition of introduced mineral sediment is also expected to provide increased swamp floor elevations. The combination of these effects will make the currently degrading swamp ecosystem more sustainable in the face of future relative sea level rise (RSLR) and increasing salinities. With-project benefits to swamps north of I-10 were determined primarily using hydrologic modeling of diversion flows (change in water surface elevation, change in total nitrogen, and salinity change), in conjunction with CRMS data. Ecological assumptions used in the analysis may be found in Appendix A. The river water re-introduction benefits were assumed to diminish with increasing distance from the discharge site (Hope Canal just north of I-10). Hence, the beneficial effects would be greatest in the Primary Benefit Area and least in the Tertiary Benefit Area (Figure 2). Keim et al. (2010) classified habitats within the Maurepas swamps as healthy closed canopy swamp and degraded transitional canopy swamp (Figure 3). Data from Suir et al. (2021) were used to quantify interspersed water and marsh within the Keim forest area yielding the acreages listed in Table 1. In addition to habitat type, acreage was also listed based on privately owned lands versus private and public lands (LDWF's Maurepas Swamp Wildlife Management Area).

Marshes interspersed amidst the forest are also expected to receive with-project benefits for many of the same reasons the swamp will. However, because of its Variable 1 (V1) Suitability Index curve, the USACE-certified WVA marsh model scores the more degraded without-project marsh condition higher for fish and wildlife habitat quality than the more healthy and intact with-project marsh condition. Therefore, under the Intermediate SLR scenario, the USACE-certified WVA yields negative AAHUs for marshes north of I-10 despite the fact that there would be more acres of marsh with-project than without-project. However, when these marshes are analyzed using the Coastal Wetlands Planning Protection and Restoration Task Force WVA marsh model, these marshes receive net positive effects (AAHUs) over the evaluated 50-year project life. This problem with the USACE WVA model occurs only under the Intermediate SLR scenario because only under this SLR scenario the FWOP percent marsh degrades from suboptimal > 80% marsh to between 60% - 80% marsh (optimal), while under FWP the percent marsh remains > 80% throughout the project life.

Figure 2. Map illustrating the locations of the Benefit Areas located north of I-10.

Figure 3. Map showing habitats within the north of I-10 project areas.

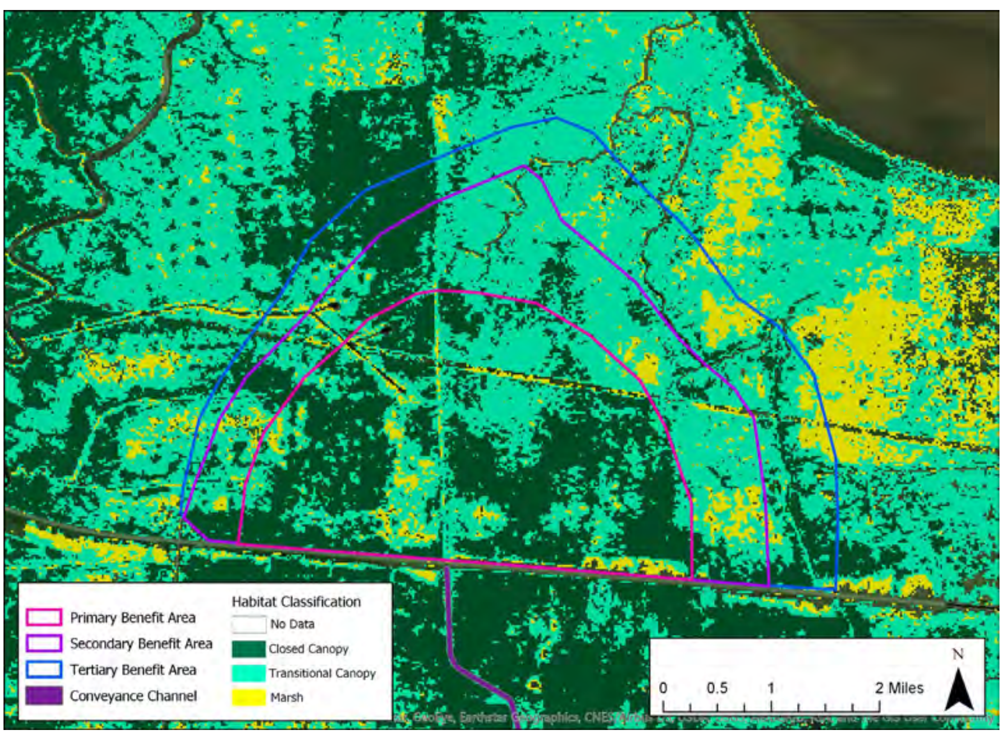


Table 1. Habitat type acres within the Primary, Secondary, and Tertiary Benefit Areas.

June 17, 2021 revised acreage data from Patrick Smith						
	Primary Benefit Area		Secondary Benefit Area		Tertiary Benefit Area	
Habitat Type	Public + Private Lands	Public ONLY Lands	Public + Private Lands	Public ONLY Lands	Public + Private Lands	Public ONLY Lands
Closed Canopy Swamp	2,743.2	1,900.4	856.0	816.4	796.6	780.8
Trans. Canopy Swamp	2,089.2	1,750.2	2,145.9	2,022.5	1,849.2	1,543.2
Marsh	262.2	208.2	251.5	244.0	288.0	283.6
Totals	5,094.6	3,858.8	3,253.4	3,082.8	2,933.8	2,607.6

Project Effects South of Interstate 10

The construction of spoil banks/guide levees along Hope Canal (needed to preclude flooding of U.S. Highway 61 and nearby developed areas) would semi-impound adjacent swamps and bottomland hardwood forest which would otherwise drain via Hope Canal (Figure 4). The inclusion and operation of culverts through those levees (Lateral Relief Valves or LRV), would ameliorate that adverse effect by maintaining some drainage opportunities, and would allow for the beneficial introduction of river water into swamps adjacent to Hope Canal for 2 weeks per year (based on current LRV operation plans). Hydrologic modeling of a 2-year rainfall event (5.1 inches) under with and without project conditions, was used to calculate monthly FWP average water surface elevation (WSE) increases (Table 2). Those were used to calculate average annual FWP WSE increases, which constituted a primary driver of anticipated adverse effects in these areas. During months of diversion operation, monthly WSE increase was greatest since the LRVs could not be used to provide storm water drainage due to the higher head within Hope Canal. See Appendix A for a list of assumptions regarding the FWP ecological effects of impoundment and river water re-introduction in receiving areas south of I-10. The south of I-10 impact areas illustrated in Figure 4 are referred to as West, East, Low, and High. Table 3 lists acreage of habitats within those impact areas.

FWP WSE increases impact not only swamps as discussed above, but also marshes and BLH in areas south of I-10. The south I-10 marshes, however, are impacted more by reduced fishery access due to construction of guide levees along Hope Canal, than by the modest FWP WSE increase. Note that the marsh WVA model issues discussed above do not apply to the south I-10 marshes because the baseline percent marsh for these areas is 63% and they degrade during the project life into the suboptimal range (< 60% marsh). BLH impacts are primarily associated with FWP WSE increases.

Figure 4. Impact areas located south of Interstate 10.

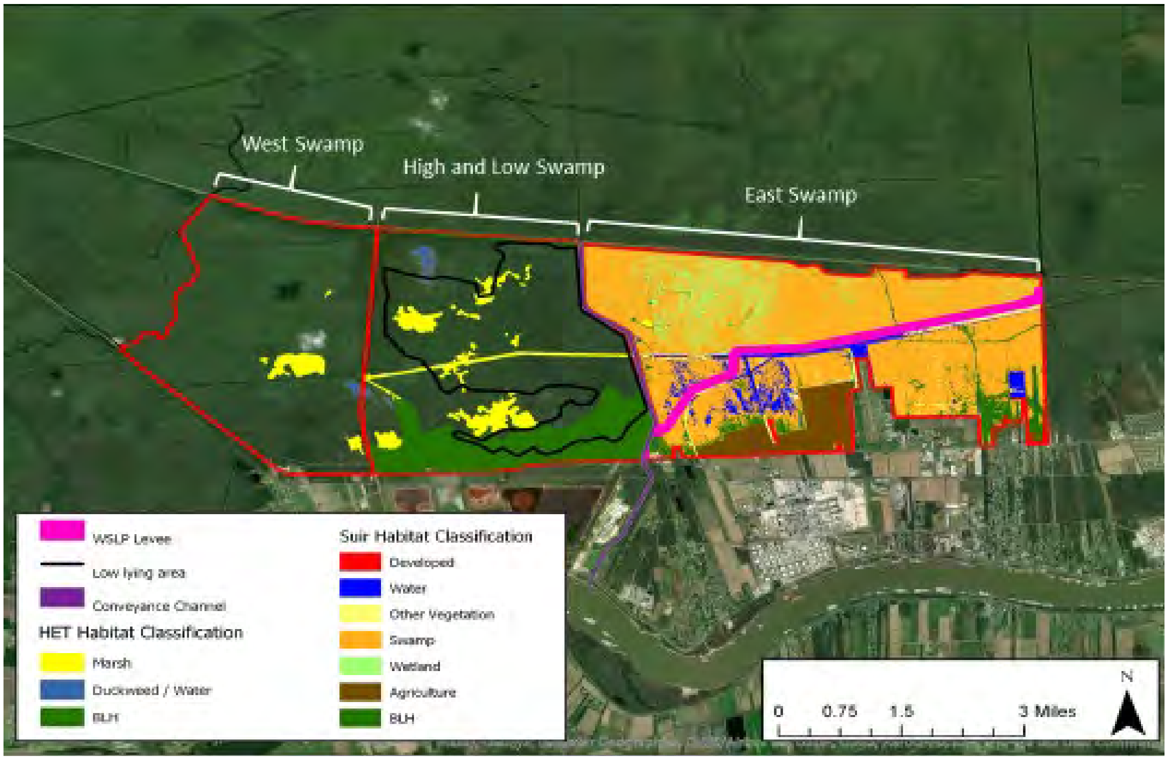


Table 2. South of I-10 FWP average annual WSE increases (ft).

Monthly Average FWP WSE Increases						
Month	Low WSE Incr. (ft)	High WSE Incr. (ft)	East WSE Incr. (ft)	West WSE Incr. (ft)	BLH West of Hope WSE Incr. (ft)	BLH West of Hope WSE Incr. (ft)
Jan	0.696	0.184	0.237	0.236	0.326	0.237
Feb	0.696	0.184	0.237	0.236	0.326	0.237
Mar	0.696	0.184	0.237	0.236	0.326	0.237
Apr	0.116	0.031	0.002	0.018	0.072	0.002
May	0.696	0.184	0.237	0.236	0.326	0.237
Jun	0.696	0.184	0.237	0.236	0.326	0.237
Jul	0.116	0.031	0.002	0.018	0.072	0.002
Aug	0.116	0.031	0.002	0.018	0.072	0.002
Sep	0.116	0.031	0.002	0.018	0.072	0.002
Oct	0.116	0.031	0.002	0.018	0.072	0.002
Nov	0.116	0.031	0.002	0.018	0.072	0.002
Dec	0.116	0.031	0.002	0.018	0.072	0.002
Ave =	**0.36**	**0.09**	**0.10**	**0.11**	**0.18**	**0.10**

Table 3. Habitat acreage within impact areas south of I-10.

Habitat Type	West of LA641	Low Elev.Zone Btn LA641 and Hope Canal	High Elev. Zone Btn LA641 and Hope Canal	East of Hope Canal
Closed Canopy Swamp	738	1,203	835	2,717
Transitional Swamp	447	1,085	488	2,305
BLH	-	471	825	534
Marsh	138	605	725	262
Water	-	4	33	976
TOTAL	1,323	3,369	2,906	6,794

Direct Construction Impacts

The Maurepas Swamp Project requires construction of a 28,000-foot-long conveyance channel extending from the Mississippi River to just north of I-10 (Figure 5) plus some additional outfall management structures. Footprint impact acres by habitat type are provided in Table 4.

Figure 5. Map illustrating locations of project direct impact areas.

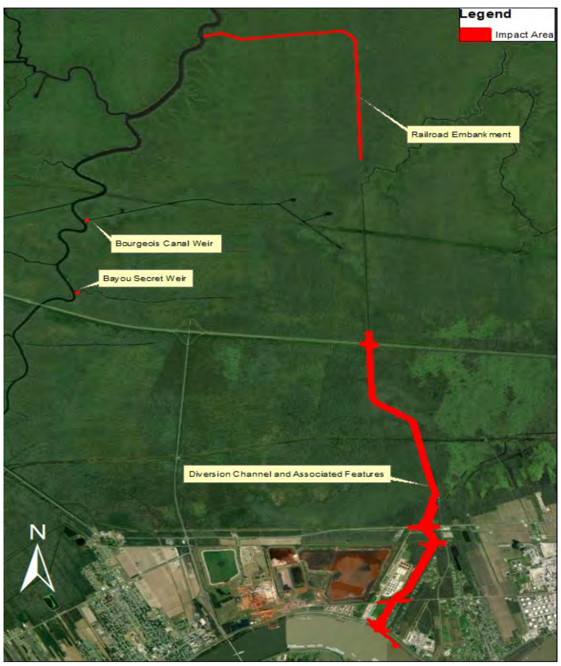


Table 4. Project direct construction impact acreage by habitat type.

Impact Area	Habitat Type	Impacts (acres)
Conveyance Channel and Associated Features	Swamp	107.26
	BLH	105.37
Weir and Embankment	Swamp	8.72
Total		221.3

Field data was collected from 13 sites within the project footprint. Those data, in combination with data from CRMS 5373 and CRMS 59 were used in the direct impact WVAs. Observed water depths, in combination with CRMS data, and RSLR projections, were used to reduce FWOP diameter at breast height (dbh) growth rates according to the magnitude of future inundation. Target year 37 was used to capture dbh growth rate reductions induced by RSLR. Because western portions of the WSLP levee system and the Maurepas Swamp Project overlap, the associated WSLP impacts in AAHUs were subtracted from the Maurepas footprint impact assessment to determine the impact attributable to the Maurepas project alone. FWP project conditions assumed zero acres of swamp and BLH habitat remain within the project footprint.

WVA Results

Because WSLP forested wetlands and marshes are aquatic resources of national importance, unavoidable losses of such habitats should be fully compensated by replacement of the same kind of habitat value; this is called "in-kind" mitigation. Therefore, WSLP impacts to swamp can only be compensated by Maurepas Swamp Project benefits to swamp habitat. Construction of the WSLP will result in -947.2 AAHUs of swamp impact (under the Intermediate SLR scenario). Because the Maurepas Swamp project would provide a net swamp benefit of 1,033 AAHUs on public lands only, and 1,275 AAHUs on public plus private lands (under the Intermediate SLR scenario), the Maurepas Swamp Project would fully compensate for WSLP swamp habitat impacts (Table 5). Given the uncertainties associated with the river water reintroduction effects, the Service recommends that any surplus swamp AAHUs not be considered available to mitigate impacts from other projects. Instead, those surplus swamp mitigation benefits should be considered as a confirmation that sufficient compensation for WSLP swamp impacts would be achieved. The Maurepas Swamp Project, however, would result in net impacts to BLH (Table 6). Those impacts would have to be mitigated for the Maurepas Swamp Project to be considered a viable mitigation project.

For north of I-10 marshes, there are conflicting results between the USACE-certified WVA marsh model vs the CWPPRA marsh model, under the Intermediate SLR scenario (Table 7). Given the conflicting model results, and because the subject marshes will eventually degrade to provide higher quality habitat, the Service recommends the marsh WVA results obtained using the USACE-certified model should not be used to quantify marsh mitigation associated with the proposed Maurepas Swamp Project. Instead, the Service recommends a zero net marsh effect for north of I-10 marshes.

Although not quantified in the WVAs for the receiving area swamp and marsh, the introduction of nutrients will increase primary productivity and thereby increase associated productivity of higher trophic levels (i.e., fish and wildlife species). Most significantly, if the seasonal introduction of river water improves dissolved oxygen concentrations and promotes red swamp crawfish production (as such hydrology patterns do in the Atchafalaya Basin), then the many species of fish and wildlife which prey on crawfish will prosper. This significant food chain dynamic is not captured in the WVA analysis. The seasonal water level increase in receiving area swamps may, however, adversely impact white-tailed deer usage. Although speculative, the flushing of receiving area swamps may help remove invasive *Salvina*, and possibly retard its growth since *Salvina* does not grow well in alkaline pH waters (Owens and Smart 2010) typical of the Mississippi River.

For south of I-10 marshes, the problem associated with the WVA marsh models (i.e., the V1 percent marsh Suitability Index curve) does not occur because the percent marsh values are mostly below the 60% to 80% marsh optimal range. Therefore, these WVA results should be considered usable for mitigation purposes. The negative WVA results for south I-10 marshes are driven primarily by a FWP loss of fishery access associated with construction of guide levees along Hope Canal (Table 8). These marsh impacts would need to be mitigated if the Maurepas Swamp Project is used to compensate for WSLP swamp impacts. Total Maurepas Swamp Project net AAHUs within affected habitat types are provided in Table 9.

Table 5. Maurepas Swamp Project WVA results for swamp habitat.

Maurepas Diversion Swamp Benefits (LOW SLR)	Public + Private Land: Closed Canopy (AAHUs)	Public + Private Land: Trans Canopy (AAHUs)	Public Land ONLY: Closed Canopy (AAHUs)	Public Land ONLY: Trans Canopy (AAHUs)
Primary Benefit Area	301.04	244.07	208.51	204.46
Secondary Benefit Area	70.45	188.02	67.18	177.19
Tertiary Benefit Area	39.34	97.22	38.55	81.12
South I-10 Indirect impacts	-73.39	-53.88	-73.39	-53.88
Subtotals	337.44	475.43	240.86	408.90
TOTALS		812.87		649.75
Construction Impacts		-52.39		-52.39
Net Project AAHUs		**760.48**		**597.36**

Maurepas Diversion Swamp Benefits (Intermediate SLR)	Public + Private Land: Closed Canopy (AAHUs)	Public + Private Land: Trans Canopy (AAHUs)	Public Land ONLY: Closed Canopy (AAHUs)	Public Land ONLY: Trans Canopy (AAHUs)
Primary Benefit Area	376.17	446.56	260.56	374.09
Secondary Benefit Area	88.03	344.01	83.95	324.20
Tertiary Benefit Area	49.16	177.87	48.18	148.43
South I-10 Indirect impacts	-83.93	-70.17	-83.93	-70.17
Subtotals	429.43	898.27	308.76	776.55
TOTALS		1327.70		1085.31
Construction Impacts		-52.39		-52.39
Net Project AAHUs		**1,275.31**		**1,032.92**

Maurepas Diversion Swamp Benefits (HIGH SLR)	Public + Private Land: Closed Canopy (AAHUs)	Public + Private Land: Trans Canopy (AAHUs)	Public Land ONLY: Closed Canopy (AAHUs)	Public Land ONLY: Trans Canopy (AAHUs)
Primary Benefit Area	1177.38	1018.53	815.54	853.25
Secondary Benefit Area	275.54	784.63	262.77	739.47
Tertiary Benefit Area	153.86	405.69	150.79	338.54
South I-10 Indirect impacts	-212.63	-345.73	-212.63	-345.73
Subtotals	1394.15	1863.13	1016.47	1585.53
TOTALS		3257.27		2602.00
Construction Impacts		-52.39		-52.39
Net Project AAHUs		**3,204.88**		**2,549.61**

Table 6. Maurepas Swamp Project total BLH impacts.

Maurepas Swamp Project BLH Impacts				
	South of I-10 Indirect Impacts			
SLR Scenario	West of Hope C. (AAHUs)	East of Hope C. (AAHUs)	Direct Construction Impacts (AAHUs)	**Total (AAHUs)**
Low	-14.21	-0.82	**-29.12**	-44.15
Int	-4.86	-1.47	**-29.12**	-35.45
High	-6.07	-1.89	**-29.12**	-37.08

Table 7. Maurepas Swamp Project north of I-10 marsh impacts.

Corps Certified WVA Marsh Model

RSLR Scenario	Primary Benefit Area All Land (AAHUs)	Primary Benefit Area Public Lands (AAHUs)	Secondary Benefit All Land (AAHUs)	Secondary Benefit Public Lands (AAHUs)	Tertiary Benefit Area All Land (AAHUs)	Tertiary Benefit Area Public Lands (AAHUs)
Low SLR	0.20	0.16	0.19	0.19	0.22	0.22
Intermediate SLR	-7.21	-5.72	-5.21	-5.04	-0.81	-0.95
High SLR	11.65	9.54	9.24	8.93	7.27	7.15

RSLR Scenario	Primary Benefit Area All Land Net ac	Primary Benefit Area Public Lands Net ac	Secondary Benefit Area All Land Net ac	Secondary Benefit Area Public Lands Net ac	Tertiary Benefit Area All Land Net ac	Tertiary Benefit Area Public Lands Net ac
Low SLR	0	0	0	0	0	0
Intermediate SLR	31	25	23	22	15	14
High SLR	31	25	23	22	14	14

CWPPRA WVA Marsh Model

RSLR Scenario	Primary Benefit Area All Land (AAHUs)	Primary Benefit Area Public Lands (AAHUs)	Secondary Benefit All Land (AAHUs)	Secondary Benefit Public Lands (AAHUs)	Tertiary Benefit Area All Land (AAHUs)	Tertiary Benefit Area Public Lands (AAHUs)
Low SLR	0.20	0.16	0.19	0.19	0.22	0.22
Intermediate SLR	10.91	8.66	7.94	7.69	6.29	6.04
High SLR	10.11	8.31	8.39	8.11	7.22	7.10

RSLR Scenario	Primary Benefit Area All Land Net ac	Primary Benefit Area Public Lands Net ac	Secondary Benefit Area All Land Net ac	Secondary Benefit Area Public Lands Net ac	Tertiary Benefit Area All Land Net ac	Tertiary Benefit Area Public Lands Net ac
Low SLR	0	0	0	0	0	0
Intermediate SLR	31	25	23	22	14	14
High SLR	31	25	23	22	14	14

Table 8. Maurepas Swamp Project south of I-10 marsh impacts (AAHUs).

South I-10 Marsh WVA Results	
Low SLR	-11.87
Intermediate SLR	-19.54
High SLR	-27.85

Table 9. Total Maurepas Swamp Project AAHUs by habitat type (intermediate SLR scenario).

Habitat Type	Net AAHUs
Swamp+	1,275.31
BLH	-35.83
Marsh	-19.54

+ Public plus privately owned

FISH AND WILDLIFE CONSERVATION MEASURES

The President's Council on Environmental Quality defined the term "mitigation" in the National Environmental Policy Act regulations to include the following elements as the desirable sequence of steps in the mitigation planning process:

a) avoiding the impact altogether by not taking a certain action or parts of an action;

b) minimizing impacts by limiting the degree or magnitude of the action and its implementation;

c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment;

d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and

e) compensation for the impact by replacing or providing substitute resources or environments.

The Service's mitigation policy (Federal Register, Volume 46, Number 15, pages 7656-7663, January 23, 1991) provides guidance to help ensure that the level of mitigation recommended by the Service is consistent with the value and scarcity of the fish and wildlife resources involved. In keeping with that policy, the Service usually recommends that losses of high-value habitats which are becoming scarce be avoided or minimized to the greatest extent possible. Unavoidable losses of such habitats should be fully compensated by replacement of the same kind of habitat value; this is called "in-kind" mitigation.

Coastal marshes and forested wetlands (BLH and swamp) are considered by the Service to be aquatic resources of national importance due to their increasing scarcity and high habitat value for fish and wildlife within Federal trusteeship (i.e., migratory waterfowl, wading birds, other migratory birds, threatened and endangered species, and interjurisdictional fisheries). Therefore, the Service recommends that unavoidable losses of those habitats be compensated in-kind. Based on the impact assessment described above, the Maurepas Swamp Project, under the Intermediate SLR scenario, would provide sufficient net benefits to compensate for the -947.2 AAHUs of swamp impacts associated with construction of the WSLP project. However, the Maurepas Swamp Project would also result in net impacts to BLH and marsh that would need to be mitigated.

The USACE and/or the local sponsor should consult with the Service to cooperatively plan those measures to avoid and/or minimize fish and wildlife impacts per the above-stated policy.

SERVICE POSITION AND RECOMMENDATIONS

Given the analysis described above, the Service believes that the Maurepas Swamp Project will compensate for WSLP impacts to swamp. In doing so, the Maurepas Swamp Project would correct freshwater, nutrient, and suspended sediment deprivation resulting from construction of flood protection levees along the Mississippi River. The planned re-introduction of those Mississippi River water inputs will also serve to improve the sustainability of the Maurepas swamp ecosystem. Given these anticipated system level benefits, the Service does not object to the selection of the Maurepas Swamp Project to mitigate WSLP swamp impacts, provided that the following recommendations are enacted to ensure that the envisioned swamp benefits are achieved, unnecessary impacts are avoided and/or minimized, and that unavoidable impacts to fish and wildlife resources are mitigated.

1. The USACE should coordinate closely with the Service and other fish and wildlife conservation agencies throughout the planning, engineering and design of project features to ensure that those features are located and designed to avoid and minimize wetland impacts and associated fish and wildlife resources.

2. Project impacts to BLH and marsh should be minimized to the greatest degree possible, and unavoidable impacts should be mitigated in a manner approved by the Service and other natural resource agencies.

3. Surplus Maurepas Swamp Project compensation should not be considered available as potential compensation for swamp impacts resulting from projects other than WSLP.

4. The USACE should coordinate with the LDWF regarding work conducted on the Maurepas Swamp WMA and should make monitoring results and operations information available to LDWF Point of Contact Kyle Balkum, Phone # 225-765-2819.

5. Monitoring of the Davis Pond and Caernarvon Diversions indicated that some contaminants were being introduced into the receiving areas from the Mississippi River. To address potential impacts of future contaminants on fish and wildlife resources, the Service recommends that pre- and post-operation sampling of wildlife, fish, and/or shellfish, from the outfall area and the Mississippi River be undertaken. Preferably, sampled species from the outfall area should forage exclusively within the diversion outfall area. The Service recommends that USACE, in coordination with the Service, develop a list of contaminants to be analyzed. The list of contaminants to be analyzed would be taken from the most recent EPA Priority Pollutants and Contaminants of Concern (COC) list. Periodic post-operational sampling should start after sufficient time for potential contaminants to accumulate (i.e., 3 to 5 years) and the frequency of subsequent periodic sampling (e.g., 3 to 5 years) would be predicated upon levels of contaminants detected. Expansion of sampling to local nesting bald eagles, (e.g., fecal and blood samples analyzed for the same contaminants) would also be predicated upon the type and level of contaminants detected. If high levels of contaminants are found, the Service and other resource agencies should be consulted. This adaptive sampling plan

should be developed in cooperation with the Service and other natural resource agencies and implemented prior to operation.

6. The Service recommends that consideration be given to operating the diversion in a manner that would prevent or minimize adverse impacts to wetlands due to prolonged inundation and focus on the overall enhancement of the entire project area to the greatest extent possible.

7. The Service recommends development of a detailed Monitoring and Adaptive Management (MAM) Plan to inform operational decisions in order to minimize adverse impacts where possible. The MAM plan should be developed through coordination with the Service, NMFS, and other resource agencies. At a minimum, the MAM Plan should conduct the monitoring described in ERDC's "Success Criteria for Mississippi River Reintroduction into Maurepas Swamp: Ten Year Targets."

8. A report documenting the status of implementation, operation, maintenance and adaptive management measures should be prepared every three years by the managing agency and provided to the USACE, the Service, NMFS, U.S. Environmental Protection Agency, Louisiana Department of Natural Resources, Louisiana Coastal Protection and Restoration Authority, and the LDWF. That report should also describe future management activities, and identify any proposed changes to the existing management plan.

9. Further detailed planning of project features and any adaptive management and monitoring plans should be developed in coordination with the Service and other State and Federal natural resource agencies so that those agencies have an opportunity to review and submit recommendations on work addressed in those reports and plans.

10. Avoid adverse impacts to bald eagle nesting locations and wading bird colonies through careful design of project features and timing of construction. During project construction a qualified biologist should inspect the proposed construction site for the presence of documented and undocumented wading bird nesting colonies and bald eagles.

    a. All construction activity during the wading bird nesting season (February through October 31 for wading bird nesting colonies, exact dates may vary) should be restricted within 1,000 feet of a wading bird colony. If restricting construction activity within 1,000 feet of a wading bird colony is not feasible, the USACE should coordinate with FWS to identify and implement alternative best management practices to protect wading bird nesting colonies.
    b. During construction activities, if a bald eagle nest is within or adjacent to the proposed project area, then an evaluation must be performed to determine whether the project is likely to disturb nesting bald eagles. That evaluation may be conducted on-line at: http://www.fws.gov/southeast/es/baldeagle. Following completion of the evaluation, that website will provide a determination of whether additional consultation is necessary and those results should be forwarded to this office.

11. The Service recommends that the USACE contact the Service and LDWF for additional consultation if: 1) the scope or location of the proposed project is changed significantly, 2) new information reveals that the action may affect listed species or designated critical habitat, 3) the action is modified in a manner that causes effects to listed species or designated critical habitat, or 4) a new species is listed or critical habitat designated. Additional consultation as a result of any of the above conditions or for changes not covered in this consultation should occur before changes are made or finalized.

12. The Service recommends that to the extent feasible, all dredged material removed from the settling basin should be used beneficially to enhance nearby coastal habitats that are in decline or to augment coastal restoration projects/features.

If the Maurepas Swamp Project is selected to mitigate WSLP impacts to swamp, then sufficient funding should be provided for full Service participation in the post-authorization engineering and design studies, and to facilitate fulfillment of our responsibilities under Section 2(b) of the Fish and Wildlife Coordination Act.

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APPENDIX A

WVA Assumptions

Receiving Area Swamps North of I-10

WVA Assumptions for V1

FWOP		Transitional Canopy:	Use data as is from CRMS 63, 97, 5414
			At TY37 (100% submergence), switch to the higher Closed Canopy loss rate (CRMS 39)
			The canopy reaches 33% coverage at TY45 - swamp acres go to zero
		Closed Canopy:	Closed Canopy site is supposed to be more healthy than Transitional
			CRMS 39 appears less healthy due likely to 100% flooded conditions
			For Closed Canopy polygon, use CRMS39 predicted canopy for TY0, thereafter use FWOP Transitional Canopy rate
			Canopy coverage never reaches 33% within the 50-yr project life
FWP		Transitional Canopy:	Apply 25% of the FWOP decrease rate
		Closed Canopy:	Same as for Transitional Canopy

WVA Assumptions for V2

FWOP	dbh/growth	Cypress Transitional:	Maintain existing dbh growth (0.33 cm/yr) till TY19 (1.0 ft submergence)
			>= TY19 (1.0 ft submergence), dbh growth drops to lowest third Pontchartrain rate (0.226 cm/yr)
			At TY37 (100% submergence), dbh growth = 0 (at TY45 swamp converts to marsh)
		Non-Cypr Transitional:	Maintain existing dbh growth (0.142 cm/yr) till TY19 (1.0 ft submergence)
			>= TY19 (1.0 ft submergence), dbh growth = zero.
			At TY45, swamp acreage is zero (33% canopy reached and swamp converts to marsh)
		Cypress Closed Canopy:	Use Transitional existing dbh growth till TY19 (1.0 ft submergence) - assuming increased competition prevents higher dbh growth rate
			>= TY19 (1.0 ft submergence), dbh growth drops to lowest third Pontchartrain rate (0.226 cm/yr)
			At TY37 (100% submergence), dbh growth = 0
		Non-Cypr Closed Canopy:	Use Transitional dbh growth till TY19 (1.0 ft submergence) - assuming increased competition prevents higher dbh growth rate
			>= TY19 (1.0 ft submergence), dbh growth = zero
FWOP	BA Change	Cypress Transitional:	2018 CRMS Ave. BA value projected forward based on % change in predicted dbh growth, plus . . .
			At TY37 (100% submergence, and Sal >= 1.56 ppt) assume increased mortality and BA growth = -0.1781 ft2/ac (Non-Cypr 2009-2018 rate adjusted for number of cypress trees at project area CRMS stations.
		Non-Cypr Transitional:	2018 CRMS Ave. BA value projected forward based on % change in predicted dbh growth, plus . . .
			From TY0 to TY18, apply BA decr rate of -0.534 ft2/ac, and -2.025 ft2/ac thereafter (ave NC CRMS 2009-2018 BA change rate, and ave BA change rate (2009-2018) for L. Maurepas edge stations (CRMS 58, 90, 5255), respectively
		Cypress Closed Canopy:	Same as per Cypress Transitional
		Non-Cypr Closed Canopy:	Same as per NON-Cypress Transitional
FWP	dbh/growth	Cypress Transitional:	Dbh growth increases from 0.330 cm/yr FWOP to ave of lowest third of CRMS Atch Basin = 0.842 cm/yr (2.55x increase in rate)
			As the 1.0 ft submergence pt is never met, this growth rate remains until TY50
		Non-Cypr Transitional:	Dbh growth increases from FWOP 0.142 cm/yr to ave of bottom half of CRMS Atch Basin = 0.342 cm/yr (2.4x increase in rate)
			As the 1.0 ft submergence pt is never met, this growth rate remains until TY50
		Cypress Closed Canopy:	Same as for FWP Cypress - Transitional Canopy
		Non-Cypr Closed Canopy:	Same as for FWP NON-Cypress - Transitional Canopy
FWP	BA Change	Cypress Transitional:	BA growth is proportional to dbh growth - no adjustment for survival/recruitment
		Non-Cypr Transitional:	BA growth is proportional to dbh growth - no adjustments for survival/recruitment
		Cypress Closed Canopy:	Same as for FWP Transitional Canopy Cypress
		Non-Cypr Closed Canopy:	Same as for FWP Closed Canopy NON-Cypress

WVA Assumptions for V3

FWOP-Flow/Exchange	FWOP = low	Flooding Duration: If TY < 100% submergence, then "semi-permanent"
FWP-Flow/Exchange	FWP = high	If TY>= 100% submergence, then "permanent"

WVA Assumptions for V4

Salinity	WVA uses the mean high growing season salinity (top 33% of salinity values during Marsh-October)
	Assume future RSLR related submergence is salinity = 2.0 ppt
	Assume introduced Mississippi River water is salinity = 0.2 ppt
	Assume FWP when diversion operates - river water flows displace all salinity
	Assume FWP when diversion not operating - river water charging of system prevents salinity for all but October during October, assume that FWP salinity is 50% of FWOP salinity

WVA Assumptions for V5 - V7

	Calculated via GIS analysis

Receiving Area Marshes North of I-10

WVA Assumptions for Receiving Area Marshes North of I-10	
Marsh acres	USGS statewide land loss Polygon # 218 was used. This area shows slight gains (0.01%/yr)
and V1	Under LowSLR, assumed no marsh acres gained or lost
	Under Int and High SLR, SLR results in loss per MIMs spreadsheet
	Marsh WVAs run separately for marsh within the Primary, Secondary, and Tertiary Benefit Areas
	Under FWP, assumed 20% increase in Primary Area accretion rate (for swamp, assumed a 100% incr in accretion)
	- for Secondary and Tertiary Benefit Areas, the accr rates reduced per % benefit reductions in those areas (25% and 65% respectively)
	- thus Primary Area accr = 2.1 mm/yr, Secondary Area = 1.6 mm/yr, Tertiary = 0.9 mm/yr
	The FWP accretion reduces submergence and lowers MIMs spreadsheet calculated RSLR land loss rate increases
V2 Submerged Aquatic Vegetation	
	FWP was assumed to increase SAV coverage
V4 Percent Shallow Open Water	
	Baseline of 10% assumed
	under FWP, V4 decrease rate was reduced due to increased accretion
V5 Salinity	Used salinities calculated for swamp Benefit Areas (FWOP and FWP)
V6 Fish Access	V6 = 1.0 for both FWOP and FWP

Habitats South of I-10 (Indirect Impacts)

South I-10 Swamp WVA Assumptions

CRMS 5373 and CRMS 59 assumed to represent swamps located btn LA641 and Reserve Relief Canal
CRMS 39 assumed to represent swamps located west of LA 641

TYs determined primarily by 100% submergence yr
- except West swamp where baseline >100% submergence - there TYs set when canopy reaches 33% threshold
- 100% submergence changes with FWP WSE incr.

FWP impacts result primarily from:
- under FWP, 100% sub occurs earlier which governs onset of more rapid canopy loss rate
- for FWP West swamp (which is > 100% subm), WSE rise is converted to yrs of RSLR (3 yrs), and canopy conversion to marsh advanced by 3 yrs
- for High and West swamps, the FWP dbh growth rate is reduced using subm vs dbh growth rate relationship

FWP benefits result primarily from:
- no decr. in dbh growth rates with WSE incr (Low and East swamps). . . . Assume river water benefits offset decr. In dbh growth
- East swamp, assume V3 increased exchange/flow-through of river water . . . Insert V3 Exchange SI value as Ave of low & mod -manually entered SI
- reduced FWP salinities - all areas

single underline = 100% submergence TY, double underline = 3.0 ft submergence TY

FWOP TYs (Low SLR)		FWP TYs (Low)	
Low Swamp FWOP	0 ,1, 50	Low Swamp FWP	0, 1, 31, 50
High Swamp FWOP	0 ,1, 50	High Swamp FWP	0 ,1, 50
West Swamp FWOP TYs		West Swamp FWOP	
Trans Canopy	0, 1, 33, 34, 50	Closed Canopy	0, 1, 30, 31, 50
Closed Canopy	0, 1, 46, 47, 50	Trans Canopy	0, 1, 43, 44, 50
East Swamp FWOP	0, 1, 50	East Swamp FWP	0, 1, 50

FWOP TYs (INT SLR)		FWP TYs (INT)	
Low Swamp FWOP	0 ,1, 34, 50	Low Swamp FWP	0, 1, 18, 50
High Swamp FWOP	0 ,1, 34, 50	High Swamp FWP	0, 1, 30, 50
West Swamp FWOP TYs		West Swamp FWOP	
Trans Canopy	0, 1, 33, 34, 50	Trans Canopy	0, 1, 30, 31, 50
Closed Canopy	0, 1, 46, 47, 50	Closed Canopy	0, 1, 43, 44, 50
East Swamp FWOP	0, 1, 34, 50	East Swamp FWP	0, 1, 30, 50

FWOP TYs (High SLR)		FWP TYs (High SLR)
Low Swamp FWOP TYs		
Trans Canopy	0 ,1, 16, 39, 50	0, 1, 8, 33, 40, 41, 50
Closed Canopy	0 ,1, 16, 39, 50	0, 1, 8, 33, 50
High Swamp FWOP		
Trans Canopy	0, 1, 16, 39, 50	0, 1, 14, 38, 45, 46, 50
Closed Canopy	0, 1, 16, 39, 50	0, 1, 14, 38, 50
West Swamp FWOP TYs		
Trans Canopy	0, 1, 31, 32, 50	0, 1, 28, 29, 50
Closed Canopy	0, 1, 31, 36, 37, 50	0, 1, 28, 33, 34, 50
East Swamp FWOP		
Trans Canopy	0, 1, 16, 39, 50	0, 1, 13, 37, 44, 45, 50
Closed Canopy	0, 1, 16, 39, 50	0, 1, 13, 37, 50

Canopy Cover Assumptions:

Low swamp: FWOP use ave CRMS 59 & 5373 rate initially (-0.0443%/yr) , then at 100% subm increase to the CRMS 59 rate (-0.4553%/yr)
FWOP rate switch at TY34, FWP rate switch at TY18

High swamp: FWOP use ave CRMS 59 & 5373 rate initially (-0.0443%/yr) , then at 100% subm increase to the CRMS 59 rate (-0.4553%/yr)
FWOP rate switch at TY34, FWP rate switch at TY30

West swamp: FWOP use CRMS 39 rate (-0.893 %/yr)
FWOP Trans Canopy converts to marsh in TY34
FWP Trans Canopy converts to marsh in TY30 - caused by the FWP WSE incr. which advances canopy decr by 3 yrs
FWOP Closed Canopy converts to marsh in TY47
FWP Closed Canopy converts to marsh in TY44 - due to FWP WSE incr. which advances canopy decr by 3 yrs

East swamp: FWOP rates same as FWOP Low swamp
FWOP rate switch at TY34, FWP rate switch at TY29 (due to FWP WSE incr.)

Herbacious cover: from CRMS 2018 data -FWOP changed in very similar manner for all swamp sites. Under FWP, slightly decreased %herb due to WSE incr.
Midstory cover: estimated (changed in very similar manner for all swamp sites, FWP vs FWOP)

Dbh Growth Rate Assumptions: CRMS obs values used initially, but at TY0 (1.0 ft sub), value reduced as explained below:

Low swamp: FWOP cypress at TY0 use weighted ave of middle and low tiers (0.275 cm/yr); at 100% subm (TY34) decrease rate to zero
FWOP non-cypress at TY0 use weighted ave of top and middle tiers (0.180 cm/yr): at 100% subm (TY34) decrease rate to zero
FWP, for pre-100% subm period, do NOT decrease rates using dbh growth vs subm relationship due to river water benefits . . .
but use FWOP pre-100% subm rate. At the 100% subm rate (TY18) reduce dbh growth to zero.

High swamp: FWOP cypress at TY0 use weighted ave of middle and low tiers (0.275 cm/yr); at 100% subm (TY34) decrease rate to zero
FWOP non-cypress at TY0 use weighted ave of top and middle tiers (0.180 cm/yr); at 100% subm (TY34) decrease rate to zero
at FWP cypress, reduce pre-100% subm rate to 0.257 cm/yr (due to WSE incr.), at the 100% subm TY30 the rate is zero (no river water benefits)
at FWP non-cypress, reduce pre-100% subm rate to 0.178 cm/yr (due to WSE incr.); at the 100% subm TY30 the rate is zero (no river water benefits)

West swamp: FWOP cypress at TY0 use CRMS39 rate of 0.296 cm/yr until swamp converts to marsh
FWOP non-cypress at TY0 use CRMS39 rate of 0.275 cm/yr until swamp converts to marsh
at FWP cypress, at TY0 reduce rate to 0.274 cm/yr (reduced due to WSE incr.)
at FWP non-cypress, at TY0 reduce rate to 0.273 cm/yr (reduced due to WSE incr.)

East swamp: FWOP cypress, at TY0 use ave of middle and low tiers (0.275 cm/yr), at 100% subm (TY34) decrease rate to zero
FWOP non-cypress, at TY0 use ave of top and middle tiers (0.180 cm/yr), at 100% subm (Ty34) decrease rate to zero
FWP - same as FWOP except 100% subm is TY29 . . . Assume no rate reduction as river water benefits swamp

Under High SLR, at 3.0 ft submergence the following were applied to swamp WVAs:
canopy loss rate increased to -2.126 % per year (from CRMS 5414)
dbh growth rates were zeroed out
non-cypress basal area loss rate of -1.258 ft2/ac (CRMS 5414 BA loss rate) were applied beginning at the 3 ft submergence year
for cypress, half the non-cypress rate (-0.629 ft2/ac) was applied beginning at the 3 ft submergence year

BA Assumptions:

CRMS data used to determine baseline BA. BA change determined by dbh growth in all cases (except for High SLR - see above ref to High SLR).

Hydrology Assumptions:

Baseline is assumed to be Low Exchange and Semi-Permnent Flooding (except for West swamp which is Permanently Flooded at baseline).
Using RSLR and CRMS data, when 100% subm year is reached, then flooding becomes "Permanent" under both FWOP and FWP

East swamp - will receive more river intro benefits than any other south I-10 area because the introduced water will flow to Miss Bayou and Res. Relief C.
- To account for those river water benefits, the dbh growth was not reduced per subm vs dbh growth relationship and . . .
- The FWP V3 exchange variable SI was calc as ave of low & mod exchange, and was manually inserted to capture effects of river water flow-through

Salinity:

Methodology same as receiving area swamp except that inundation for each specific South I-10 site is used.
Baseline salinity for Low, High, and East swamps are from CRMS 59 and 5373
Baseline salinity for West swamps are from CRMS 39

Forest Size:

Determined via GIS analysis

Land Use:

Determined via GIS analysis

Disturbance:

Determined via GIS analysis

Misc Assumptions:

Diversion operation ramp-up is not assumed to be an issue for south I-10 swamp river water benefits as the two week Lateral Relief Valve operations can be achieved during any ramp-up year

Accretion:

FWOP accretion assumed to be 5 mm/yr which is the basin's swamp average

FWP accretion, with or without river water inputs, are not assumed to differ from FWOP

FWP Water Surface Elevation (WSE) Increase:

Delft modeling results were used to calc WSE difference btn FWOP and FWP during 2-yr rain event (2-yr event =5.1 inches per New Orleans data)

This 2-yr rain = ave monthly precip for non-diversion operation months. During diversion operation months, ave monthly precip was 110% of 5.1 inches.

It was assumed that area under the WSE difference curve (17-days), could be averaged over 1-month to obtain a monthly ave WSE incr.

This model derived ave monthly WSE incr was multiplied by 110% to obtain the monthly WSE incr during diversion operation months

The monthly WSE incr amounts were averaged to calc an average annual WSE increase

South I-10 BLH Assumptions

WSE increases were used to establish the 100% inundation year (TY)

At the 100% inundation TY, dbh growth rates were reduced in the In-Growth spreadsheet (using Tupelo forest rates)

Pre 100% inundation, the -1.79 adj factor was used, post 100% inundation, the -2.06 adj factor was used.

South I-10 Marsh Assumptions

Using marsh acres in east swamp area, a weighted ave WSE was calculated (0.19 ft)

Under FWP, that WSE increase was added to RSLR to compute adjusted RSLR marsh loss rates beginning in TY1

No river water benefits assumed

V6 fish access much reduced along Hope Canal under FWP - this is primary driver of negative AAHU results for marsh

APPENDIX B

Manatee Conservation Measures

The threatened West Indian manatee (*Trichechus manatus*) is known to regularly occur in Lakes Pontchartrain and Maurepas and their associated coastal waters and streams. It also can be found less regularly in other Louisiana coastal areas, most likely while the average water temperature is warm. Based on data maintained by the Louisiana Natural Heritage Program (LNHP), over 80 percent of reported manatee sightings (1999-2011) in Louisiana have occurred from the months of June through December. Manatee occurrences in Louisiana appear to be increasing and they have been regularly reported in the Amite, Blind, Tchefuncte, and Tickfaw Rivers, and in canals within the adjacent coastal marshes of southeastern Louisiana. Manatees may also infrequently be observed in the Mississippi River and coastal areas of southwestern Louisiana. Cold weather and outbreaks of red tide may adversely affect these animals. However, human activity is the primary cause for declines in species number due to collisions with boats and barges, entrapment in flood control structures, poaching, habitat loss, and pollution.

During in-water work in areas that potentially support manatees all personnel associated with the project should be instructed about the potential presence of manatees, manatee speed zones, and the need to avoid collisions with and injury to manatees. All personnel should be advised that there are civil and criminal penalties for harming, harassing, or killing manatees, which are protected under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. Additionally, personnel should be instructed not to attempt to feed or otherwise interact with the animal, although passively taking pictures or video would be acceptable.

- All on-site personnel are responsible for observing water-related activities for the presence of manatee(s). We recommend the following to minimize potential impacts to manatees in areas of their potential presence:

- All work, equipment, and vessel operation should cease if a manatee is spotted within a 50-foot radius (buffer zone) of the active work area. Once the manatee has left the buffer zone on its own accord (manatees must not be herded or harassed into leaving), or after 30 minutes have passed without additional sightings of manatee(s) in the buffer zone, in-water work can resume under careful observation for manatee(s).

- If a manatee(s) is sighted in or near the project area, all vessels associated with the project should operate at “no wake/idle” speeds within the construction area and at all times while in waters where the draft of the vessel provides less than a four-foot clearance from the bottom. Vessels should follow routes of deep water whenever possible.

- If used, siltation or turbidity barriers should be properly secured, made of material in which manatees cannot become entangled, and be monitored to avoid manatee entrapment or impeding their movement.

- Temporary signs concerning manatees should be posted prior to and during all in-water project activities and removed upon completion. Each vessel involved in construction activities should display at the vessel control station or in a prominent location, visible to all employees operating the vessel, a temporary sign at least 8½ " X 11" reading language similar to the following: “CAUTION BOATERS: MANATEE AREA/ IDLE SPEED IS REQUIRED IN CONSRUCTION AREA AND WHERE THERE IS LESS THAN FOUR FOOT BOTTOM CLEARANCE WHEN MANATEE IS PRESENT”. A second temporary sign measuring 8½ " X 11” should be posted at a location prominently visible to all personnel engaged in water-related activities and should read language similar to the following: “CAUTION: MANATEE AREA/ EQUIPMENT MUST BE SHUTDOWN IMMEDIATELY IF A MANATEE COMES WITHIN 50 FEET OF OPERATION”.

- Collisions with, injury to, or sightings of manatees should be immediately reported to the Service’s Louisiana Ecological Services Office (337-291-3100) and the Louisiana Department of Wildlife and Fisheries, Natural Heritage Program (225-765-2821). Please provide the nature of the call (i.e., report of an incident, manatee sighting, etc.); time of incident/sighting; and the approximate location, including the latitude and longitude coordinates, if possible.

- To ensure manatees are not trapped due to construction of containment or water control structures, we recommend that the project area be surveyed prior to commencement of work activities. Should a manatee be observed within those areas, the contractor should immediately contact the Service’s Louisiana Ecological Services Office (337-291-3100) and the Louisiana Department of Wildlife and Fisheries, Natural Heritage Program (225-765-2821).

Should a proposed action directly or indirectly affect the West Indian manatee, further consultation with this office will be necessary.

Coordination with LDWF on Maurepas WMA, Potential Deer Impacts

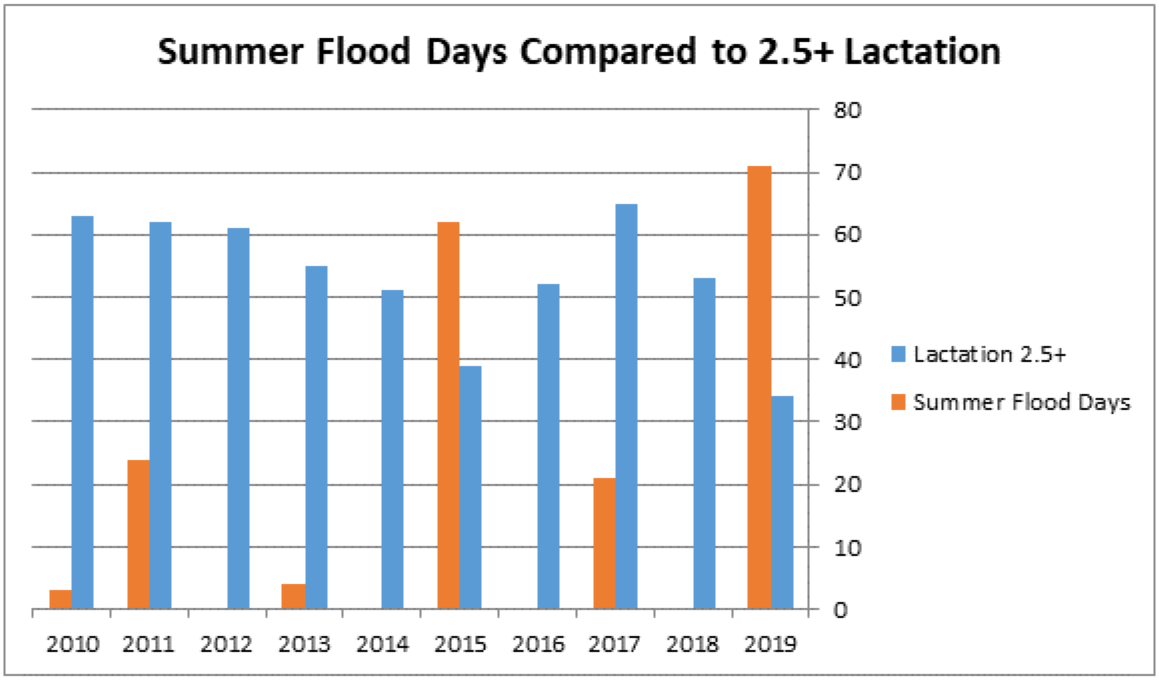
From:	Johnathan Bordelon
To:	Meden, Daniel C CIV USARMY CEMVN (USA)
Cc:	Behrens, Elizabeth H CIV USARMY CEMVN (USA)
Subject:	[Non-DoD Source] RE: Maurepas WMA Deer harvesting data; wildlife impacts
Date:	Wednesday, September 1, 2021 3:33:45 PM
Attachments:	image001.png image002.png image004.png

Daniel,

Thanks for reaching out in reference to Maurepas WMA. In light of the recent storm, I hope you and your family are ok. I was on a call a week ago with Elizabeth and Bradley Breland, unfortunately my audio was not working for the call but Bradley covered primary concerns that had been previously identified.

The research mentioned by Jones et. al does include Louisiana data that we provided for the meta-analysis. That data is specific to the Mississippi batture lands in northeast Louisiana but we have observed similar trends in other river basins (Atchafalaya) in Louisiana as well as backwater areas. Evaluation of deer condition in backwater and batture areas did not reveal any significant changes in body condition, regardless of cohort. However, there was an association with late summer flooding, which occurred during fawning, and lower fall lactation rates in adult does. The increased frequency of summer floods over the past ten years was the catalyst for the discussion and eventual collaboration with Mississippi State University for the meta-analysis. More recently, we have modified deer seasons and harvest recommendations in specific areas due to the anticipated impacts to recruitment in response to late summer flooding.

Example of late summer flooding and lactation rates in the Atchafalaya basin. Period in question uses June 1st for summer. While flooding was observed in often observed in June, the lactation rates below 50% occurred when water persisted into August. (Peak fawning for this area is late July into early August, similar to Maurepas swamp)



An important difference between the meta-analysis and the Maurepas system is the refuge habitat adjacent to flood impacts. Deer living within the batture lands are transient in nature based on the flood tendencies and pulses. Adjacent forests and agriculture on the protected side of the levee offer comparable habitat and refuge from flood waters. This in turn is believed to compensate for the loss of available forage on the unprotected side of the levee during floods. However, while there are no significant changes in body condition, the concentration of wildlife, both predators and prey, likely contribute to the before mentioned declines in lactation. However, that is an assumption, we only know there is an association between late summer flooding and lower lactation rates. While referencing batture lands, refuge habitat adjacent to Maurepas swamp is different than the mosaic of bottomland hardwood forests and farmland that border the Mississippi River in northeast Louisiana. We are less clear on the impacts to deer condition as well as the pressure deer place on food resources adjacent to flood impacted areas. There is potential for increased herbivory outside of flood impacted areas which in turn will have an impact on forest ecosystems in close proximity to Maurepas swamp. These are potential impacts and do not represent data that we have collected.

Data specific to Maurepas WMA is limited due to sample size. I pulled up last season's results from the WMA managed hunt held the weekend after Thanksgiving. Sample size for adult does was 7 and age specific data was available for 5 bucks. This does not provide meaningful averages per age class, in some cases an individual deer is the only representative of a cohort. The generalizations and observances from other systems impacted by flooding may be more meaningful simply due to the sample size used in the assessment.

In addition to deer condition and reproductive output, we are currently observing changes in plant species composition in batture and river basin habitats. Forest structure is also changing due to the mortality of less water tolerant species. While some of the those species can tolerate seasonal flooding, longer pulses that end outside of traditional seasons has stressed and even led to mortality. In some cases, this could be viewed as a positive since it allows more sunlight to reach the forest floor which promotes the growth of forest plants. However, composition in some cases is skewed towards more water tolerant species which in turn do not offer the same forage potential or use by certain species. The variability across the areas we survey has not been written into a publishable document. At this time, it is site specific indices for a particular tract. Some changes are viewed as positive in the short term due to plant species composition and others are an obvious negative due to less favorable plant species composition. Of course, I use positive and negative as it would pertain to deer, realizing certain wildlife species will be better suited for a more aquatic landscape with water tolerant plant species. In the case of Maurepas swamp, increased water levels will lead to fewer available acres of habitat for deer. In addition, I would anticipate some plant species conversion due to hydrologic changes, these more water tolerant plants often offer less in the form of preferred browse for deer but this is a generalization. There will certainly be exceptions.

I am not sure what baseline data is available for the forested floristic quality index for Maurepas swamp. We do have browse survey transect data specific to the WMA. The transects we conduct measure species composition and available stems as well as utilization by deer for specific transects. Due to transect bias, transects are located on dry land, it does not represent species composition for the system. I am curious of whether or not there are already changes in the forested floristic quality index for Maurepas. Are we seeing more water tolerant species over time or have vegetative communities remained relatively unchanged. I anticipate a shift towards more water tolerant grasses and sedges with increased water levels.

Most of this information may be a repackage of previous discussions. Your original question in reference to Maurepas specific deer data has limited value due to sample size. Unfortunate in this situation. The browse survey data may be of relevance when comparing pre-project baselines to conditions post project. However, it will not provide any predictive data at this time for the purpose of your impact assessment. The continued references to reduced lactation rates and recruitment are tied to late summer flooding which may not be applicable due to traditional river levels and the timing of likely diversion based on historical water levels. The loss of available dry acres and plant species conversion may have a greater impact.

Thanks again for reaching out. I will search for additional data that may be useful towards your evaluation. Just wanted to send you something in the interim.

Johnathan

Johnathan Bordelon
LA Dept. of Wildlife and Fisheries
Deer Program Manager
765 Maryhill Rd.
Pineville, LA 71360
(318) 487-5334
jbordelon@wlf.la.gov

From: Meden, Daniel C CIV USARMY CEMVN (USA) <Daniel.C.Meden@usace.army.mil>
Sent: Friday, August 27, 2021 2:41 PM
To: Johnathan Bordelon <jbordelon@wlf.la.gov>
Cc: Behrens, Elizabeth H CIV USARMY CEMVN (USA) <Elizabeth.H.Behrens@usace.army.mil>
Subject: FW: Maurepas WMA Deer harvesting data; wildlife impacts

Hey Johnathon,

I got off a call with Matt Weigel on the Amite Diversion modeling and wanted to touch base with you as the LDWF deer study leader.

I'm currently working on the wildlife writeup for the supplemental environmental impact statement on the Maurepas Diversion project that is mitigation from the Westshore Lake Pontchartrain levees. Although swamp vegetation could improve, my concern is in addressing potential impacts to terrestrial wildlife, especially white-tailed deer, associated with the 2,000 cfs diversion canal. Bradley had also mentioned that nesting alligators, rabbits, deer, etc. generally experience increased mortality following flood events. Other research by Jones et. al. (2019) also reflects that the reduced lactation rates also factors in to reduced fitness in fawns, etc.

Please let me know if you have any new or current population data about deer populations within the Maurepas WMA and/or research on flood stress impacts to deer in general.

Thanks!

Daniel Meden
Biologist, Coastal Environmental Planning
RPEDS, New Orleans District
Office: 504-862-1014

Environmental Manager for: Amite River and Tributaries feasibility study – BBA18
Mississippi River and Tributaries, Morganza to the Gulf of Mexico
LCA Beneficial Use of Dredged Materials – Barataria Bay Waterway; Mississippi River Outlets at Venice.

Environmental Workgroup member for Coastal Wetland Planning, Protection, and Restoration Act.

From: Bradley Breland <bbreland@wlf.la.gov>
Sent: Friday, August 27, 2021 2:09 PM
To: Meden, Daniel C CIV USARMY CEMVN (USA) <Daniel.C.Meden@usace.army.mil>
Cc: Matthew Weigel <mweigel@wlf.la.gov>
Subject: [Non-DoD Source] RE: Maurepas WMA Deer harvesting data; wildlife impacts

https://www.amitebasin.org/

The attachment is a DOTD reoprt on the Amite River Diversion inmacts and the link above is to the Amite River Basin Drainage & Water Conservation District website. There are several reports about the efffects of the 2016 flood.
I have copied Matt Weigel on this email and he said he would he happy to discuss further with you if needed.

Bradley Breland
Louisiana Department of Wildlife and Fisheries
bbreland@wlf.la.gov
42371 Phyllis Ann Drive
Hammond, LA 70403
(O) 985-543-4782 ex 2205
(F) 985-543-4787

From: Meden, Daniel C CIV USARMY CEMVN (USA) <Daniel.C.Meden@usace.army.mil>
Sent: Friday, August 27, 2021 8:12 AM
To: Bradley Breland <bbreland@wlf.la.gov>
Cc: Perez, Andrew R CIV USARMY CEMVN (USA) <Andrew.R.Perez@usace.army.mil>; Behrens, Elizabeth H CIV USARMY CEMVN (USA) <Elizabeth.H.Behrens@usace.army.mil>; Williams, Eric M CIV USARMY CEMVN (USA) <Eric.M.Williams@usace.army.mil>
Subject: Maurepas WMA Deer harvesting data; wildlife impacts

Good morning, Brad!

Thanks for the earlier input on the Maurepas WMA, as it is very helpful information to capture wildlife impacts with for the Maurepas Diversion environmental impact statement. Yesterday, Libby and I went over the potentially negative impacts associated with flooding to alligators and deer populations. I am planning on expanding the impact analysis to also include other terrestrial animals (rabbits, rodents, etc.) that could be impacted for general flooding impacts without the project as well as cumulatively when accounting for hydrologic

I have a few questions to discuss and can set up a call or meeting next week, probably better for Tuesday considering potential storm impacts from Ida.

1) Do you have any mapping data from tracking alligator nesting locations and deer harvests, etc. within the Maurepas WMA (*Note: information would not be shared outside of our agency)?
2) Are there any other terrestrial species of conservation need that have been impacted within the WMA from flooding?
3) With flooding from upstream from the Amite River (e.g. the Baton Rouge 2016 floods), has there been any recent research on how flow from the Amite River Diversion Canal has impacted deer and other terrestrial wildlife in the WMA?

I am going to also look into some LiDAR data to determine potential acres of natural ridges that serve as higher ground for wildlife during flood events. Andrew Perez, who is assessing recreational-based impacts, is CC'ed.

Thanks!

Daniel Meden
Biologist, Coastal Environmental Planning
RPEDS, New Orleans District
Office: 504-862-1014
Cell: 563-949-5530

Environmental Manager for: Amite River and Tributaries feasibility study – BBA18
Mississippi River and Tributaries, Morganza to the Gulf of Mexico
LCA Beneficial Use of Dredged Materials – Barataria Bay Waterway; Mississippi River Outlets at Venice.

Environmental Workgroup member for Coastal Wetland Planning, Protection, and Restoration Act.

Natural and Scenic Rivers

From:	Chris Davis
To:	Meden, Daniel C CIV USARMY CEMVN (USA)
Cc:	Parr, Landon CIV USARMY CEMVN (USA)
Subject:	[Non-DoD Source] No Permit Required: WSLP mitigation -embankment cuts
Date:	Wednesday, August 25, 2021 9:47:48 AM

Dan,
The LDWF Scenic Rivers Program has determined that no permit will be required for the proposed access to perform embankment work that is located more than 100’ from the MLW of Blind River. This determination is based on maintenance clearing along existing rights to facilitate access for equipment. For this determination to remain valid, the Corps shall adhere to the following:

1. Following completion of work activities, the Corps shall restore any cleared areas within 100’ of Blind River to pre-project conditions. This includes planting any native trees that were cleared along the right of ways. Trees shall be planted on a 10-foot spacing and shall be fitted with nutria excluder devices (NEDs).

2. Any trees removed within 100’ of the Blind River shall be stored at an offsite location or chipped in a manner not to exceed 4 inches in height. Placement of felled trees within Blind River is a violation of the Scenic Rivers Act and will be pursued accordingly.

3. The Corps shall ensure that all contractors, subcontractors, and workers are made fully aware of the limits of the work authorized by this determination and adhere to and comply with all conditions listed in this determination. Non-compliance with terms and conditions may result in a Scenic Rivers violation or / and a permit being required.

4. Upon completion of the activities authorized by this determination, the Corps shall immediately contact this Department (*Chris Davis at (225)765-2642)* and submit post-construction, photographic documentation of the proposed project to LDWF within 30 days following project completion. LDWF will review the completed activity to assure that all activities were performed in accordance with the conditions of this determination.

Thanks,

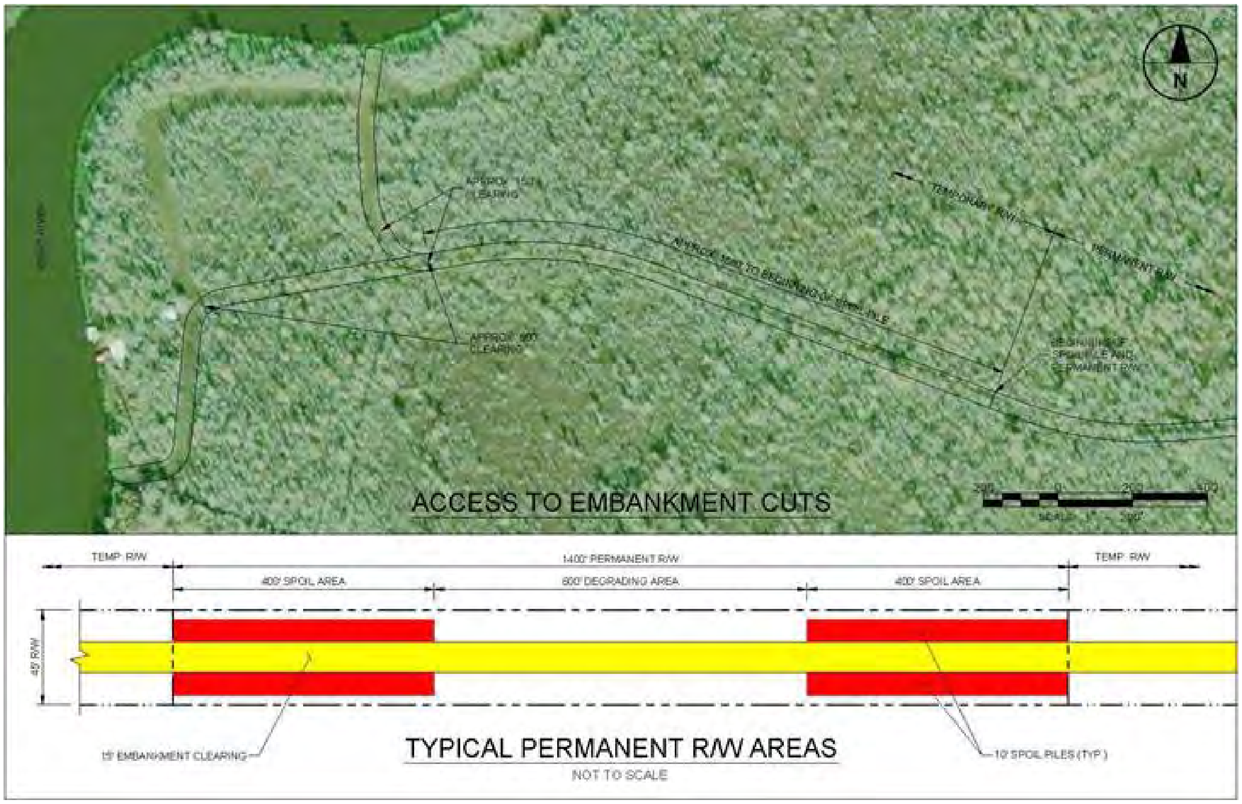
Chris Davis
Scenic Rivers Coordinator
Louisiana Department of Wildlife and Fisheries
2000 Quail Drive, Room 432
Baton Rouge, LA 70808
Phone: (225)765-2642 Fax (225)765-2625

From: Meden, Daniel C CIV USARMY CEMVN (USA) <Daniel.C.Meden@usace.army.mil>
Sent: Tuesday, August 24, 2021 2:53 PM
To: Chris Davis <rcdavis@wlf.la.gov>
Cc: Parr, Landon CIV USARMY CEMVN (USA) <Landon.Parr@usace.army.mil>
Subject: WSLP mitigation; embankment cuts

Hey Chris,

I wanted to extend a friendly reminder following the morning call that the embankments for the WSLP Mitigation (Maurepas Diversion) are outside the 100 foot distance from Blind River and the access clearings off of Blind River would not result in any impacts to the scenic river. Please let me know your verdict regarding the permitting requirement for the project.

Emphasized in the previous email: The least amount of trees impacted (about 150-ft long section) to get onto the Embankment would come from the North route. The clearing of the Embankment will be 15-ft wide. I have copied a figure with closer details of this area if that helps.



Thanks!

Daniel Meden
Biologist, Coastal Environmental Planning
RPEDS, New Orleans District
Office: 504-862-1014

Environmental Manager for: Amite River and Tributaries feasibility study – BBA18
Mississippi River and Tributaries, Morganza to the Gulf of Mexico
LCA Beneficial Use of Dredged Materials – Barataria Bay Waterway; Mississippi River Outlets at Venice.

Environmental Workgroup member for Coastal Wetland Planning, Protection, and Restoration Act.

Prime and Unique Farmland

United States Department of Agriculture

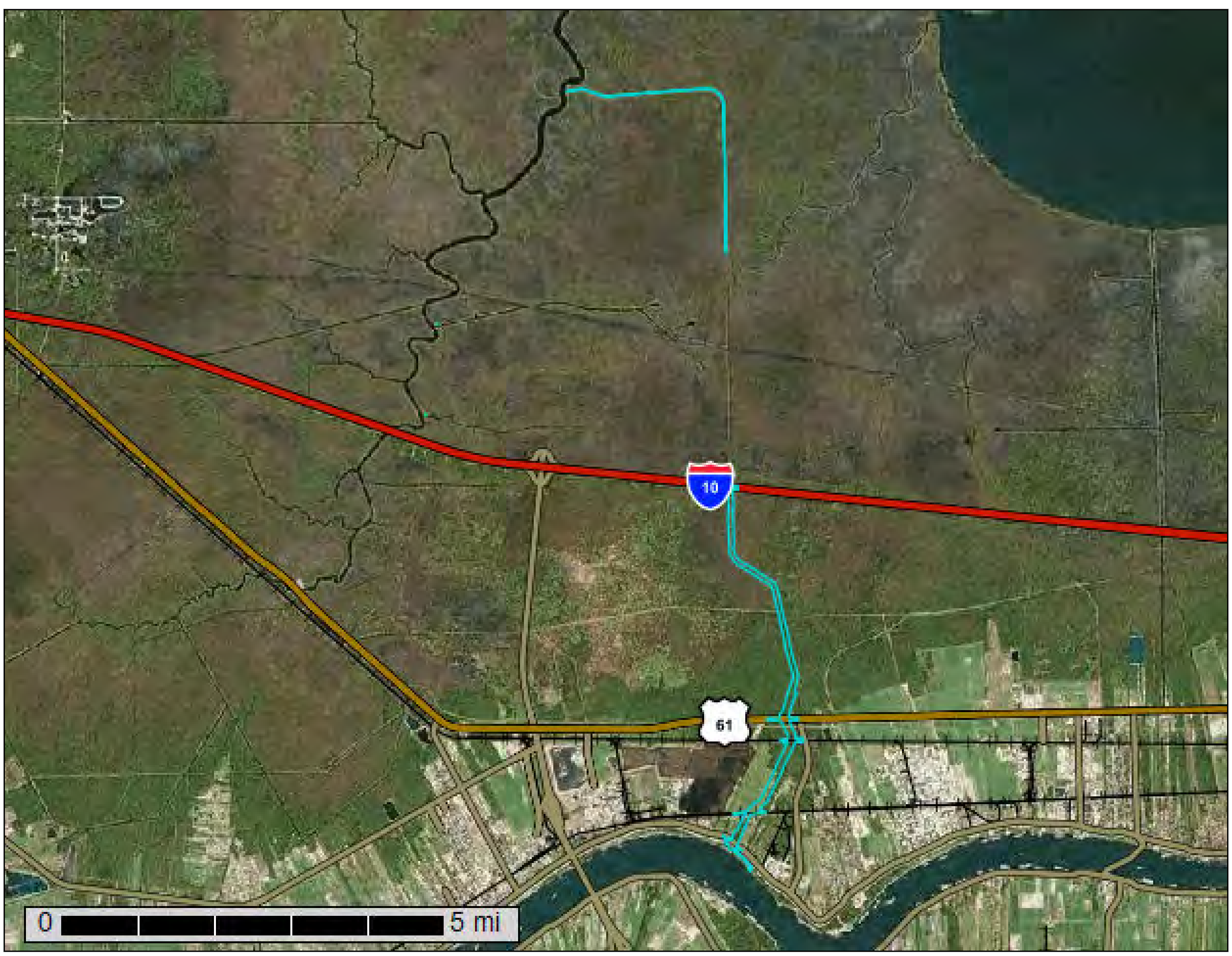
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

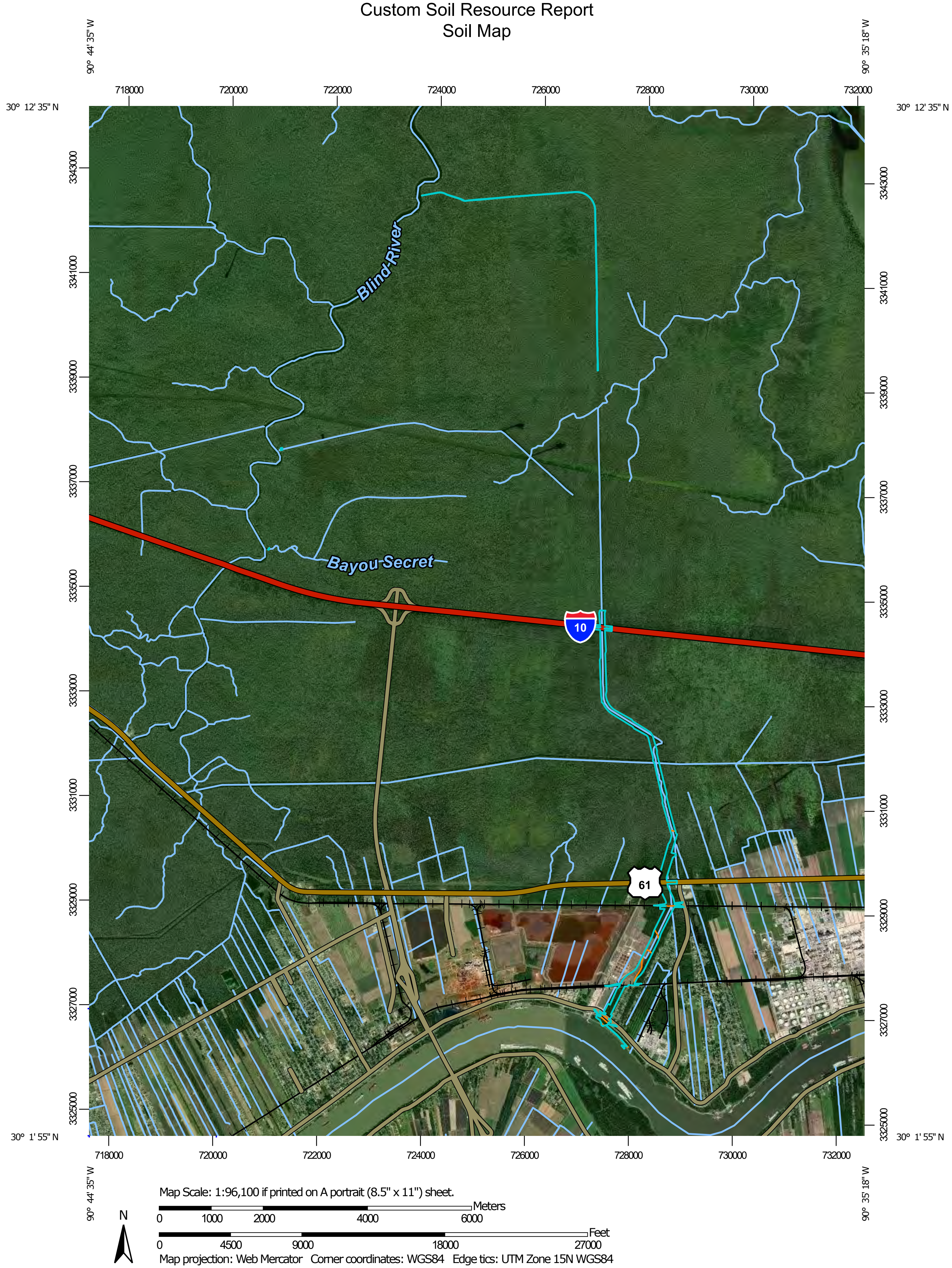
Custom Soil Resource Report for Ascension Parish, Louisiana, St. James Parish, Louisiana, and St. John the Baptist Parish, Louisiana

Maurepas Swamp Project Area (Construction)



October 18, 2021

Soil Map


90° 44' 35" W
90° 35' 18" W
30° 12' 35" N
30° 1' 55" N
718000
720000
722000
724000
726000
728000
730000
732000
3343000
3341000
3339000
3337000
3335000
3333000
3331000
3329000
3327000
3325000
Blind River
Bayou Secret
10
61
Map Scale: 1:96,100 if printed on A portrait (8.5" x 11") sheet.
Meters
0 1000 2000 4000 6000
Feet
0 4500 9000 18000 27000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

Table—Farmland Classification

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BA	Barbary muck, 0 to 1 percent slopes, frequently flooded	Not prime farmland	8.5	2.9%
Subtotals for Soil Survey Area			**8.5**	**2.9%**
Totals for Area of Interest			**288.3**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BA	Barbary soils, 0 to 1 percent slopes, frequently flooded	Not prime farmland	0.1	0.0%
Lp	Levees-Borrow pits complex, 0 to 25 percent slopes	Not prime farmland	0.1	0.0%
W	Water	Not prime farmland	0.3	0.1%
Subtotals for Soil Survey Area			**0.4**	**0.2%**
Totals for Area of Interest			**288.3**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Ba	Barbary soils, 0 to 1 percent slopes, frequently flooded	Not prime farmland	114.6	39.7%
CmA	Cancienne silt loam, 0 to 1 percent slopes	All areas are prime farmland	14.7	5.1%
CT	Cancienne and Carville soils, gently undulating, frequently flooded	Not prime farmland	5.6	1.9%
GrA	Gramercy silty clay, 0 to 1 percent slopes	All areas are prime farmland	53.4	18.5%
LP	Levees-Borrow pits complex, 0 to 25 percent slopes	Not prime farmland	4.7	1.6%
SkA	Schriever clay, 0 to 1 percent slopes, rarely flooded	All areas are prime farmland	24.8	8.6%
Sm	Schriever clay, 0 to 1 percent slopes, frequently flooded	Not prime farmland	60.8	21.1%
W	Water	Not prime farmland	0.7	0.3%
Subtotals for Soil Survey Area			**279.4**	**96.9%**
Totals for Area of Interest			**288.3**	**100.0%**

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

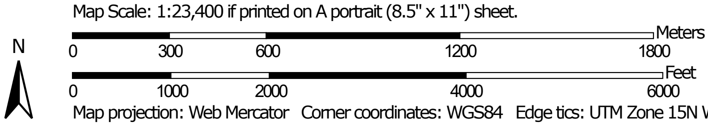
St. James Parish, Louisiana

St. James Project Area (Construction)

October 18, 2021

Custom Soil Resource Report
Soil Map

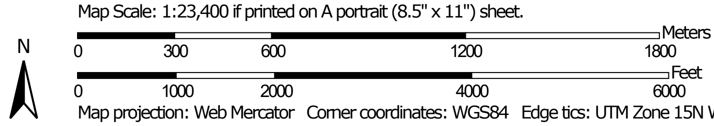
Map Scale: 1:23,400 if printed on A portrait (8.5" x 11") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

Map—Farmland Classification

Map Scale: 1:23,400 if printed on A portrait (8.5" x 11") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

Table—Farmland Classification

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
CmA	Cancienne silt loam, 0 to 1 percent slopes	All areas are prime farmland	149.1	11.0%
CnA	Cancienne silty clay loam, 0 to 1 percent slopes	All areas are prime farmland	157.1	11.6%
CvA	Carville silt loam, 0 to 1 percent slopes	All areas are prime farmland	77.7	5.7%
GrA	Gramercy silty clay, 0 to 1 percent slopes	All areas are prime farmland	626.0	46.3%
SkA	Schriever clay, 0 to 1 percent slopes, rarely flooded	All areas are prime farmland	121.6	9.0%
VhA	Vacherie very fine sandy loam, 0 to 1 percent slopes	All areas are prime farmland	221.6	16.4%
Totals for Area of Interest			**1,353.0**	**100.0%**

Rating Options—Farmland Classification

Aggregation Method: No Aggregation Necessary

Tie-break Rule: Lower

U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*	Date Of Land Evaluation Request
Name of Project BBA Construction Projects Mitigation	Federal Agency Involved USACE
Proposed Land Use Conversion to Forested Wetlands	County and State Louisiana St. Mary Ascension St. John E. Feliciana EBR St. James St. Tammany Tangipahoa
PART II *(To be completed by NRCS)*	Date Request Received By NRCS / Person Completing Form:

Does the site contain Prime, Unique, Statewide or Local Important Farmland? *(If no, the FPPA does not apply - do not complete additional parts of this form)*	YES ☐	NO ☐	Acres Irrigated	Average Farm Size

Major Crop(s)	Farmable Land In Govt. Jurisdiction Acres: %	Amount of Farmland As Defined in FPPA Acres: %
Name of Land Evaluation System Used	Name of State or Local Site Assessment System	Date Land Evaluation Returned by NRCS

PART III *(To be completed by Federal Agency)*	Maximum Points	Site A	Site B	Site C	Site D
A. Total Acres To Be Converted Directly		3,268			
B. Total Acres To Be Converted Indirectly		—			
C. Total Acres In Site		3,268			
PART IV *(To be completed by NRCS)* Land Evaluation Information					
A. Total Acres Prime And Unique Farmland					
B. Total Acres Statewide Important or Local Important Farmland					
C. Percentage Of Farmland in County Or Local Govt. Unit To Be Converted					
D. Percentage Of Farmland in Govt. Jurisdiction With Same Or Higher Relative Value					
PART V (To be completed by NRCS) Land Evaluation Criterion Relative Value of Farmland To Be Converted (Scale of 0 to 100 Points)					
PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(Criteria are explained in 7 CFR 658.5 b. For Corridor project use form NRCS-CPA-106)*	**Maximum Points**	Site A	Site B	Site C	Site D
		See Attached			
1. Area In Non-urban Use	(15)				
2. Perimeter In Non-urban Use	(10)				
3. Percent Of Site Being Farmed	(20)				
4. Protection Provided By State and Local Government	(20)				
5. Distance From Urban Built-up Area	(15)				
6. Distance To Urban Support Services	(15)				
7. Size Of Present Farm Unit Compared To Average	(10)				
8. Creation Of Non-farmable Farmland	(10)				
9. Availability Of Farm Support Services	(5)				
10. On-Farm Investments	(20)				
11. Effects Of Conversion On Farm Support Services	(10)				
12. Compatibility With Existing Agricultural Use	(10)				
TOTAL SITE ASSESSMENT POINTS	160				
PART VII ***(To be completed by Federal Agency)***					
Relative Value Of Farmland *(From Part V)*	100				
Total Site Assessment *(From Part VI above or local site assessment)*	160				
TOTAL POINTS ***(Total of above 2 lines)***	260				

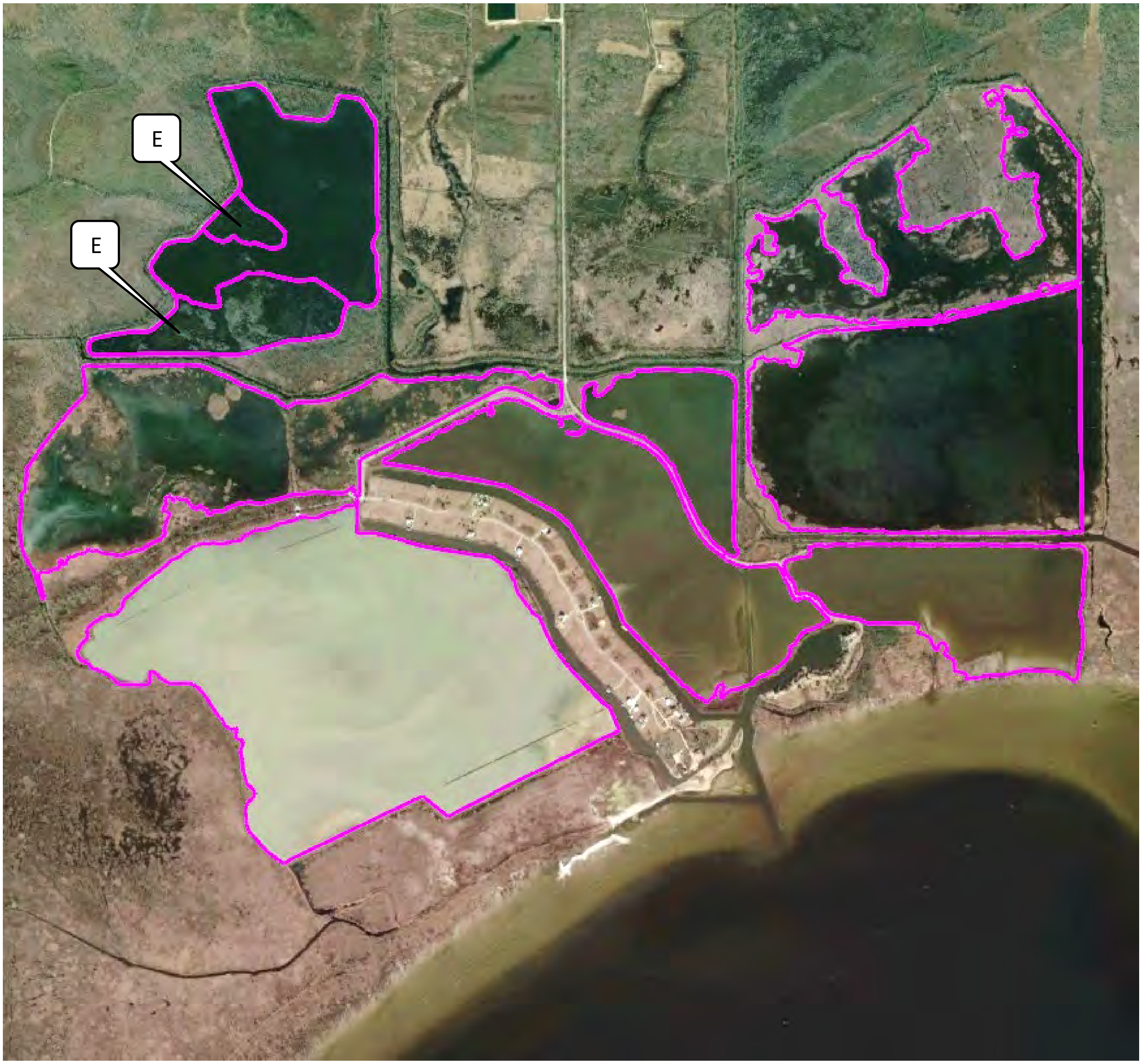
Site Selected: All Sites Attached	Date Of Selection July 8, 2019	Was A Local Site Assessment Used? YES ☐ NO ☐

Reason For Selection:

Name of Federal agency representative completing this form:	Date:

(See Instructions on reverse side)

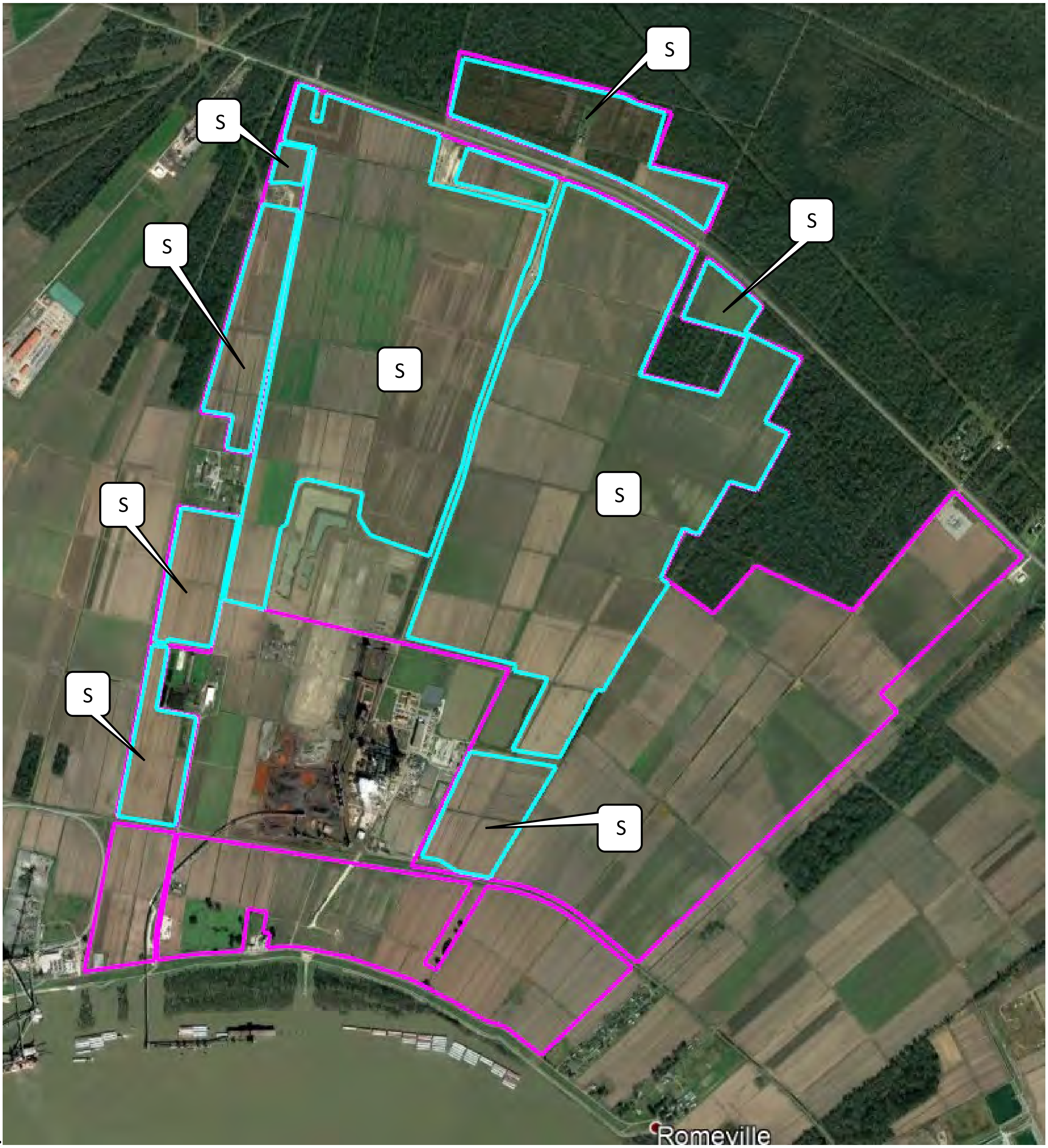
Form AD-1006 (03-02)



PINE ISLAND (P1)

SWAMP: 1,946 acres (865 AAHUs)

Not Prime Farmland



SAINT JAMES (P2)

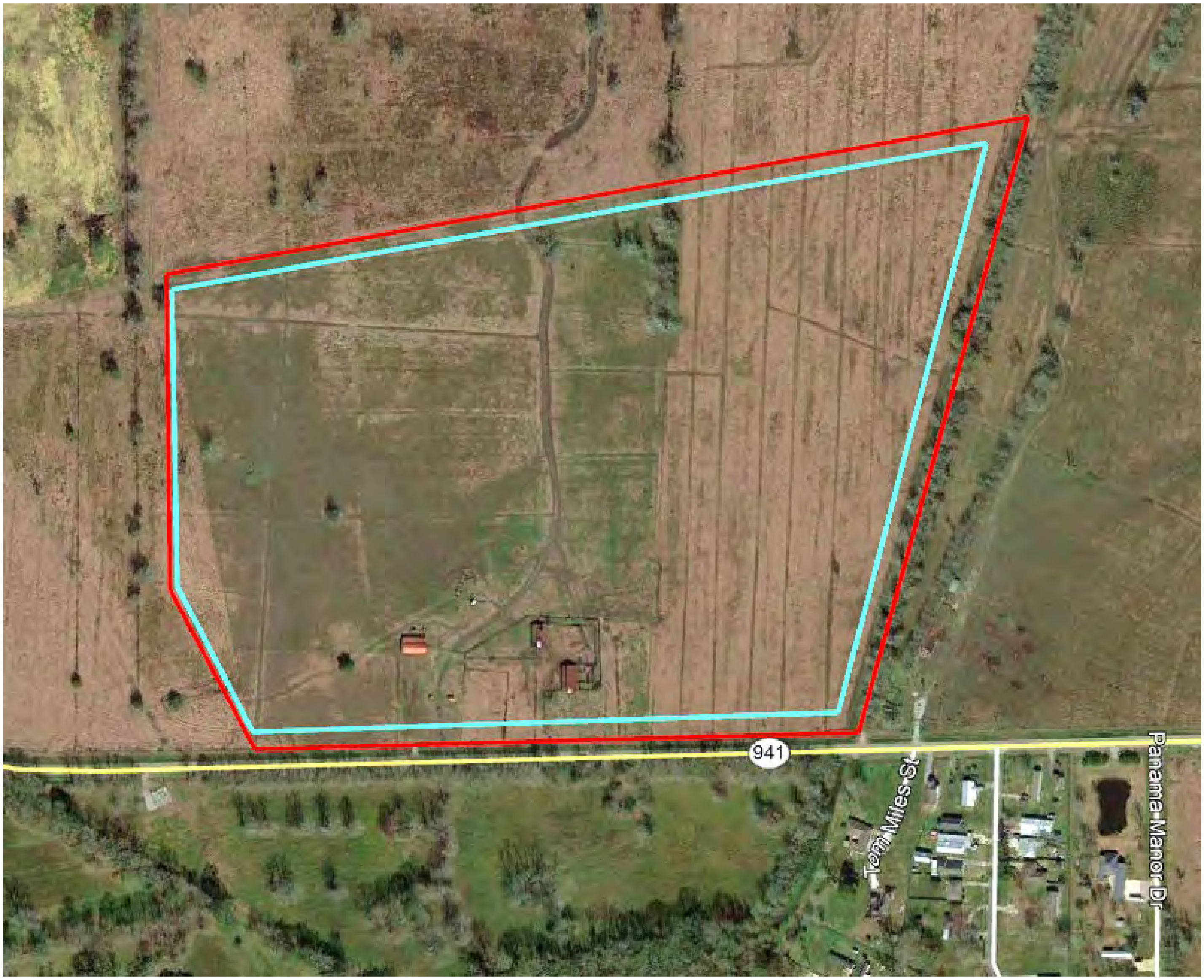
SWAMP (S) = 1,246.6 acres (561 AAHUs) OR – All mitigation areas may be BLH restoration (685.6 AAHUs)

1. 15	7. 10
2. 10	8. 10
3. 20	9. 5
4. 0	10. 15
5. 15	11. 10
6. 15	12. 0

SAINT JOHN (P3)

BLH = 94.7 acres (47 AAHUs)

1. 15	7. 0
2. 10	8. 10
3. 20	9. 5
4. 0	10. 15
5. 15	11. 10
6. 15	12. 0



ASCENSION SB (P6)

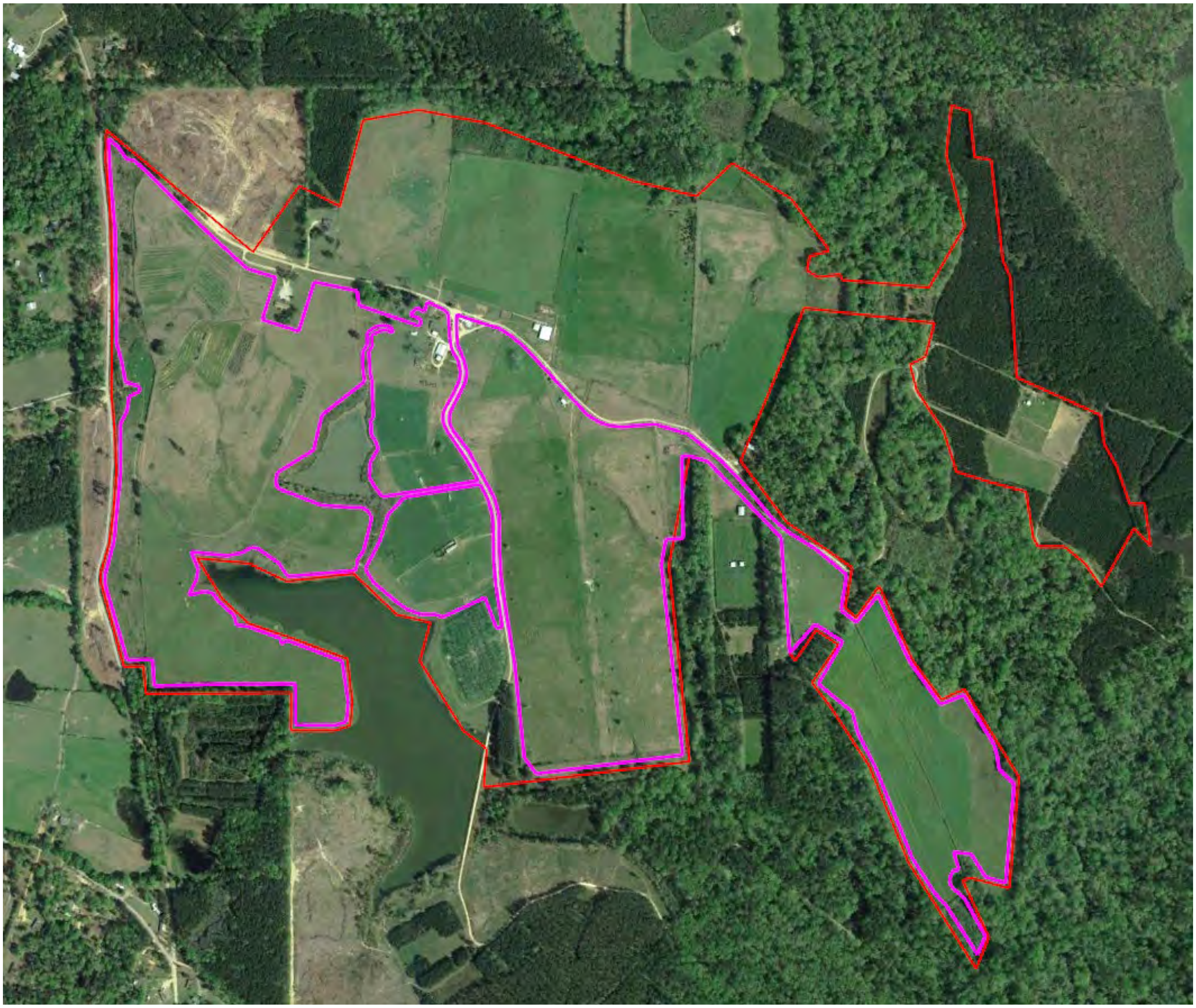
BLH = 56 acres (31 AAHUs)

1. 15	7. 0
2. 10	8. 10
3. 20	9. 5
4. 0	10. 19
5. 15	11. 10
6. 15	12. 0

GBRPC (P10)

BLH = 135 acres (68 AAHUs)

1. 15	7. 10
2. 10	8. 10
3. 20	9. 5
4. 0	10. 15
5. 15	11. 10
6. 15	12. 0



FELICIANA (P12)

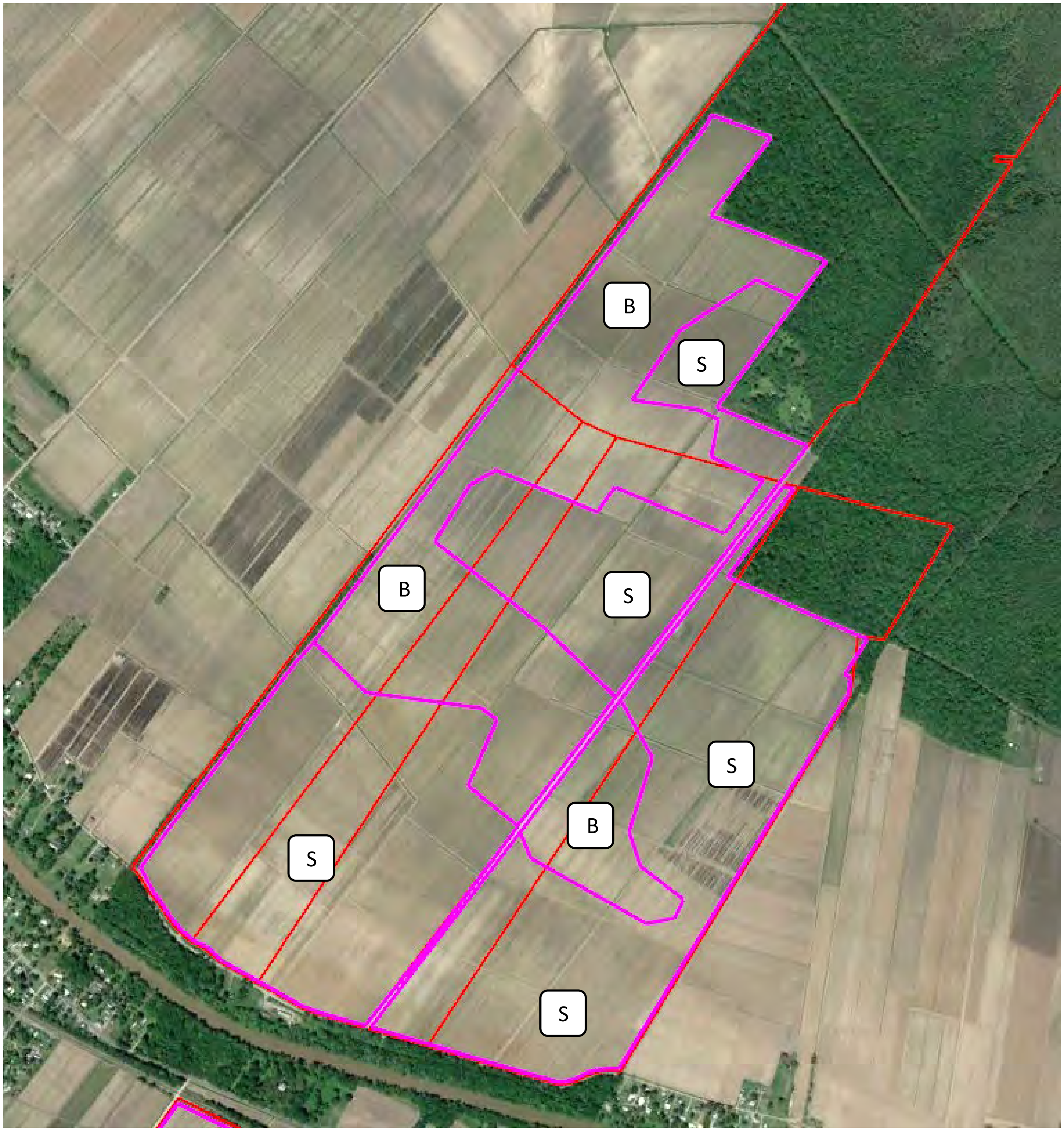
BLH = 267 acres (160 AAHUs)

1. 15	7. 7
2. 10	8. 10
3. 20	9. 5
4. 0	10. 16
5. 15	11. 10
6. 15	12. 0

r

JOYCE WMA (P14)
SWAMP = 1,126 acres, enhancement (338 AAHUs)

Not Prime Farmland

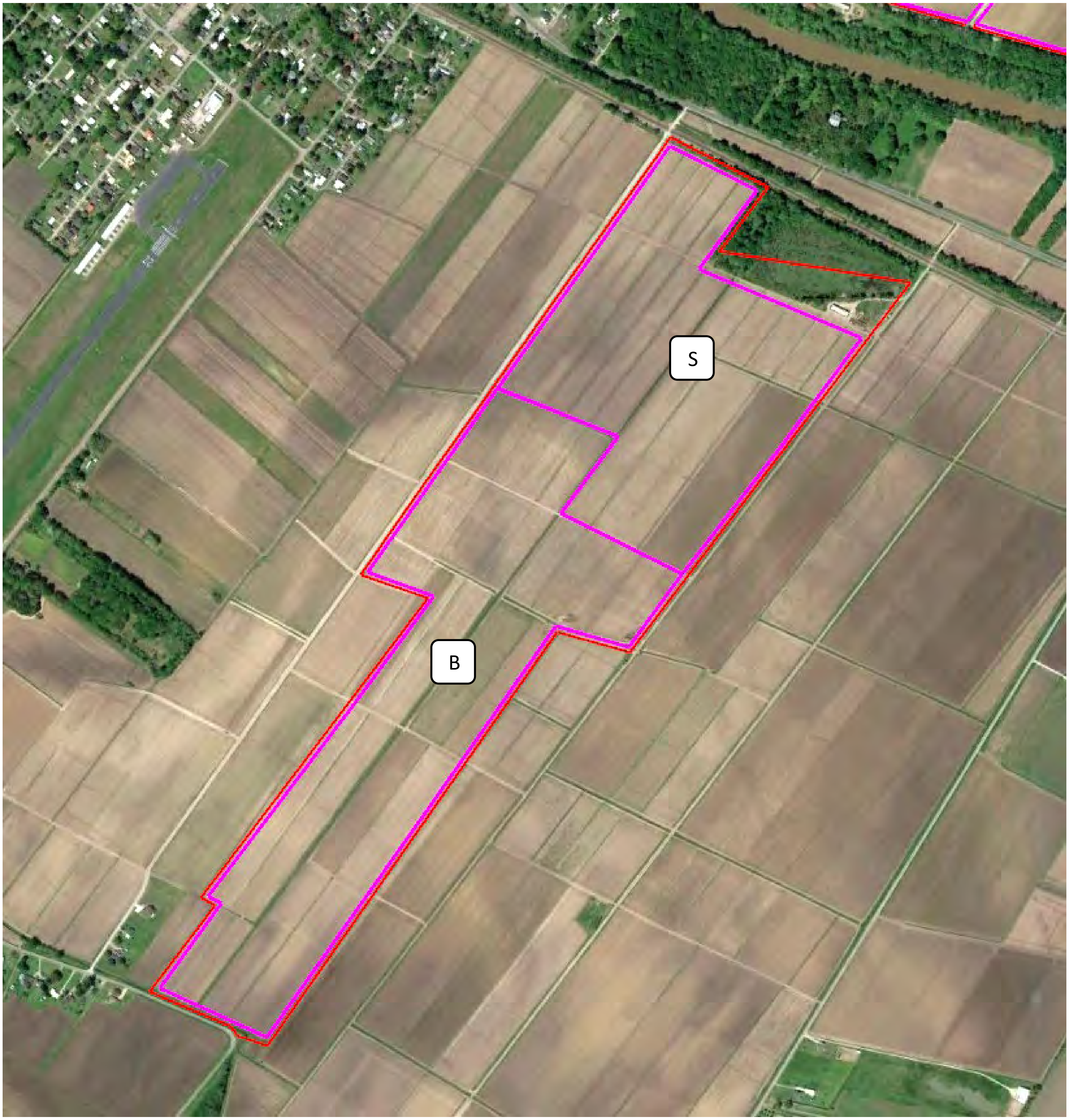


ALBANIA NORTH (V1)

SWAMP (S) = 633 acres (285 AAHUs)

BLH (B) = 332 acres (199 AAHUs)

1. 15	7. 5
2. 10	8. 10
3. 20	9. 5
4. 0	10. 12
5. 15	11. 10
6. 15	12. 0

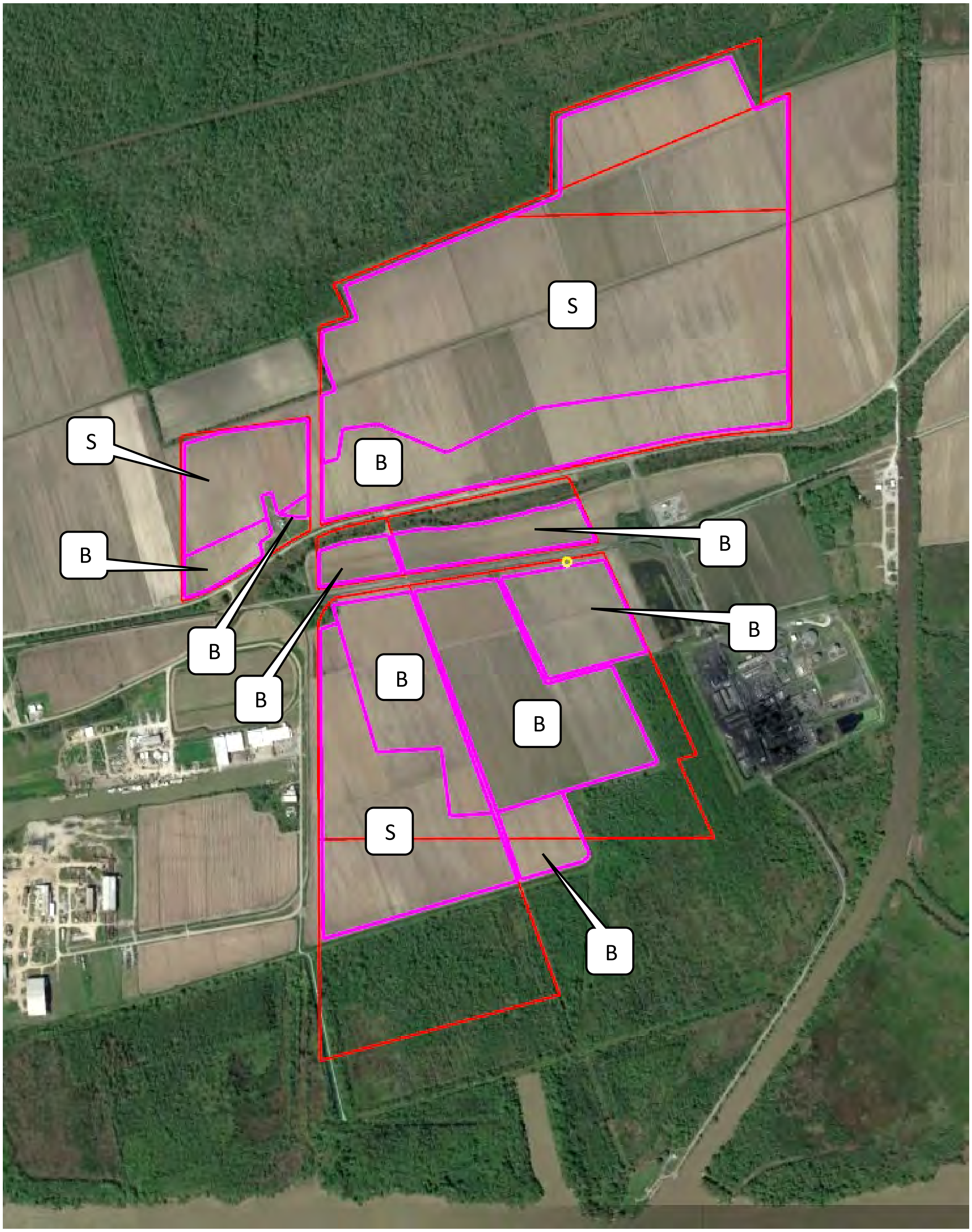


ALBANIA SOUTH (V2)

SWAMP (S) = 81 acres (32 AAHUs)

BLH (B) = 111 acres (61 AAHUs)

1. 15	7. 5
2. 10	8. 10
3. 20	9. 5
4. 0	10. 12
5. 15	11. 10
6. 15	12. 0



COTE BLANCHE (V3)

SWAMP (S) = 279 acres (126 AAHUs)

BLH (B) = 168 acres (92 AAHUs)

1. 15	7. 5
2. 10	8. 10
3. 20	9. 5
4. 0	10. 12
5. 15	11. 10
6. 15	12. 0

USDA

United States Department of Agriculture

September 24, 2019

Tammy Gilmore, Biologist/Environmental Resource Specialist
U.S. Army Corps of Engineers
Regional Planning and Environmental Division South
CEMVN-PDN-CEP
7400 Leake Avenue
New Orleans, LA 70118

RE: BBA Construction Project Mitigation – Multiple Parishes – Farmland Conversion Impact Rating; West Shore Lake Pontchartrain, Comite River Diversion, and East Baton Rouge Flood Risk Management

Dear Ms. Gilmore:

I have reviewed the above referenced project for potential requirements of the Farmland Protection Policy Act (FPPA) and potential impact to Natural Resource Conservation Service projects in the immediate vicinity.

Projects are subject to FPPA requirements if they may irreversibly convert farmland (directly or indirectly) to nonagricultural use and are completed by a federal agency or with assistance from a federal agency. For the purpose of FPPA, farmland includes prime farmland, unique farmland, and land of statewide or local importance. Farmland subject to FPPA requirements can be forest land, pastureland, cropland, or other land, but not water or urban built-up land.

The project map and narrative submitted with your request indicates that the proposed construction areas will potentially impact the following prime or unique farmland soils:

Albania North

Soil Map Unit and Symbol	Acres		RV
Iberia Parish			
Ba – Baldwin silty clay loam, 0 to 1 percent slopes	0.7		92
Gv – Galvez silt loam	0.6		100
Lo – Loreauville silt loam	0.7		100
Sh – Schriever clay, 0 to 1 percent slopes	0.2		92
Total Acres	2.2	Weighted Avg. RV	97

Natural Resources Conservation Service
State Office
3737 Government Street
Alexandria, Louisiana 71302
Voice: (318) 473-7751 Fax: (844) 325-6947

Helping People Help the Land

Soil Map Unit and Symbol	Acres		RV
St. Mary Parish			
BdA – Baldwin silty clay loam, 0 to 1 percent slopes	386.4		88
GaA – Galvez silt loam, 0 to 1 percent slopes	239.2		93
GxA – Uderts and Glenwild soils, 0 to 3 percents slopes	47.3		93
IbA – Iberia clay, 0 to 1 percent slopes	180.2		88
LoA – Loreauville silt loam, 0 to 1 percent slopes	118.7		96
ShA – Schriever clay, 0 to 1 percent slopes	19.1		81
Total Acres	990.9	Weighted Avg. RV	90

Albania South

Soil Map Unit and Symbol	Acres		RV
BdA – Baldwin silty clay loam, 0 to 1 percent slopes	24.9		100
CoA – Coteau silt, 0 to 1 percent slopes	16.2		93
IbA – Iberia clay, 0 to 1 percent slopes	67.5		100
JaA – Jeanerette silt loam, 0 to 1 percent slopes	21.3		100
PaA – Patoutville silt, 0 to 1 percent slopes	77.1		93
Total Acres	207.0	Weighted Avg. RV	97

Ascension

Soil Map Unit and Symbol	Acres		RV
Es – Essen silt loam	0.1		72
Sa – Sharkey silty clay loam	3.1		85
Sc – Sharkey clay, 0 to 1 percent slopes, rarely flooded	59.9		85
Total Acres	63.0	Weighted Avg. RV	85

Cote Blanche

Soil Map Unit and Symbol	Acres		RV
BdA – Baldwin silty clay loam, 0 to 1 percent slopes	230.1		96
DrA – Dupuy silt loam, 0 to 1 percent slopes	69.0		93
IbA – Iberia clay, 0 to 1 percent slopes	108.8		88
LoA – Loreauville silt loam, 0 to 1 percent slopes	88.6		100
Total Acres	496.5	Weighted Avg. RV	95

Feliciana

Soil Map Unit and Symbol	Acres		RV
Ca – Calhoun silt loam, 0 to 1 percent slopes	0.2		59
Dx – Dexter silt loam, 1 to 3 percent slopes	4.7		88
Fk – Fluker silt loam, 0 to 2 percent slopes	17.6		70
Lt – Lytle silt loam, 1 to 3 percent slopes	4.4		80
Ta – Tangi silt loam, 1 to 3 percent slopes	102.4		80
To – Toula silt loam, 1 to 3 percent slopes	6.0		80
Total Acres	135.3		79

GBRPC

Soil Map Unit and Symbol	Acres	RV
CmA – Cancienne silt loam, 0 to 1 percent slopes	11.3	81
ShB – Schriever-Thibaut clays, gently undulating	149.0	70
Total Acres	160.3	71

Gravity

Soil Map Unit and Symbol	Acres	RV
Cm – Commerce silt loam, 0 to 1 percent slopes	5.2	100
Co – Commerce silty clay loam	18.4	100
Sc – Sharkey clay, 0 to 1 percent slopes, rarely flooded	61.6	85
Total Acres	85.2	89

Saint James

Soil Map Unit and Symbol	Acres	RV
CmA – Cancienne silt loam, 0 to 1 percent slopes	149.0	100
CnA – Cancienne silty clay loam, 0 to 1 percent slopes	157.1	100
CvA – Carville silt loam, 0 to 1 percent slopes	77.7	100
GrA – Gramercy silty clay, 0 to 1 percent slopes	626.1	85
SkA – Schriever clay, 0 to 1 percent slopes	121.5	85
VhA – Vacherie very fine sandy loam, 0 to 1 percent slopes	221.6	100
Total Acres	1353.0	92

Saint John

Soil Map Unit and Symbol	Acres	RV
CmA – Cancienne silt loam, 0 to 1 percent slopes	101.6	100
GrA – Gramercy silty clay, 0 to 1 percent slopes	2.5	85
Total Acres	104.1	100

Please find attached an AD-1006 'Farmland Conversion Impact Rating' form for each construction area related to this project with our agency's information completed. Furthermore, we do not predict impacts to NRCS work in the vicinity.

For specific information about the soils found in the project area, please visit our Web Soil Survey at the following location: http://websoilsurvey.nrcs.usda.gov/

For more information on FPPA requirements or the process to receive a Farmland Conversion Impact Rating (Form AD-1006 or CPA-106) please visit the following location: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/landuse/fppa/

Please direct all future correspondence to me at the address shown below.

Respectfully,

W. B.

Acting for Tim Landreneau
Acting State Conservationist

Attachment

Section 106

APPENDIX J
CULTURAL RESOURCES

TABLE OF CONTENTS

INTRODUCTION

On October 19, 2021, CEMVN sent letters to consulting Federally Recognized Tribes, Louisiana State Historic Preservation Office, and the Advisory Council of Historic Preservation notifying the consulting parties to the BBA 18 Habitat Mitigation Programmatic Agreement (PA) that it is adding an additional swamp mitigation project to those already under consideration under Appendix B of the PA, providing rational for doing so, and sharing currently available information about the additional proposed mitigation alternative. This Appendix Q includes those letters, the responses CEMVN received to the letters, and a copy of the executed BBA 18 Habitat Mitigation PA.

AQ-1 ITEM 1: SEIS TO WSLP PROJECT COORDINATION LETTERS AND RESPONSES

AQ-1.1: SEIS to WSLP Project Coordination Letters

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 Leake Ave, New Orleans, LA 70118

October 19, 2021

Regional Planning and
Environment Division, South
Environmental Planning Branch
Attn: CEMVN-PDS-N

Cecilia Flores, Tribal Council Chairperson
Alabama-Coushatta Tribe of Texas
571 State Park Rd 56
Livingston, TX 77351

RE: **Section 106 Notification -** Addition of Maurepas Swamp Project (MSP) to Appendix B of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA).

Dear Chairperson Flores:

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative.

Background

Previously, CEMVN evaluated environmental impacts due to construction of the West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Project (WSLP Project) through a Supplemental Environmental Assessment (SEA) 576, which addressed mitigation for habitat impacts associated with each of the Bipartisan Budget Act (BBA) 18 construction projects (i.e., WSLP Project, Comite Project, and East Baton Rouge Project). The Finding of No Significant Impact (FONSI) for SEA 576 was signed by the CEMVN District Commander on April 4, 2020. Associated with this effort was the development and execution of the BBA 18 Habitat Mitigation PA to provide an alternative NHPA Section 106

process tailored to the construction of habitat mitigation projects (enclosed). As part of the public review process, the Non-Federal Sponsor, Louisiana's Coastal Protection Restoration Authority (CPRA), requested that CEMVN evaluate the Mississippi River Diversion into Maurepas Swamp [PO-29; Maurepas Swamp Project (MSP)], a proposed ecological restoration project that shares construction features with the WSLP Project, be considered as a mitigation alternative for impacts to swamp habitat associated with the construction of the WSLP Project.

In order to evaluate the proposed mitigation project in a manner similar to the other proposed mitigation projects, CEMVN is preparing a Supplemental Environmental Impact Statement to West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study (WSLP SEIS) to compare viable swamp mitigation alternatives within the Pontchartrain Basin. As part of this effort, CEMVN will be utilizing the currently executed BBA 18 Habitat Mitigation PA to conduct any additional necessary Historic Property identification, NRHP evaluation, consultation, and mitigation, as this mitigation project clear meets the intent of the PA after reviewing the preamble and the applicability description in Appendix B.

Initial notification was distributed to consulting parties as part of the annual report of activities on March 25, 2021, via email (enclosed). The Louisiana State Historic Preservation Office (LA SHPO) responded on March 25, 2021 saying, "the State Historic Preservation Office concurs that incorporating the WSLP Maurepas Diversion Habitat Management Site under the terms of the BBA-18 Habitat Mitigation Programmatic Agreement is appropriate."

Description of Undertaking- Maurepas Swamp Project (MSP)

Pursuant to Stipulation II. C., Defining the Undertaking, CEMVN is sharing the current designs for the plan and the initial historic property findings for this mitigation project. The proposed Maurepas Swamp Project (MSP) involves a freshwater diversion that would reconnect the Mississippi River to the Maurepas Swamp, strategically delivering nutrient-laden river water to restore the health of the dying Cypress-Tupelo Swamp. The project is proposed as a 2,000 cubic foot per second (cfs) freshwater diversion with the intake of the conveyance channel located on the West Bank of the Mississippi River in St. John the Baptist Parish, immediately west of Garyville, Louisiana, at River Mile 144 Above Head of Passes (AHP). The 300 ft wide construction corridor for the conveyance channel extends from LA 44 (River Road) northward. It extends northward for 5½ miles, terminating approximately 1,000 ft north of Interstate 10 (I-10) (Figure 1, 2 and 3).

The primary project features are located in St. John the Baptist Parish and are comprised of, but not limited to, the following elements:

- an intake channel from the Mississippi River; *(Figure 4, Figure 3)*
- an automated gate structure in the Mississippi River Levee (MRL); *(Figure 4)*
- a sedimentation basin; *(within the conveyance channel)*
- a 5.5-mile long open conveyance channel; *(Figure 4)*
- box culverts under River Road, Canadian National Railroad (CN), and Airline Highway; *(Figure4)*

- a bridge over the channel at Kansas City Southern Railroad (KCS); *(Figure 4)*
- 8 lateral discharge valves between Airline Highway and I-10 to carry flow from the conveyance channel to areas east and west of the channel (Figure 3);
- check valving on culverts underneath I-10 to mitigate southward backflow (Figure 3);
- reshaping the geometry of the existing Hope Canal channel under I-10 (Figure 3 and 2)
- embankment cuts in the existing ridge of an old railroad embankment; *(Figure 3)* and
- submerged rock rip-rap weirs in Bayou Secret and Bourgeois Canal; *(Figure 3)*

The intake channel is roughly 400 ft long by 200 ft wide, with a bottom depth at EL (-) 4 ft NAVD88 excavated into the batture to route flow from the Mississippi River into the diversion headworks. The channel will be lined with riprap to prevent scour. The primary function of the headworks structure is to convey flow from the intake channel underneath the Mississppi River Levee (MRL). It will be comprised of a multi-cell box culvert with vertical lift gates (sluice gates) (Figure 4).

The outlet for the conveyance channel is along the existing centerline of Hope Canal. The guide levee elevations from the Interstate 10 (I-10) bridges to the termination point gradually transition to existing grade. At that point the diverted water will overflow the canal banks and dissipate into the area above I-10, south of Lake Maurepas.

The diversion flow of 2,000 cfs generally spreads radially outwards as it enters the swamp north of I-10. Approximately, one-third flows westward through the swamp, one-third flows through Dutch Bayou and the remaining third flows eastward through the swamp. The westward flow enters Blind River and largely proceeds to Lake Maurepas. The eastward flow enters the Reserve Relief Canal and mostly proceeds to Lake Maurepas. Most of the swamp water is displaced by the introduced Mississippi River water (Figure 1,3, and 5). This spreading water is captured in the figures and is what accounts for this being a mitigation project for swamp habitat.

Required earthwork would consist of clearing, grubbing, excavation, and removal of earthen material for the project's conveyance channel and disposal at an approved disposal site. When possible, unsuitable excavated material could be utilized beneficially. If a borrow study in subsequent design phases indicates sufficient suitable material within the excavated material, the Contractor may elect to use that material on-site. Any material used on site would stay within the right-of-way (ROW) and would be used to construct features.

Additional earthwork outside of the conveyance channel will occur along the existing ridge of an old railroad embankment. 7.51 acres along the old railroad embankment will be cleared for equipment access. 5 individual areas along the embankment will be excavated to existing grade while all spoil will be placed in 20 individual areas along the embankment. It is anticipated that no material will be removed from the project area.

Area of Potential Effect (APE)

Pursuant to Stipulation II. D. (1-4) of the BBA 18 Mitigation PA, CEMVN has defined a

preliminary APE in Figure 1 and 5. The APE incorporates both direct effects (e.g., access, staging, and construction areas), indirect effects (e.g., visual), and areas of inundation (outflow area). The direct construction APE of the MSP is approximately 288.30 acres (116.67 hectares). The Indirect APE extends beyond the construction footprint for roughly 50 feet. The outflow area APE includes Maurepas Swamp and Lake Maurepas and is approximately 90,357 acres (36,566 hectares). The total APE, direct and indirect, is approximately 90,652.7 acres (36,686.12 hectares) (Figure 1 and 5). It is acknowledged that this APE is preliminary based on the state of development of the project. Should the APE need to be revised, CEMVN will follow provision II. D. 3. Of the BBA 18 Mitigation PA to proposed revisions.

Historic Property Identification and Evaluation Efforts

CEMVN identified historic properties within the project footprint, mitigation areas, and impact areas (collectively the APE) based on a review of the NRHP database, the Louisiana Division of Archaeology (LDOA) Louisiana Cultural Resources Map (LDOA Website), historic maps, pertinent regional and local cultural resources investigations, historic aerial photography, and other appropriate sources. This review identified 15 previous cultural resources surveys, 11 previously recorded archaeological sites, and three (3) previously recorded architectural resources within the MSP APE (Figure 5).

Archaeological

A total of eleven (11) archaeological sites are present within the MSP APE. Two (2) of these sites are not eligible for the NRHP, 16SJ73 (Blind River Timber Rail) and 16SJB68 (Angelina Plantation, Note: Locus A of 16SJ68 is of unknown eligibility). Seven (7) sites are listed as unknown eligibility (16AN8, 16LV24, 16LV73, 16LV74, 16LV103, 16SJ72, and 16SJB4). These sites include four (4) prehistoric shell middens (16AN8, 16LV73, 16LV24, 16SJB4), 2 possible watercrafts/shipwrecks (16LV74, 16SJ72), one (1) railroad bridge (16SJ72), and the Amite River Diversion Canal (16LV103). Two (2) cemeteries are present within the APE (16SJ58, 16SJ61), both dating back to the Civil War.

Fifteen (15) previous cultural surveys have been performed within the MSP APE. Most of these surveys did not discover existing cultural resources within the MSP APE. A total of nine (9) surveys occurred near or in the Angelina Plantation site (16SJB68). They are 22-3023, 22-3793, 22-4288, 22-4571, 22-4571-1, 22-4571-2, 22-4690, 22-5431, 22-6238. A Phase I Cultural Resources Survey of the River Reintroduction Corridor, Maurepas Swamp (PO-29), St. John the Baptist Parish, Louisiana was performed by Coastal Environments, Inc. in 2008, and included the proposed footprint of the Maurepas Diversion Canal corridor from Interstate-10 to the Mississippi River (Wells 2008; 22-3023). No eligible archaeological sites were recorded as a result of this survey.

Architectural

The proposed project is located approximately one (1) mile from the Garyville Historic District, a National Register Historic District (NRHD) listed in the NRHP in 1990. Tree coverage along the majority of LA-54 separates the Garyville Historic District from the proposed project. The proposed project is located west of LA-54 while the Garyville Historic District is located east of LA-54. No individual historic properties were identified as listed, or formally determined eligible for listing by the Keeper, in the NRHP within the project, mitigation, and impact areas. No previously recorded built resources are located

within the mitigation and impact areas.

Review of previous investigations revealed three built resources (Louisiana Historic Resource Inventory (LHRI) ID Number 48-01071, 48-01073, and 48-01089) within or adjacent to the project area that were individually documented in 1985. According to the LDOA Cultural Resources Map, these three resources are near River Road and the proposed headworks and intake structures. During the mid-1980's, many of the surveyed resources were identified by Post Office Box or only the street name. As a result, LHRI Numbers 48-01071, 48-01073, and 48-01089 do not have identifying street numbers and street names. Visual inspection via Google Street View suggests that these three (3) resources may have been demolished or their LHRI locations are plotted incorrectly on the LDOA Cultural Resources Map.

The Earnest Amann Subdivision borders the proposed project to the east. Marigold Street runs parallel to the proposed project footprint and was developed likely in the late 1950s with dwellings constructed on the east side of the street by the early 1960s (NETR 1961). A review of aerial photographs and historic USGS maps reveal that the east side of Marigold Street was fully developed by the early 1980s (NETR 1981). The west side of Marigold Street developed sometime after 1970 (NETR 1971). As a result, built resources 50 years of age or older are present adjacent to the proposed project area.

Assessment of the Undertaking's Potential to Effect Historic Properties

The exact impact assessment for this project is currently unknown but will be updated as the MSP develops, and consultation continues. This project includes ground disturbing activities involving access, staging, construction of structural features (intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, box culverts, and other features as described in Figures 1-2), and borrow fill. These activities may directly impact both known and undocumented cultural resources listed or eligible for listing in the NRHP not limited to: archaeological sites; historic built resources; cemeteries or other sites that may contain human remains, funerary objects, sacred objects, or objects of cultural patrimony; and TCPs; that exist both within the project footprint and associated areas in a way that will diminish the integrity of these property's location, design, setting, materials, workmanship, feeling, or association.

The MSP includes the introduction of new visual elements to the project area's viewshed that have the potential to indirectly impact known and previously undocumented cultural resources that may be listed or eligible for listing in the NRHP. These elements include a roughly 400 ft. long by 200 ft. wide intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, and other features as described in Figures 1-2. The introduction of new visual elements that are inconsistent with the historic or cultural character of these potential resources could indirectly diminish the integrity of the property's setting, feeling, or association and/or cause changes to the integrity of feeling or character associated with a historic resource or TCP.

The proposed project is located approximately one mile from the Garyville Historic District, a NRHD listed in the NRHP in 1990. No indirect effects to the Garyville Historic District would occur due to tree coverage along the majority of LA-54 which separates the Garyville Historic District from the proposed project. However, the proposed project could

potentially indirectly effect three built resources (LHRI ID Number 48-01071, 48-01073, and 48-01089). Additionally, the proposed project could potentially indirectly affect built resources 50 years of age or older within the Earnest Amann Subdivision, which borders the proposed project to the east.

Based on the current understanding of the historic properties in the APE and the potential effects from direct and indirect causes, CEMVN will continue to consult as anticipated historic property identification surveys are completed and affect determination are made following the terms of the BBA 18 PA. The commitment to follow the procedures in the BBA 18 Mitigation PA will also be reflected in the WSLP SEIS and the Record of Decision.

If you have any questions or require additional information concerning this undertaking, please contact Ms. Ashley Fedoroff, archaeologist, at (601) 631-5278 or via e-mail Ashley.M.Fedoroff@usace.army.mil, Ms. Jill Enersen, Architectural Historian, at (504) 862-1741 or Jill.A.Enersen@usace.army.mil, or Mr. Jason Emery, Tribal Liaison, at (504) 862-2364 or via email Jason.A.Emery@usace.army.mil.

Sincerely,

MARSHALL K. HARPER
Chief, Environmental Planning Branch

Enclosures
1. BBA 18 Mitigation PA
2. 25 March 2021, Annual Report with project list to include WSLP Swamp Mitigation.

CC: File
An electronic copy of this letter with enclosures will be provided to Mr. Bryant J. Celestine, Historic Preservation Officer, Alabama Coushatta Tribe of Texas, celestine.bryant@actribe.org.

List of Recipients:
Alabama Coushatta Tribe of Texas
Chitimacha Tribe of Louisiana
Choctaw Nation of Oklahoma
Coushatta Tribe of Louisiana
Jena Band of Choctaw Indians
Mississippi Band of Choctaw Indians
Muscogee (Creek) Nation
Seminole Nation of Oklahoma
Tunica-Biloxi Tribe of Louisiana
Louisiana State Historic Preservation Office (SHPO)
Advisory Council of Historic Places (ACHP)

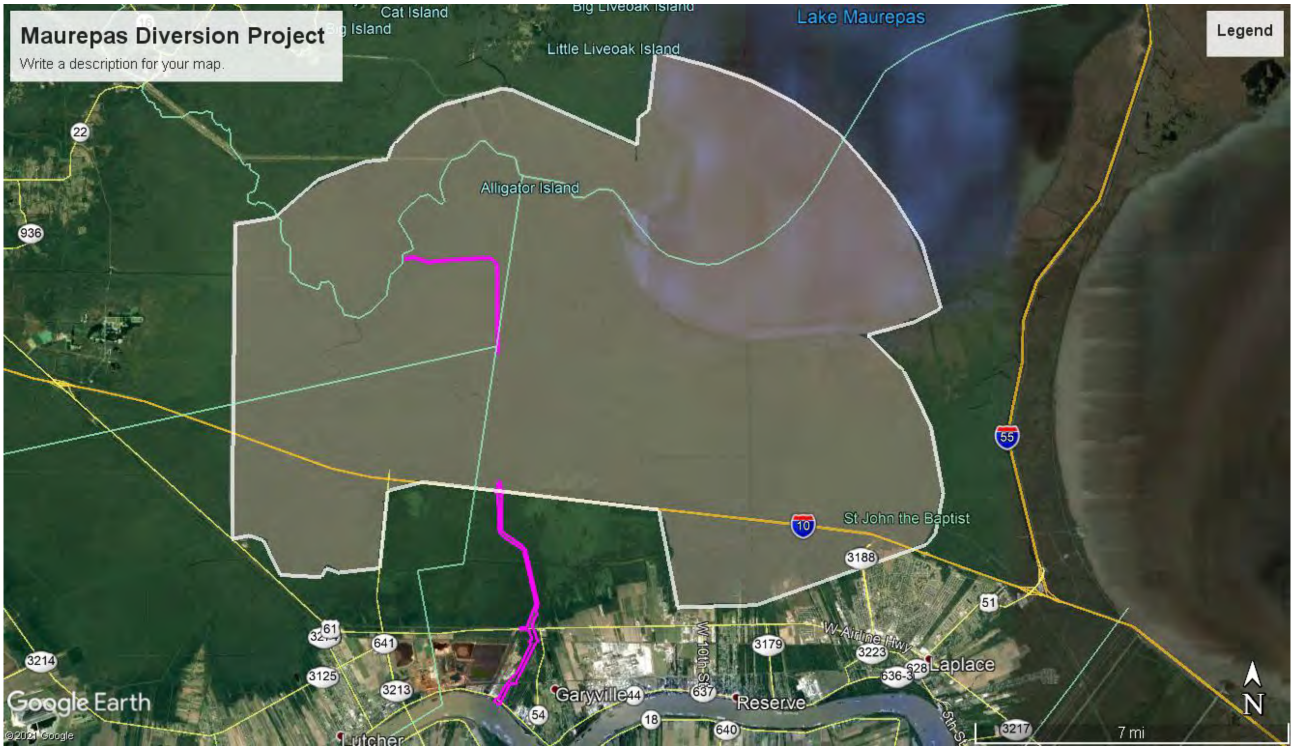


Figure 1. Overview of Maurepas Swamp Project APE: Direct Impact APE (pink) and Indirect Impact APE (white).

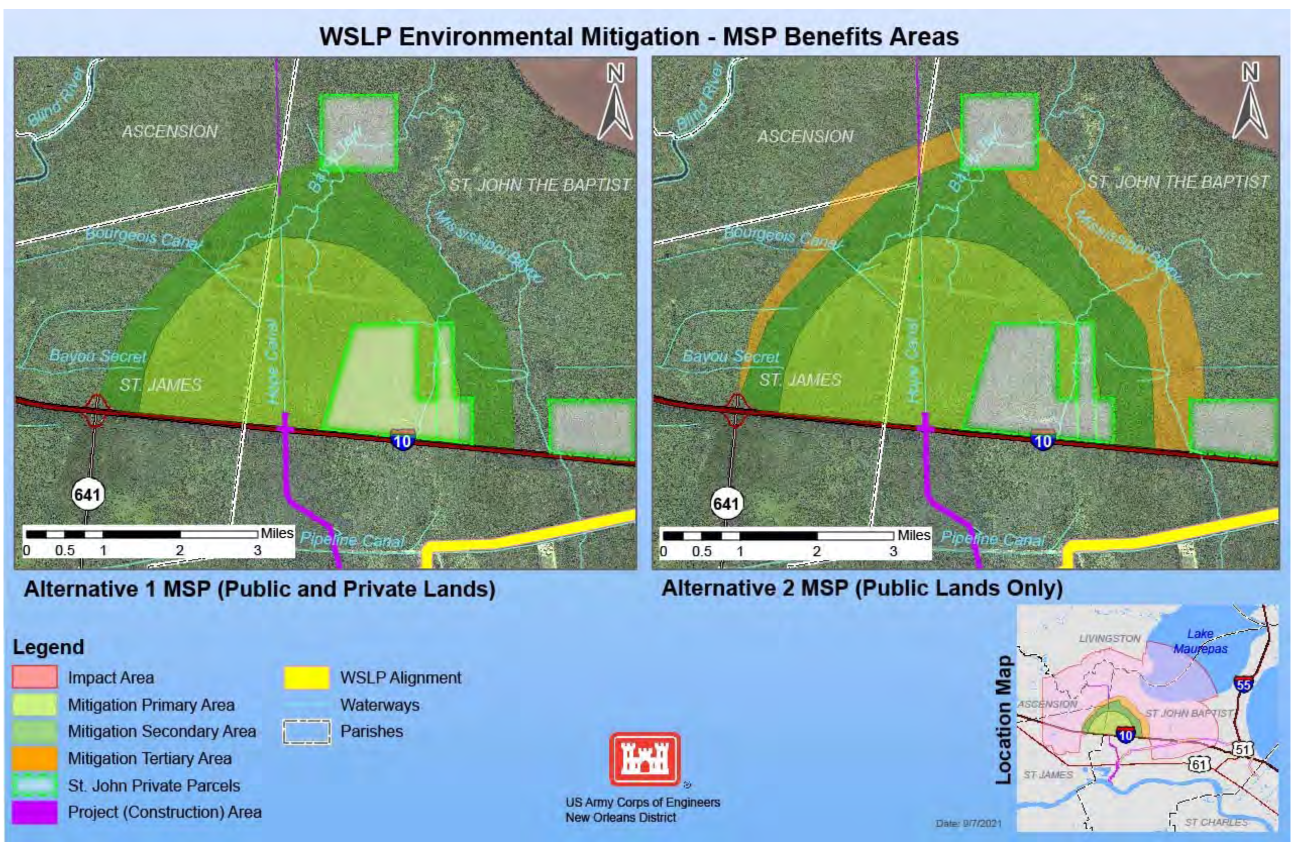


Figure 2. Detail of the Marurepas Swamp Project Mitigation Alternatives MSP 1 and MSP2.

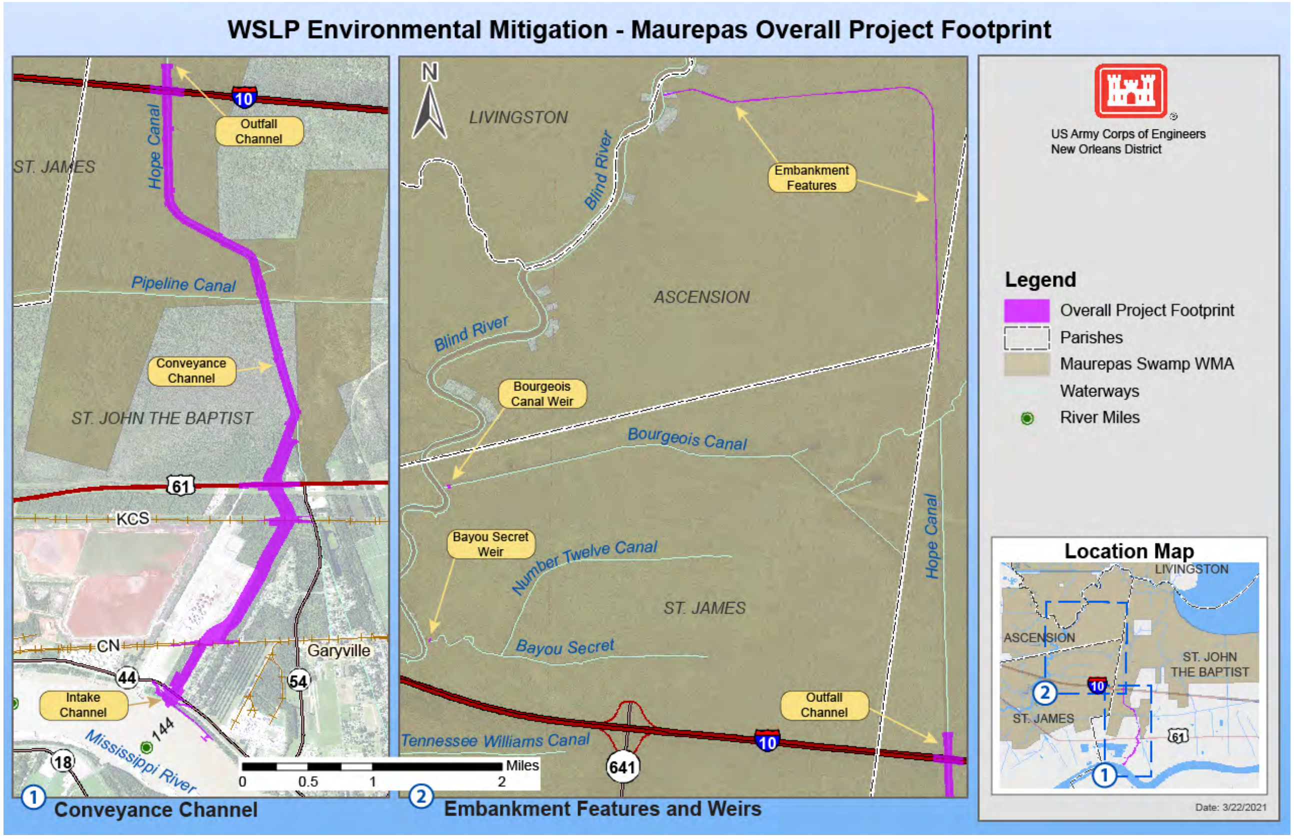


Figure 3. Detail of the construction features of for the diversion to facilitate the Maurepas Swamp Mitigation Project. Intake structure and convenance channel (left) and the weir and embankment features (right).

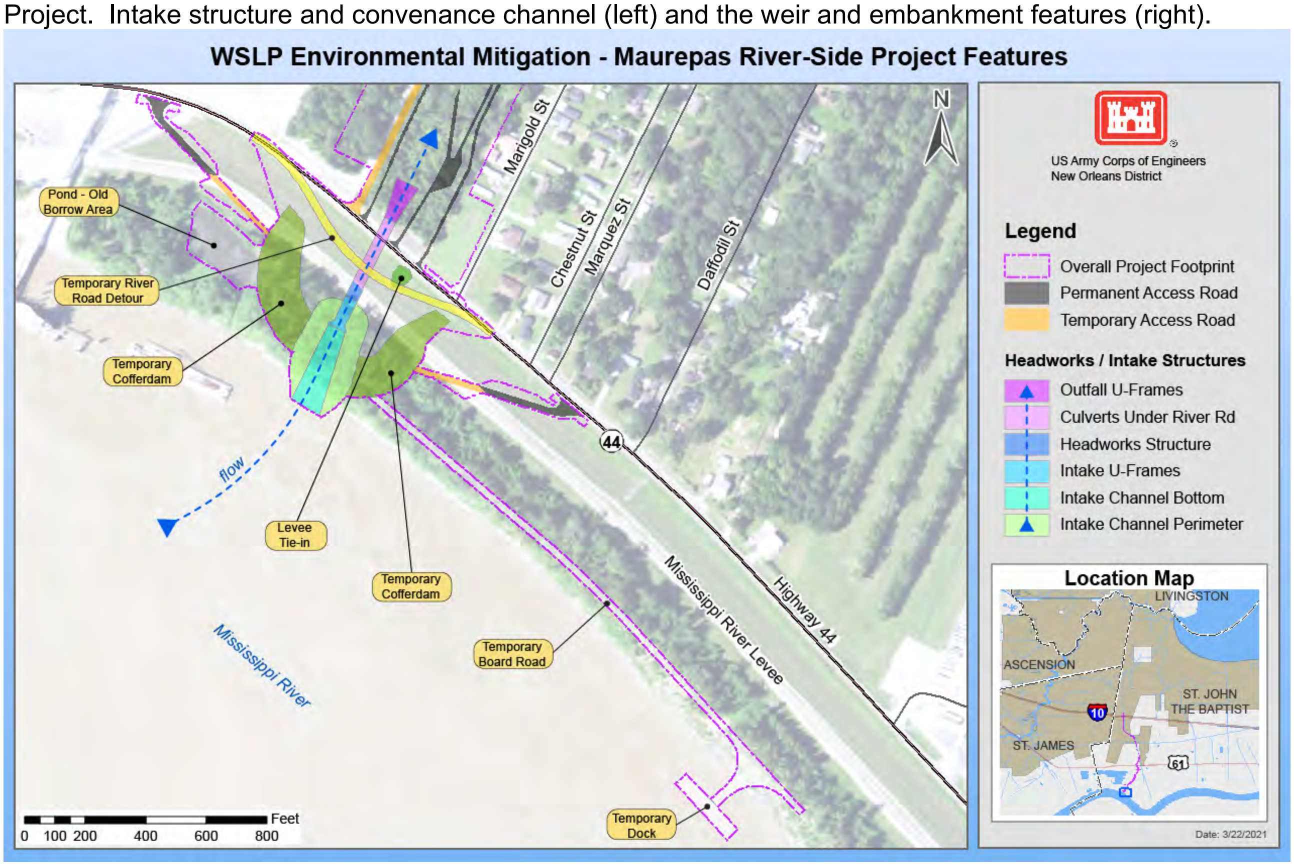


Figure 4 : Detail of the Intake Structure and appurtenant features.

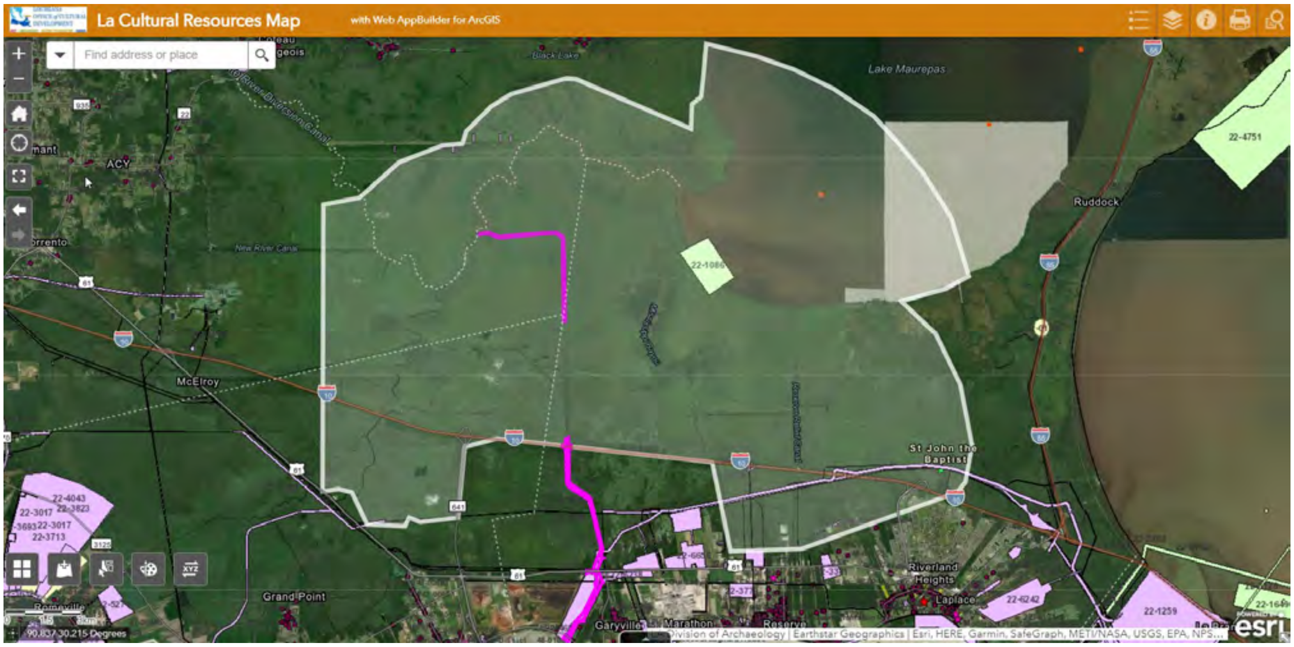


Figure 5: Maurepas Swamp Project APE: Direct Impact APE (pink) and Indirect Impact APE (white). LDOA Cultural Resources Map. Note that the conveyance channel area has been surveyed under LDOA Report # 22-3023.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 Leake Ave, New Orleans, LA 70118

October 19, 2021

Regional Planning and
Environment Division, South
Environmental Planning Branch
Attn: CEMVN-PDS-N

Melissa Darden, Chairman
Chitimacha Tribe of Louisiana
P.O. Box 661
Charenton, LA 70523

RE: Section 106 Notification - Addition of Maurepas Swamp Project (MSP) to Appendix B of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA).

Dear Chairman Darden:

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative.

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process tailored to the construction of habitat mitigation projects (enclosed). As part of the public review process, the Non-Federal Sponsor, Louisiana's Coastal Protection Restoration Authority (CPRA), requested that CEMVN evaluate the Mississippi River Diversion into Maurepas Swamp [PO-29; Maurepas Swamp Project (MSP)], a proposed ecological restoration project that shares construction features with the WSLP Project, be considered as a mitigation alternative for impacts to swamp habitat associated with the construction of the WSLP Project.

In order to evaluate the proposed mitigation project in a manner similar to the other proposed mitigation projects, CEMVN is preparing a Supplemental Environmental Impact Statement to West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study (WSLP SEIS) to compare viable swamp mitigation alternatives within the Pontchartrain Basin. As part of this effort, CEMVN will be utilizing the currently executed BBA 18 Habitat Mitigation PA to conduct any additional necessary Historic Property identification, NRHP evaluation, consultation, and mitigation, as this mitigation project clear meets the intent of the PA after reviewing the preamble and the applicability description in Appendix B.

Initial notification was distributed to consulting parties as part of the annual report of activities on March 25, 2021, via email (enclosed). The Louisiana State Historic Preservation Office (LA SHPO) responded on March 25, 2021 saying, "the State Historic Preservation Office concurs that incorporating the WSLP Maurepas Diversion Habitat Management Site under the terms of the BBA-18 Habitat Mitigation Programmatic Agreement is appropriate."

Description of Undertaking- Maurepas Swamp Project (MSP)

Pursuant to Stipulation II. C., Defining the Undertaking, CEMVN is sharing the current designs for the plan and the initial historic property findings for this mitigation project. The proposed Maurepas Swamp Project (MSP) involves a freshwater diversion that would reconnect the Mississippi River to the Maurepas Swamp, strategically delivering nutrient-laden river water to restore the health of the dying Cypress-Tupelo Swamp. The project is proposed as a 2,000 cubic foot per second (cfs) freshwater diversion with the intake of the conveyance channel located on the West Bank of the Mississippi River in St. John the Baptist Parish, immediately west of Garyville, Louisiana, at River Mile 144 Above Head of Passes (AHP). The 300 ft wide construction corridor for the conveyance channel extends from LA 44 (River Road) northward. It extends northward for 5½ miles, terminating approximately 1,000 ft north of Interstate 10 (I-10) (Figure 1, 2 and 3).

The primary project features are located in St. John the Baptist Parish and are comprised of, but not limited to, the following elements:

- an intake channel from the Mississippi River; *(Figure 4, Figure 3)*
- an automated gate structure in the Mississippi River Levee (MRL); *(Figure 4)*
- a sedimentation basin; *(within the conveyance channel)*
- a 5.5-mile long open conveyance channel; *(Figure 4)*
- box culverts under River Road, Canadian National Railroad (CN), and Airline Highway; *(Figure4)*

- a bridge over the channel at Kansas City Southern Railroad (KCS); *(Figure 4)*
- 8 lateral discharge valves between Airline Highway and I-10 to carry flow from the conveyance channel to areas east and west of the channel (Figure 3);
- check valving on culverts underneath I-10 to mitigate southward backflow (Figure 3);
- reshaping the geometry of the existing Hope Canal channel under I-10 (Figure 3 and 2)
- embankment cuts in the existing ridge of an old railroad embankment; *(Figure 3)* and
- submerged rock rip-rap weirs in Bayou Secret and Bourgeois Canal; *(Figure 3)*

The intake channel is roughly 400 ft long by 200 ft wide, with a bottom depth at EL (-) 4 ft NAVD88 excavated into the batture to route flow from the Mississippi River into the diversion headworks. The channel will be lined with riprap to prevent scour. The primary function of the headworks structure is to convey flow from the intake channel underneath the Mississppi River Levee (MRL). It will be comprised of a multi-cell box culvert with vertical lift gates (sluice gates) (Figure 4).

The outlet for the conveyance channel is along the existing centerline of Hope Canal. The guide levee elevations from the Interstate 10 (I-10) bridges to the termination point gradually transition to existing grade. At that point the diverted water will overflow the canal banks and dissipate into the area above I-10, south of Lake Maurepas.

The diversion flow of 2,000 cfs generally spreads radially outwards as it enters the swamp north of I-10. Approximately, one-third flows westward through the swamp, one-third flows through Dutch Bayou and the remaining third flows eastward through the swamp. The westward flow enters Blind River and largely proceeds to Lake Maurepas. The eastward flow enters the Reserve Relief Canal and mostly proceeds to Lake Maurepas. Most of the swamp water is displaced by the introduced Mississippi River water (Figure 1,3, and 5). This spreading water is captured in the figures and is what accounts for this being a mitigation project for swamp habitat.

Required earthwork would consist of clearing, grubbing, excavation, and removal of earthen material for the project's conveyance channel and disposal at an approved disposal site. When possible, unsuitable excavated material could be utilized beneficially. If a borrow study in subsequent design phases indicates sufficient suitable material within the excavated material, the Contractor may elect to use that material on-site. Any material used on site would stay within the right-of-way (ROW) and would be used to construct features.

Additional earthwork outside of the conveyance channel will occur along the existing ridge of an old railroad embankment. 7.51 acres along the old railroad embankment will be cleared for equipment access. 5 individual areas along the embankment will be excavated to existing grade while all spoil will be placed in 20 individual areas along the embankment. It is anticipated that no material will be removed from the project area.

Area of Potential Effect (APE)

Pursuant to Stipulation II. D. (1-4) of the BBA 18 Mitigation PA, CEMVN has defined a

preliminary APE in Figure 1 and 5. The APE incorporates both direct effects (e.g., access, staging, and construction areas), indirect effects (e.g., visual), and areas of inundation (outflow area). The direct construction APE of the MSP is approximately 288.30 acres (116.67 hectares). The Indirect APE extends beyond the construction footprint for roughly 50 feet. The outflow area APE includes Maurepas Swamp and Lake Maurepas and is approximately 90,357 acres (36,566 hectares). The total APE, direct and indirect, is approximately 90,652.7 acres (36,686.12 hectares) (Figure 1 and 5). It is acknowledged that this APE is preliminary based on the state of development of the project. Should the APE need to be revised, CEMVN will follow provision II. D. 3. Of the BBA 18 Mitigation PA to proposed revisions.

Historic Property Identification and Evaluation Efforts

CEMVN identified historic properties within the project footprint, mitigation areas, and impact areas (collectively the APE) based on a review of the NRHP database, the Louisiana Division of Archaeology (LDOA) Louisiana Cultural Resources Map (LDOA Website), historic maps, pertinent regional and local cultural resources investigations, historic aerial photography, and other appropriate sources. This review identified 15 previous cultural resources surveys, 11 previously recorded archaeological sites, and three (3) previously recorded architectural resources within the MSP APE (Figure 5).

Archaeological

A total of eleven (11) archaeological sites are present within the MSP APE. Two (2) of these sites are not eligible for the NRHP, 16SJ73 (Blind River Timber Rail) and 16SJB68 (Angelina Plantation, Note: Locus A of 16SJ68 is of unknown eligibility). Seven (7) sites are listed as unknown eligibility (16AN8, 16LV24, 16LV73, 16LV74, 16LV103, 16SJ72, and 16SJB4). These sites include four (4) prehistoric shell middens (16AN8, 16LV73, 16LV24, 16SJB4), 2 possible watercrafts/shipwrecks (16LV74, 16SJ72), one (1) railroad bridge (16SJ72), and the Amite River Diversion Canal (16LV103). Two (2) cemeteries are present within the APE (16SJ58, 16SJ61), both dating back to the Civil War.

Fifteen (15) previous cultural surveys have been performed within the MSP APE. Most of these surveys did not discover existing cultural resources within the MSP APE. A total of nine (9) surveys occurred near or in the Angelina Plantation site (16SJB68). They are 22-3023, 22-3793, 22-4288, 22-4571, 22-4571-1, 22-4571-2, 22-4690, 22-5431, 22-6238. A Phase I Cultural Resources Survey of the River Reintroduction Corridor, Maurepas Swamp (PO-29), St. John the Baptist Parish, Louisiana was performed by Coastal Environments, Inc. in 2008, and included the proposed footprint of the Maurepas Diversion Canal corridor from Interstate-10 to the Mississippi River (Wells 2008; 22-3023). No eligible archaeological sites were recorded as a result of this survey.

Architectural

The proposed project is located approximately one (1) mile from the Garyville Historic District, a National Register Historic District (NRHD) listed in the NRHP in 1990. Tree coverage along the majority of LA-54 separates the Garyville Historic District from the proposed project. The proposed project is located west of LA-54 while the Garyville Historic District is located east of LA-54. No individual historic properties were identified as listed, or formally determined eligible for listing by the Keeper, in the NRHP within the project, mitigation, and impact areas. No previously recorded built resources are located

within the mitigation and impact areas.

Review of previous investigations revealed three built resources (Louisiana Historic Resource Inventory (LHRI) ID Number 48-01071, 48-01073, and 48-01089) within or adjacent to the project area that were individually documented in 1985. According to the LDOA Cultural Resources Map, these three resources are near River Road and the proposed headworks and intake structures. During the mid-1980’s, many of the surveyed resources were identified by Post Office Box or only the street name. As a result, LHRI Numbers 48-01071, 48-01073, and 48-01089 do not have identifying street numbers and street names. Visual inspection via Google Street View suggests that these three (3) resources may have been demolished or their LHRI locations are plotted incorrectly on the LDOA Cultural Resources Map.

The Earnest Amann Subdivision borders the proposed project to the east. Marigold Street runs parallel to the proposed project footprint and was developed likely in the late 1950s with dwellings constructed on the east side of the street by the early 1960s (NETR 1961). A review of aerial photographs and historic USGS maps reveal that the east side of Marigold Street was fully developed by the early 1980s (NETR 1981). The west side of Marigold Street developed sometime after 1970 (NETR 1971). As a result, built resources 50 years of age or older are present adjacent to the proposed project area.

Assessment of the Undertaking’s Potential to Effect Historic Properties

The exact impact assessment for this project is currently unknown but will be updated as the MSP develops, and consultation continues. This project includes ground disturbing activities involving access, staging, construction of structural features (intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, box culverts, and other features as described in Figures 1-2), and borrow fill. These activities may directly impact both known and undocumented cultural resources listed or eligible for listing in the NRHP not limited to: archaeological sites; historic built resources; cemeteries or other sites that may contain human remains, funerary objects, sacred objects, or objects of cultural patrimony; and TCPs; that exist both within the project footprint and associated areas in a way that will diminish the integrity of these property’s location, design, setting, materials, workmanship, feeling, or association.

The MSP includes the introduction of new visual elements to the project area’s viewshed that have the potential to indirectly impact known and previously undocumented cultural resources that may be listed or eligible for listing in the NRHP. These elements include a roughly 400 ft. long by 200 ft. wide intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, and other features as described in Figures 1-2. The introduction of new visual elements that are inconsistent with the historic or cultural character of these potential resources could indirectly diminish the integrity of the property’s setting, feeling, or association and/or cause changes to the integrity of feeling or character associated with a historic resource or TCP.

The proposed project is located approximately one mile from the Garyville Historic District, a NRHD listed in the NRHP in 1990. No indirect effects to the Garyville Historic District would occur due to tree coverage along the majority of LA-54 which separates the Garyville Historic District from the proposed project. However, the proposed project could

potentially indirectly effect three built resources (LHRI ID Number 48-01071, 48-01073, and 48-01089). Additionally, the proposed project could potentially indirectly affect built resources 50 years of age or older within the Earnest Amann Subdivision, which borders the proposed project to the east.

Based on the current understanding of the historic properties in the APE and the potential effects from direct and indirect causes, CEMVN will continue to consult as anticipated historic property identification surveys are completed and affect determination are made following the terms of the BBA 18 PA. The commitment to follow the procedures in the BBA 18 Mitigation PA will also be reflected in the WSLP SEIS and the Record of Decision.

If you have any questions or require additional information concerning this undertaking, please contact Ms. Ashley Fedoroff, archaeologist, at (601) 631-5278 or via e-mail Ashley.M.Fedoroff@usace.army.mil, Ms. Jill Enersen, Architectural Historian, at (504) 862-1741 or Jill.A.Enersen@usace.army.mil, or Mr. Jason Emery, Tribal Liaison, at (504) 862-2364 or via email Jason.A.Emery@usace.army.mil.

Sincerely,

MARSHALL K. HARPER
Chief, Environmental Planning Branch

Enclosures
1. BBA 18 Mitigation PA
2. 25 March 2021, Annual Report with project list to include WSLP Swamp Mitigation.

CC: File
An electronic copy of this letter with enclosures will be provided to Mrs. Kimberly Walden, M. Ed., Cultural Director/Tribal Historic Preservation Officer, Chitimacha Tribe of Louisiana, kim@chitimacha.gov.

List of Recipients:
Alabama Coushatta Tribe of Texas
Chitimacha Tribe of Louisiana
Choctaw Nation of Oklahoma
Coushatta Tribe of Louisiana
Jena Band of Choctaw Indians
Mississippi Band of Choctaw Indians
Muscogee (Creek) Nation
Seminole Nation of Oklahoma
Tunica-Biloxi Tribe of Louisiana
Louisiana State Historic Preservation Office (SHPO)
Advisory Council of Historic Places (ACHP)

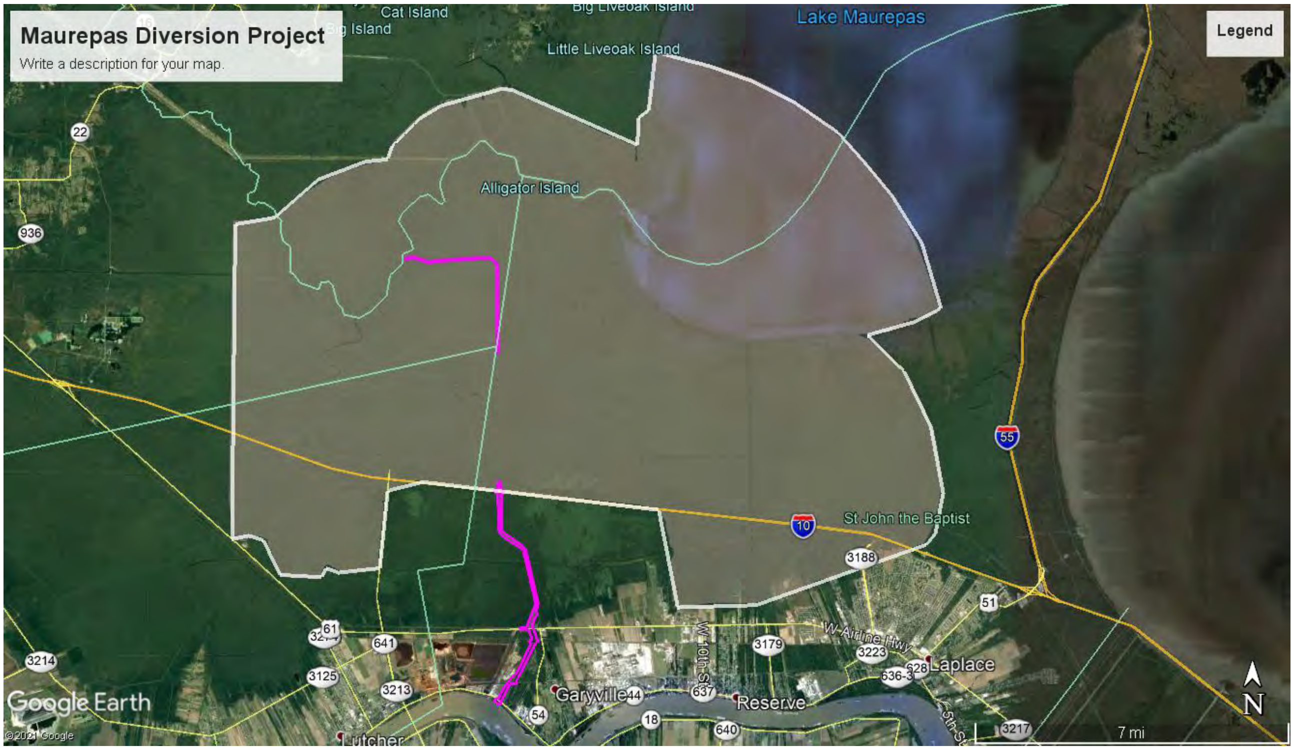

Figure 1. Overview of Maurepas Swamp Project APE: Direct Impact APE (pink) and Indirect Impact APE (white).

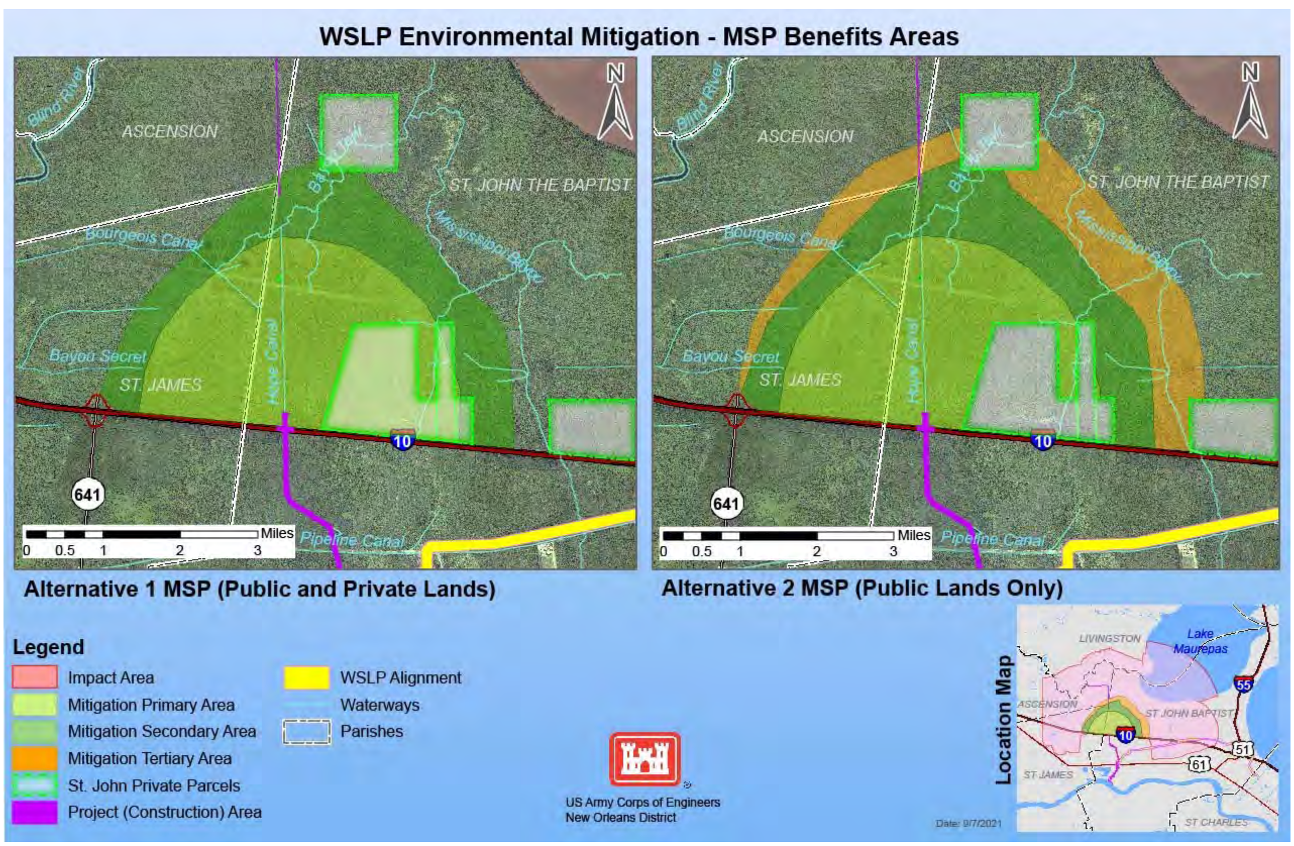

Figure 2. Detail of the Marurepas Swamp Project Mitigation Alternatives MSP 1 and MSP2.

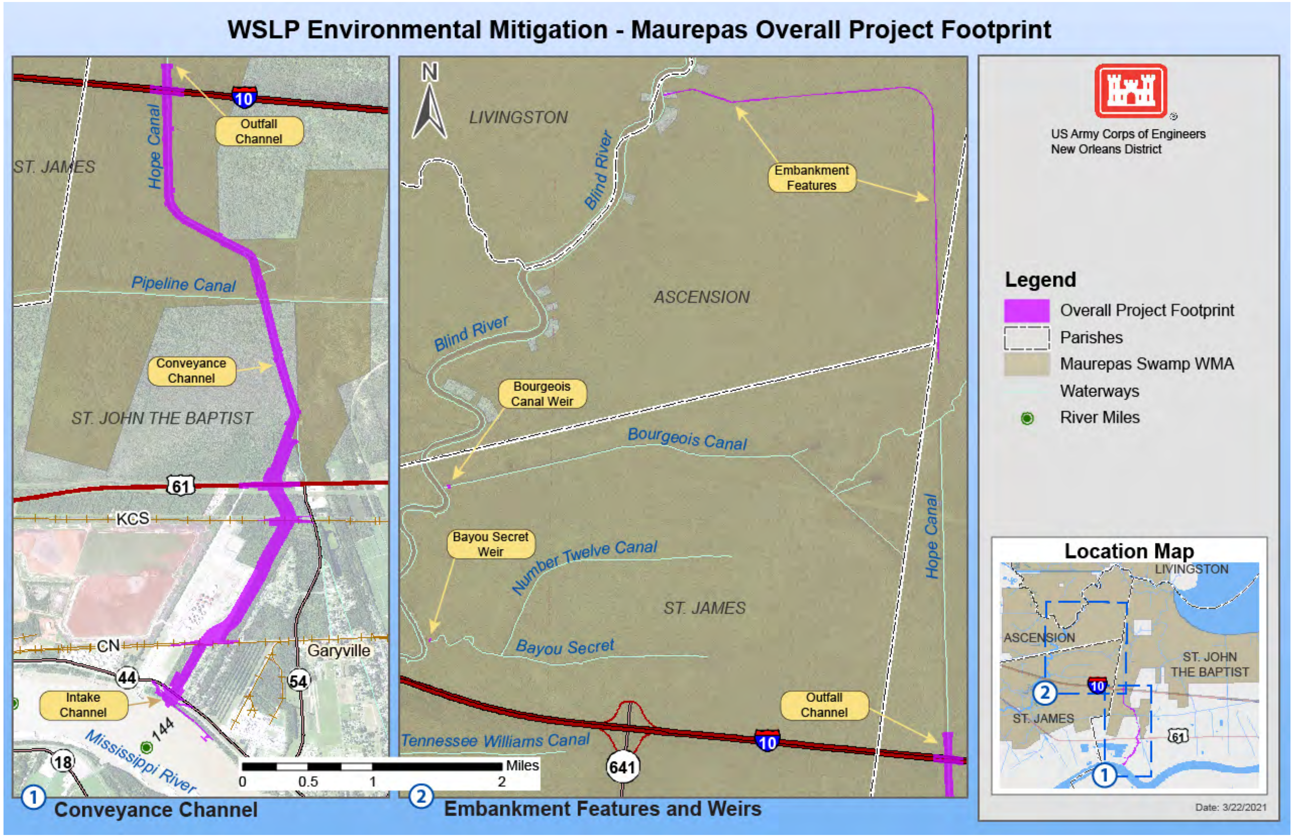

Figure 3. Detail of the construction features of for the diversion to facilitate the Maurepas Swamp Mitigation Project. Intake structure and convenance channel (left) and the weir and embankment features (right).

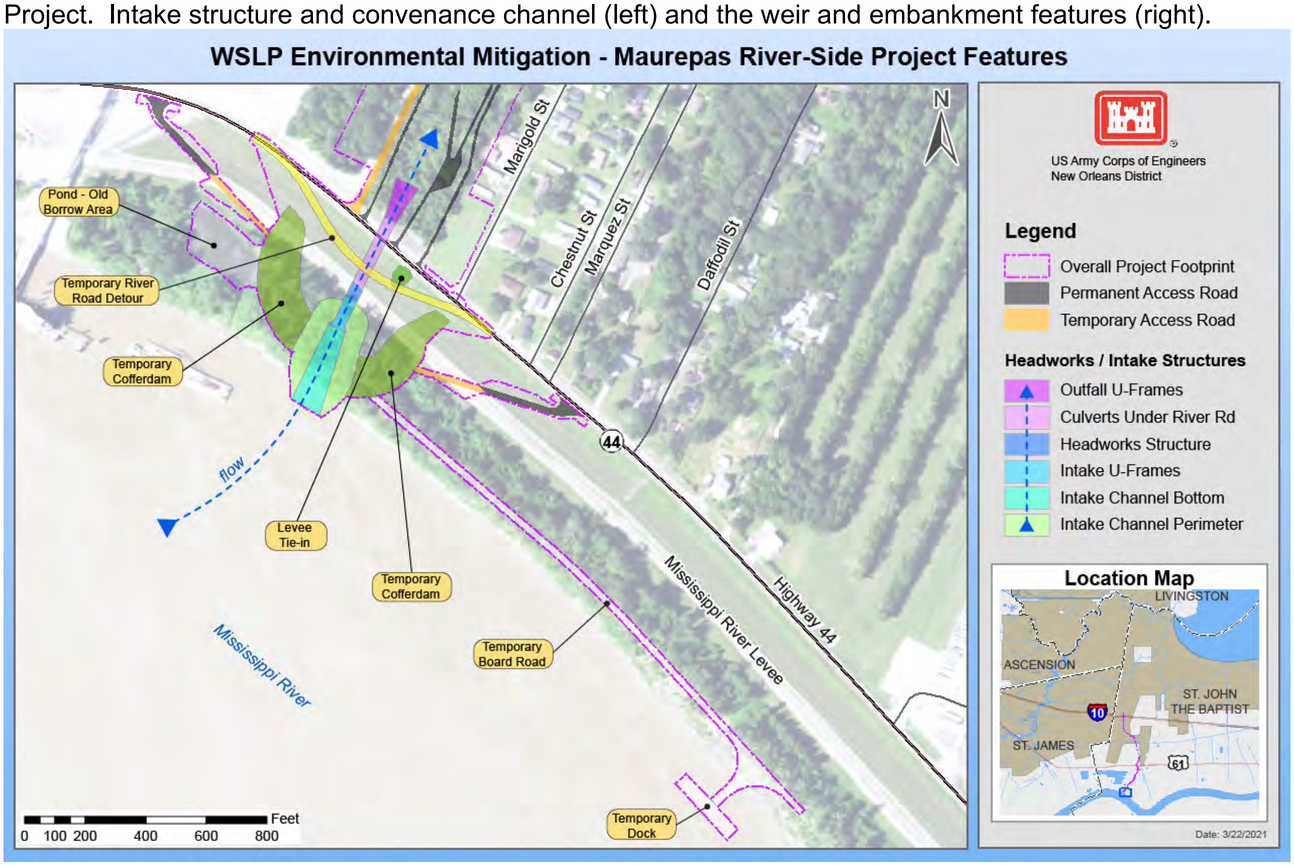

Figure 4 : Detail of the Intake Structure and appurtenant features.

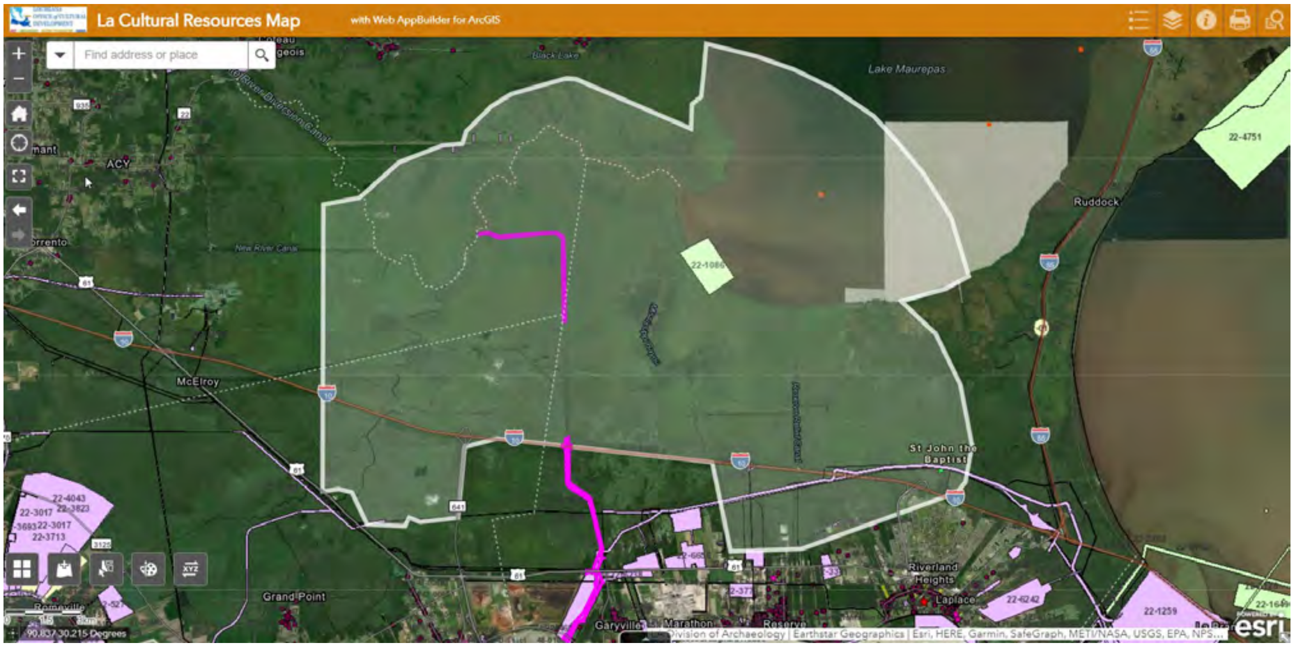

Figure 5: Maurepas Swamp Project APE: Direct Impact APE (pink) and Indirect Impact APE (white). LDOA Cultural Resources Map. Note that the conveyance channel area has been surveyed under LDOA Report # 22-3023.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 Leake Ave, New Orleans, LA 70118

October 19, 2021

Regional Planning and
 Environment Division, South
Environmental Planning Branch
Attn: CEMVN-PDS-N

Gary Batton, Chief
Choctaw Nation of Oklahoma
Attn: Choctaw Nation Historic Preservation Department
P.O. Box 1210
Durant, OK 74702-1210

RE: **Section 106 Notification -** Addition of Maurepas Swamp Project (MSP) to Appendix B of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA).

Dear Chief Batton:

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative.

Background

Previously, CEMVN evaluated environmental impacts due to construction of the West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Project (WSLP Project) through a Supplemental Environmental Assessment (SEA) 576, which addressed mitigation for habitat impacts associated with each of the Bipartisan Budget Act (BBA) 18 construction projects (i.e., WSLP Project, Comite Project, and East Baton Rouge Project). The Finding of No Significant Impact (FONSI) for SEA 576 was signed by the CEMVN District Commander on April 4, 2020. Associated with this effort was the development and

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If you have any questions or require additional information concerning this undertaking, please contact Ms. Ashley Fedoroff, archaeologist, at (601) 631-5278 or via e-mail Ashley.M.Fedoroff@usace.army.mil, Ms. Jill Enersen, Architectural Historian, at (504) 862-1741 or Jill.A.Enersen@usace.army.mil, or Mr. Jason Emery, Tribal Liaison, at (504) 862-2364 or via email Jason.A.Emery@usace.army.mil.

Sincerely,

MARSHALL K. HARPER
Chief, Environmental Planning Branch

Enclosures
1. BBA 18 Mitigation PA
2. 25 March 2021, Annual Report with project list to include WSLP Swamp Mitigation.

CC: File
An electronic copy of this letter with enclosures will be provided to Dr. Ian Thompson, Director/Tribal Historic Preservation Officer, Choctaw Nation of Oklahoma, ithompson@choctawnation.com and Ms. Lindsey Bilyeu, NHPA Section 106 Reviewer, Choctaw Nation of Oklahoma, lbilyeu@choctawnation.com.

List of Recipients:
Alabama Coushatta Tribe of Texas
Chitimacha Tribe of Louisiana
Choctaw Nation of Oklahoma
Coushatta Tribe of Louisiana
Jena Band of Choctaw Indians
Mississippi Band of Choctaw Indians
Muscogee (Creek) Nation
Seminole Nation of Oklahoma

Tunica-Biloxi Tribe of Louisiana
Louisiana State Historic Preservation Office (SHPO)
Advisory Council of Historic Places (ACHP)

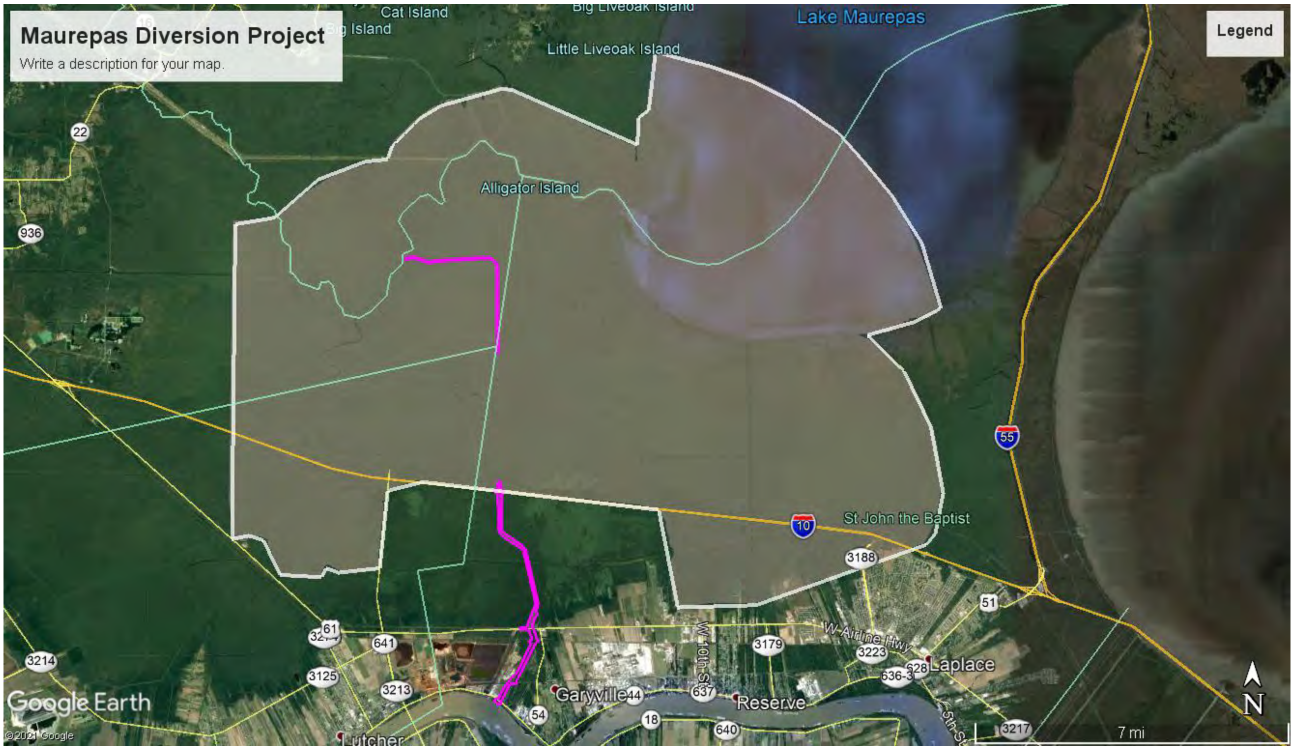
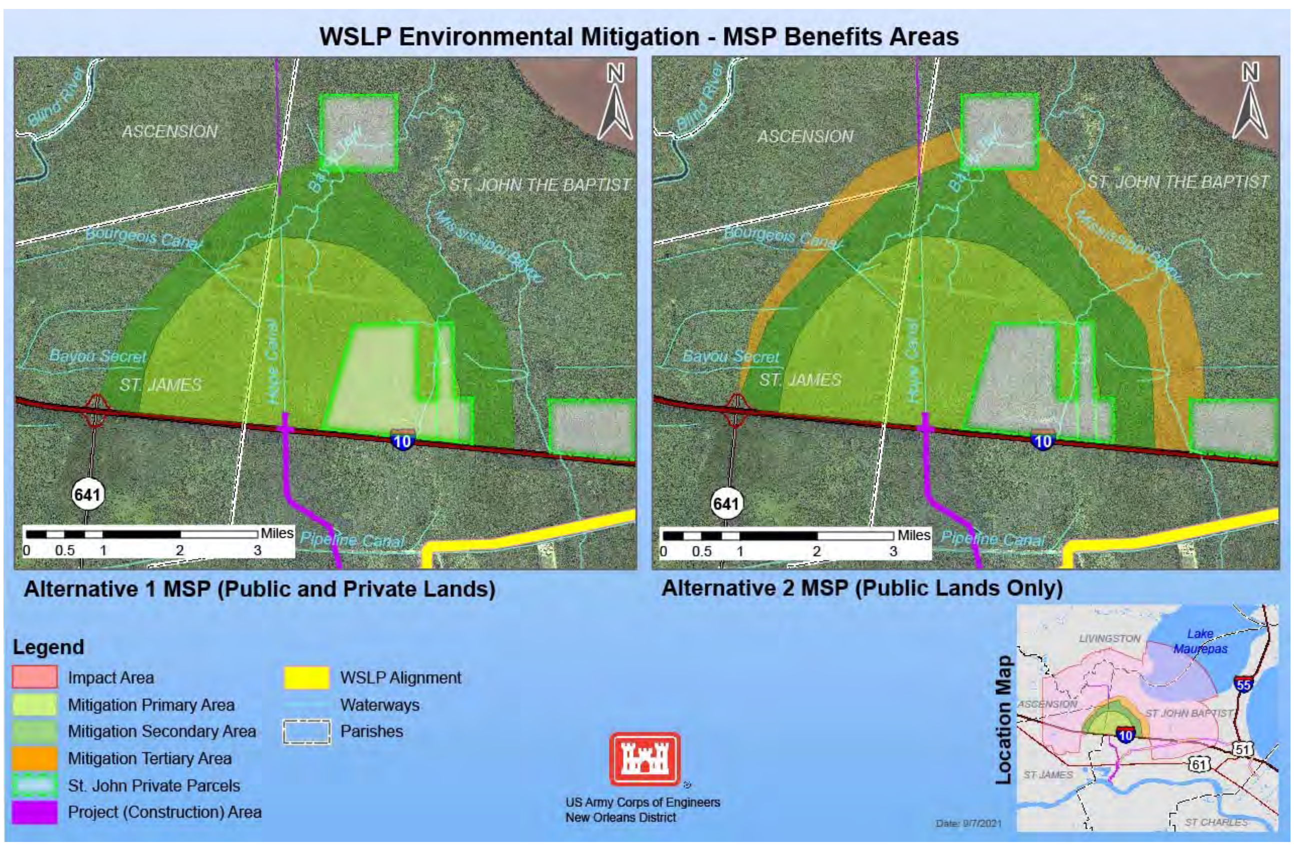


Figure 1. Overview of Maurepas Swamp Project APE: Direct Impact APE (pink) and Indirect Impact APE (white).



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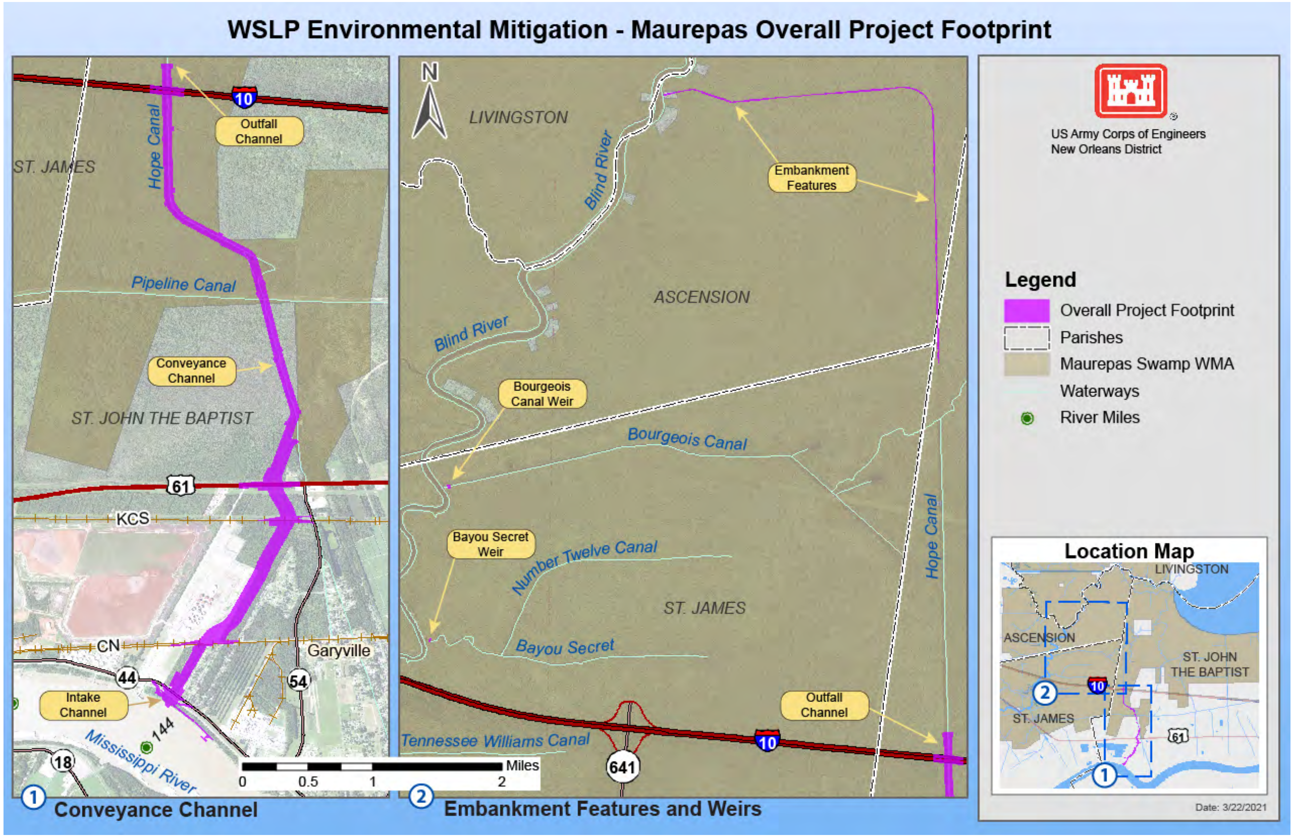

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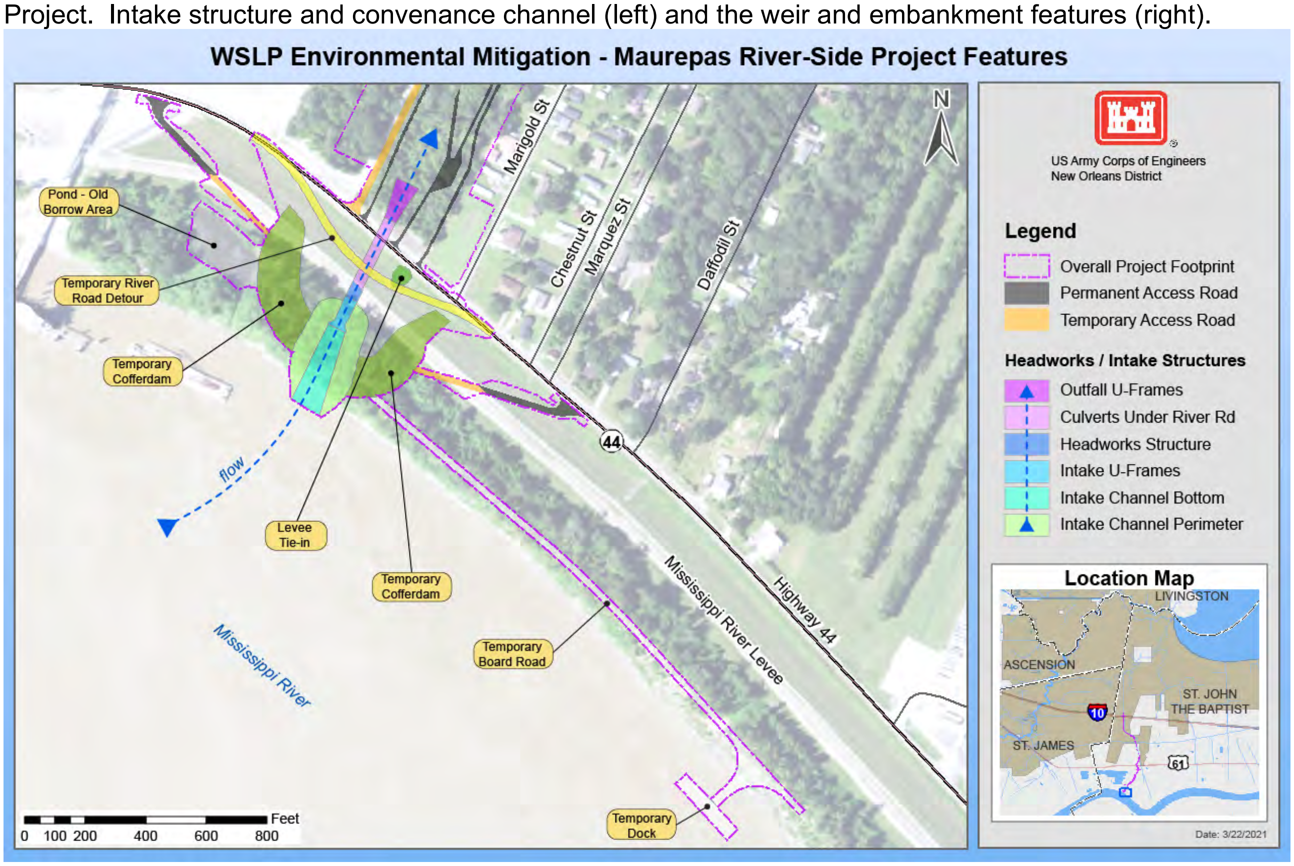

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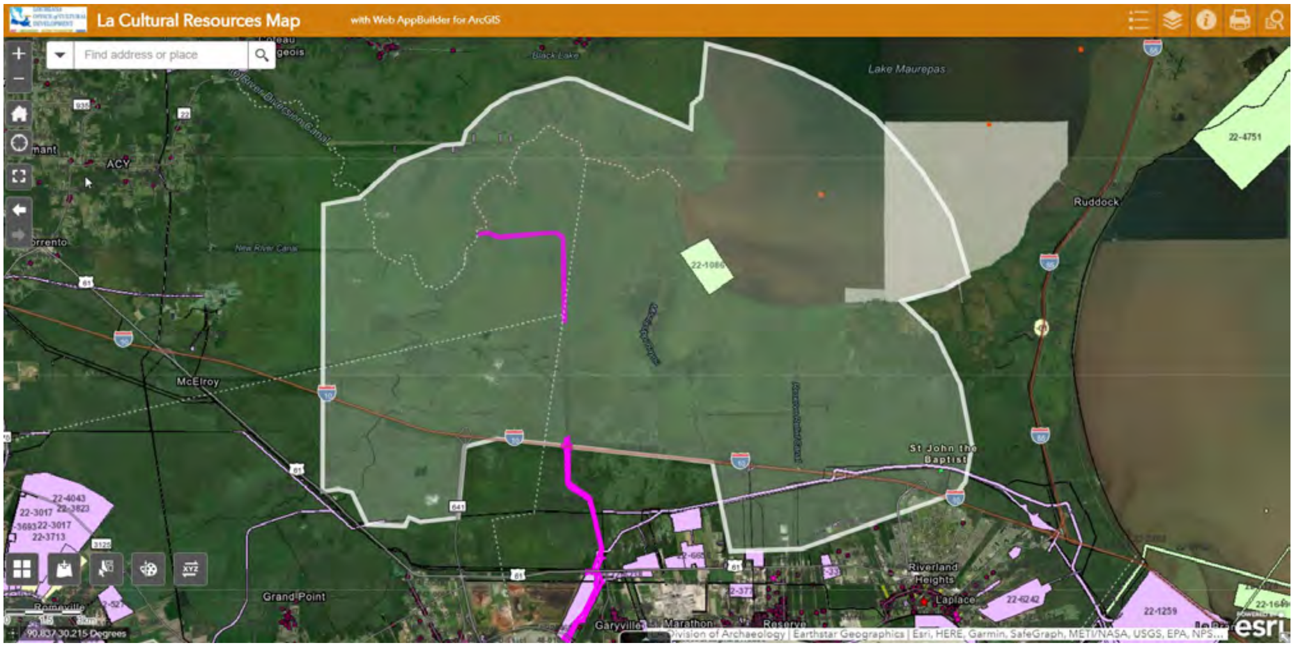

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DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 Leake Ave, New Orleans, LA 70118

October 19, 2021

Regional Planning and
Environment Division, South
Environmental Planning Branch
Attn: CEMVN-PDS-N

David Sickey, Chairman
Coushatta Tribe of Louisiana
P.O. Box 818
Elton, LA 70532

RE: **Section 106 Notification -** Addition of Maurepas Swamp Project (MSP) to Appendix B of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA).

Dear Chairman Sickey:

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative.

Background

Previously, CEMVN evaluated environmental impacts due to construction of the West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Project (WSLP Project) through a Supplemental Environmental Assessment (SEA) 576, which addressed mitigation for habitat impacts associated with each of the Bipartisan Budget Act (BBA) 18 construction projects (i.e., WSLP Project, Comite Project, and East Baton Rouge Project). The Finding of No Significant Impact (FONSI) for SEA 576 was signed by the CEMVN District Commander on April 4, 2020. Associated with this effort was the development and execution of the BBA 18 Habitat Mitigation PA to provide an alternative NHPA Section 106

process tailored to the construction of habitat mitigation projects (enclosed). As part of the public review process, the Non-Federal Sponsor, Louisiana's Coastal Protection Restoration Authority (CPRA), requested that CEMVN evaluate the Mississippi River Diversion into Maurepas Swamp [PO-29; Maurepas Swamp Project (MSP)], a proposed ecological restoration project that shares construction features with the WSLP Project, be considered as a mitigation alternative for impacts to swamp habitat associated with the construction of the WSLP Project.

In order to evaluate the proposed mitigation project in a manner similar to the other proposed mitigation projects, CEMVN is preparing a Supplemental Environmental Impact Statement to West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study (WSLP SEIS) to compare viable swamp mitigation alternatives within the Pontchartrain Basin. As part of this effort, CEMVN will be utilizing the currently executed BBA 18 Habitat Mitigation PA to conduct any additional necessary Historic Property identification, NRHP evaluation, consultation, and mitigation, as this mitigation project clear meets the intent of the PA after reviewing the preamble and the applicability description in Appendix B.

Initial notification was distributed to consulting parties as part of the annual report of activities on March 25, 2021, via email (enclosed). The Louisiana State Historic Preservation Office (LA SHPO) responded on March 25, 2021 saying, "the State Historic Preservation Office concurs that incorporating the WSLP Maurepas Diversion Habitat Management Site under the terms of the BBA-18 Habitat Mitigation Programmatic Agreement is appropriate."

Description of Undertaking- Maurepas Swamp Project (MSP)

Pursuant to Stipulation II. C., Defining the Undertaking, CEMVN is sharing the current designs for the plan and the initial historic property findings for this mitigation project. The proposed Maurepas Swamp Project (MSP) involves a freshwater diversion that would reconnect the Mississippi River to the Maurepas Swamp, strategically delivering nutrient-laden river water to restore the health of the dying Cypress-Tupelo Swamp. The project is proposed as a 2,000 cubic foot per second (cfs) freshwater diversion with the intake of the conveyance channel located on the West Bank of the Mississippi River in St. John the Baptist Parish, immediately west of Garyville, Louisiana, at River Mile 144 Above Head of Passes (AHP). The 300 ft wide construction corridor for the conveyance channel extends from LA 44 (River Road) northward. It extends northward for 5½ miles, terminating approximately 1,000 ft north of Interstate 10 (I-10) (Figure 1, 2 and 3).

The primary project features are located in St. John the Baptist Parish and are comprised of, but not limited to, the following elements:

- an intake channel from the Mississippi River; *(Figure 4, Figure 3)*
- an automated gate structure in the Mississippi River Levee (MRL); *(Figure 4)*
- a sedimentation basin; *(within the conveyance channel)*
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The intake channel is roughly 400 ft long by 200 ft wide, with a bottom depth at EL (-) 4 ft NAVD88 excavated into the batture to route flow from the Mississippi River into the diversion headworks. The channel will be lined with riprap to prevent scour. The primary function of the headworks structure is to convey flow from the intake channel underneath the Mississppi River Levee (MRL). It will be comprised of a multi-cell box culvert with vertical lift gates (sluice gates) (Figure 4).

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The diversion flow of 2,000 cfs generally spreads radially outwards as it enters the swamp north of I-10. Approximately, one-third flows westward through the swamp, one-third flows through Dutch Bayou and the remaining third flows eastward through the swamp. The westward flow enters Blind River and largely proceeds to Lake Maurepas. The eastward flow enters the Reserve Relief Canal and mostly proceeds to Lake Maurepas. Most of the swamp water is displaced by the introduced Mississippi River water (Figure 1,3, and 5). This spreading water is captured in the figures and is what accounts for this being a mitigation project for swamp habitat.

Required earthwork would consist of clearing, grubbing, excavation, and removal of earthen material for the project's conveyance channel and disposal at an approved disposal site. When possible, unsuitable excavated material could be utilized beneficially. If a borrow study in subsequent design phases indicates sufficient suitable material within the excavated material, the Contractor may elect to use that material on-site. Any material used on site would stay within the right-of-way (ROW) and would be used to construct features.

Additional earthwork outside of the conveyance channel will occur along the existing ridge of an old railroad embankment. 7.51 acres along the old railroad embankment will be cleared for equipment access. 5 individual areas along the embankment will be excavated to existing grade while all spoil will be placed in 20 individual areas along the embankment. It is anticipated that no material will be removed from the project area.

Area of Potential Effect (APE)

Pursuant to Stipulation II. D. (1-4) of the BBA 18 Mitigation PA, CEMVN has defined a

preliminary APE in Figure 1 and 5. The APE incorporates both direct effects (e.g., access, staging, and construction areas), indirect effects (e.g., visual), and areas of inundation (outflow area). The direct construction APE of the MSP is approximately 288.30 acres (116.67 hectares). The Indirect APE extends beyond the construction footprint for roughly 50 feet. The outflow area APE includes Maurepas Swamp and Lake Maurepas and is approximately 90,357 acres (36,566 hectares). The total APE, direct and indirect, is approximately 90,652.7 acres (36,686.12 hectares) (Figure 1 and 5). It is acknowledged that this APE is preliminary based on the state of development of the project. Should the APE need to be revised, CEMVN will follow provision II. D. 3. Of the BBA 18 Mitigation PA to proposed revisions.

Historic Property Identification and Evaluation Efforts

CEMVN identified historic properties within the project footprint, mitigation areas, and impact areas (collectively the APE) based on a review of the NRHP database, the Louisiana Division of Archaeology (LDOA) Louisiana Cultural Resources Map (LDOA Website), historic maps, pertinent regional and local cultural resources investigations, historic aerial photography, and other appropriate sources. This review identified 15 previous cultural resources surveys, 11 previously recorded archaeological sites, and three (3) previously recorded architectural resources within the MSP APE (Figure 5).

Archaeological

A total of eleven (11) archaeological sites are present within the MSP APE. Two (2) of these sites are not eligible for the NRHP, 16SJ73 (Blind River Timber Rail) and 16SJB68 (Angelina Plantation, Note: Locus A of 16SJ68 is of unknown eligibility). Seven (7) sites are listed as unknown eligibility (16AN8, 16LV24, 16LV73, 16LV74, 16LV103, 16SJ72, and 16SJB4). These sites include four (4) prehistoric shell middens (16AN8, 16LV73, 16LV24, 16SJB4), 2 possible watercrafts/shipwrecks (16LV74, 16SJ72), one (1) railroad bridge (16SJ72), and the Amite River Diversion Canal (16LV103). Two (2) cemeteries are present within the APE (16SJ58, 16SJ61), both dating back to the Civil War.

Fifteen (15) previous cultural surveys have been performed within the MSP APE. Most of these surveys did not discover existing cultural resources within the MSP APE. A total of nine (9) surveys occurred near or in the Angelina Plantation site (16SJB68). They are 22-3023, 22-3793, 22-4288, 22-4571, 22-4571-1, 22-4571-2, 22-4690, 22-5431, 22-6238. A Phase I Cultural Resources Survey of the River Reintroduction Corridor, Maurepas Swamp (PO-29), St. John the Baptist Parish, Louisiana was performed by Coastal Environments, Inc. in 2008, and included the proposed footprint of the Maurepas Diversion Canal corridor from Interstate-10 to the Mississippi River (Wells 2008; 22-3023). No eligible archaeological sites were recorded as a result of this survey.

Architectural

The proposed project is located approximately one (1) mile from the Garyville Historic District, a National Register Historic District (NRHD) listed in the NRHP in 1990. Tree coverage along the majority of LA-54 separates the Garyville Historic District from the proposed project. The proposed project is located west of LA-54 while the Garyville Historic District is located east of LA-54. No individual historic properties were identified as listed, or formally determined eligible for listing by the Keeper, in the NRHP within the project, mitigation, and impact areas. No previously recorded built resources are located

within the mitigation and impact areas.

Review of previous investigations revealed three built resources (Louisiana Historic Resource Inventory (LHRI) ID Number 48-01071, 48-01073, and 48-01089) within or adjacent to the project area that were individually documented in 1985. According to the LDOA Cultural Resources Map, these three resources are near River Road and the proposed headworks and intake structures. During the mid-1980's, many of the surveyed resources were identified by Post Office Box or only the street name. As a result, LHRI Numbers 48-01071, 48-01073, and 48-01089 do not have identifying street numbers and street names. Visual inspection via Google Street View suggests that these three (3) resources may have been demolished or their LHRI locations are plotted incorrectly on the LDOA Cultural Resources Map.

The Earnest Amann Subdivision borders the proposed project to the east. Marigold Street runs parallel to the proposed project footprint and was developed likely in the late 1950s with dwellings constructed on the east side of the street by the early 1960s (NETR 1961). A review of aerial photographs and historic USGS maps reveal that the east side of Marigold Street was fully developed by the early 1980s (NETR 1981). The west side of Marigold Street developed sometime after 1970 (NETR 1971). As a result, built resources 50 years of age or older are present adjacent to the proposed project area.

Assessment of the Undertaking's Potential to Effect Historic Properties

The exact impact assessment for this project is currently unknown but will be updated as the MSP develops, and consultation continues. This project includes ground disturbing activities involving access, staging, construction of structural features (intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, box culverts, and other features as described in Figures 1-2), and borrow fill. These activities may directly impact both known and undocumented cultural resources listed or eligible for listing in the NRHP not limited to: archaeological sites; historic built resources; cemeteries or other sites that may contain human remains, funerary objects, sacred objects, or objects of cultural patrimony; and TCPs; that exist both within the project footprint and associated areas in a way that will diminish the integrity of these property's location, design, setting, materials, workmanship, feeling, or association.

The MSP includes the introduction of new visual elements to the project area's viewshed that have the potential to indirectly impact known and previously undocumented cultural resources that may be listed or eligible for listing in the NRHP. These elements include a roughly 400 ft. long by 200 ft. wide intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, and other features as described in Figures 1-2. The introduction of new visual elements that are inconsistent with the historic or cultural character of these potential resources could indirectly diminish the integrity of the property's setting, feeling, or association and/or cause changes to the integrity of feeling or character associated with a historic resource or TCP.

The proposed project is located approximately one mile from the Garyville Historic District, a NRHD listed in the NRHP in 1990. No indirect effects to the Garyville Historic District would occur due to tree coverage along the majority of LA-54 which separates the Garyville Historic District from the proposed project. However, the proposed project could

potentially indirectly effect three built resources (LHRI ID Number 48-01071, 48-01073, and 48-01089). Additionally, the proposed project could potentially indirectly affect built resources 50 years of age or older within the Earnest Amann Subdivision, which borders the proposed project to the east.

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MARSHALL K. HARPER
Chief, Environmental Planning Branch

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Chitimacha Tribe of Louisiana
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Coushatta Tribe of Louisiana
Jena Band of Choctaw Indians
Mississippi Band of Choctaw Indians
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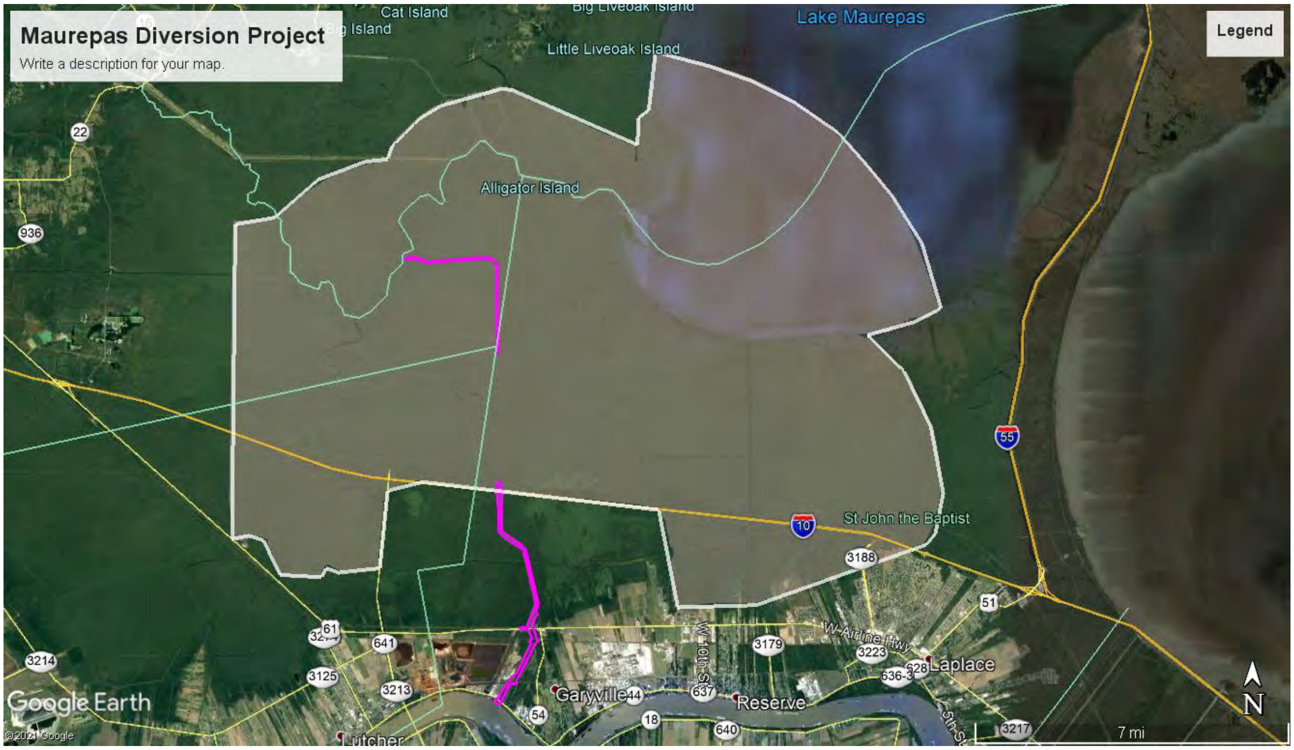

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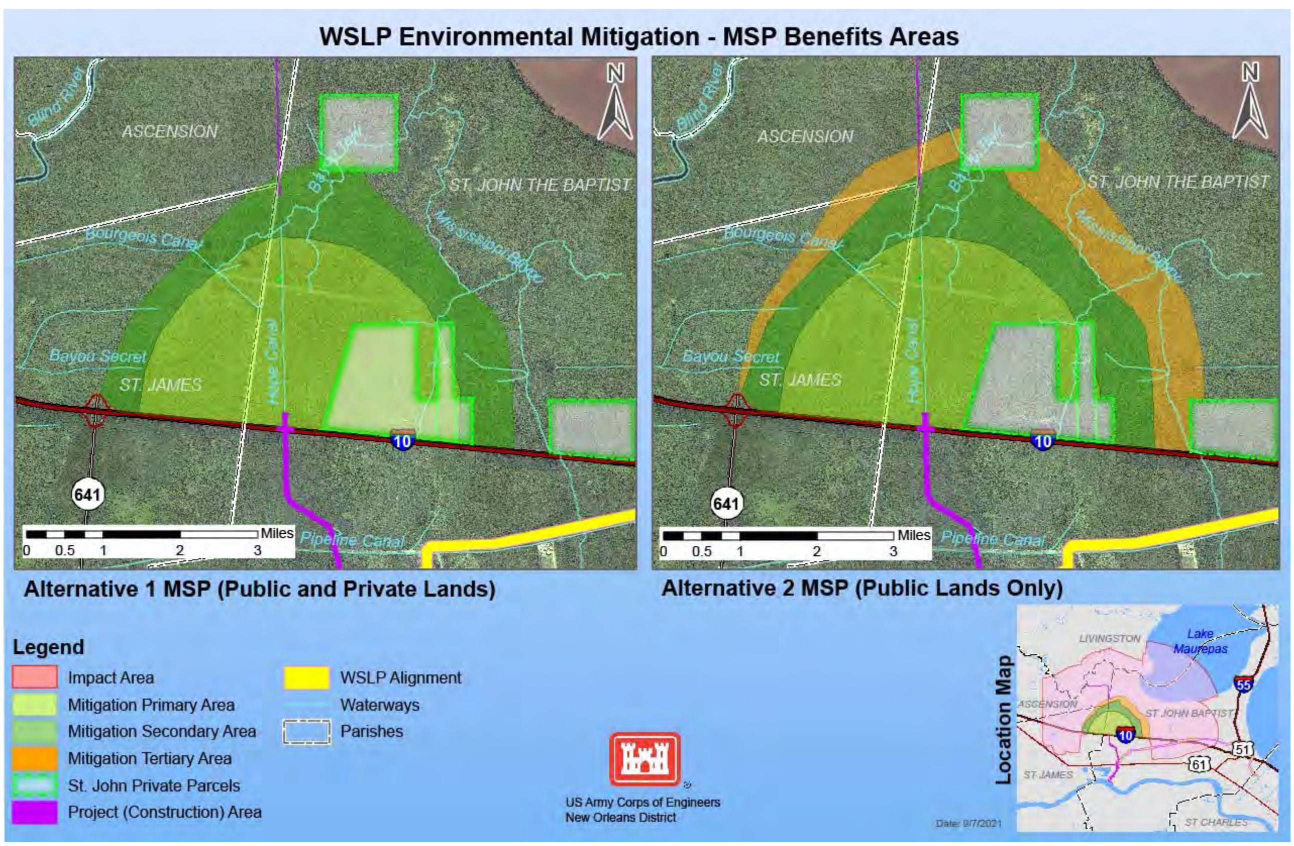

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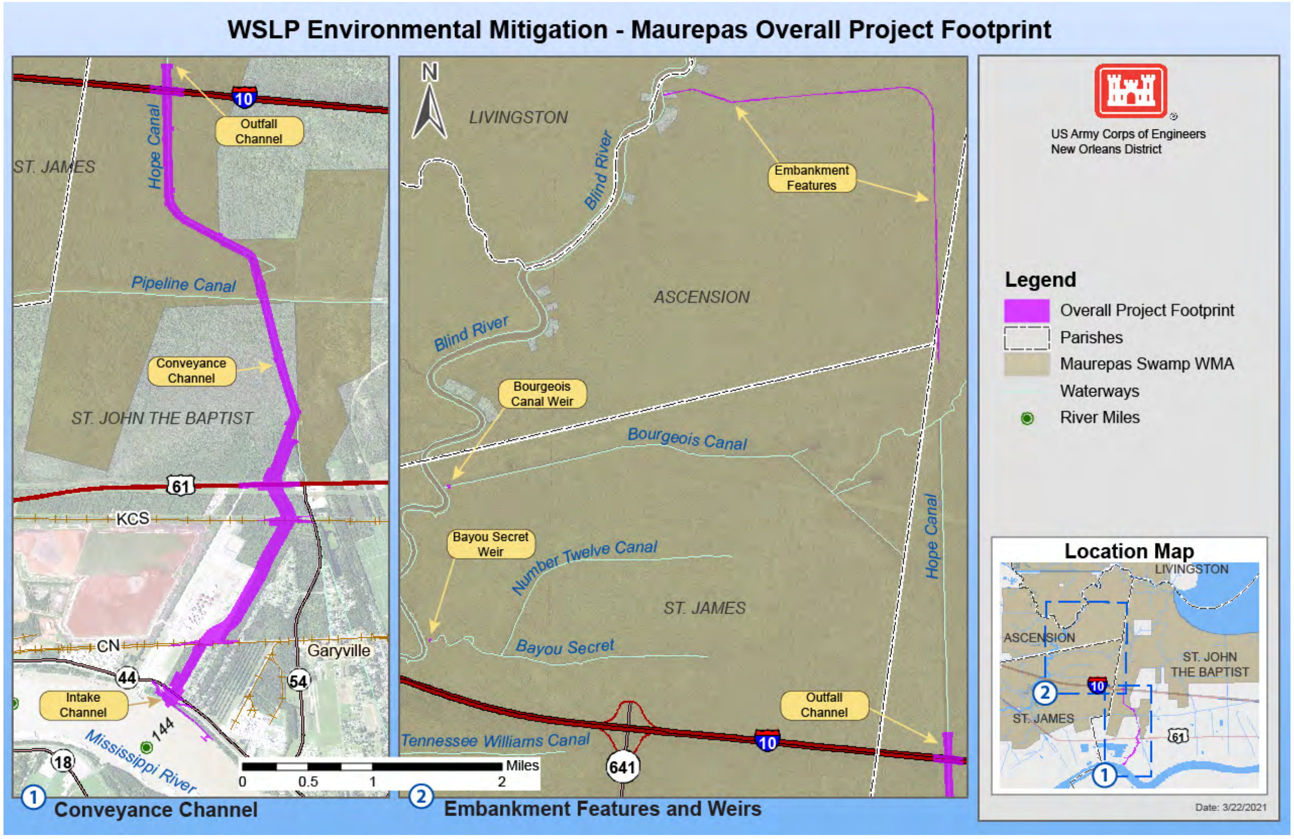

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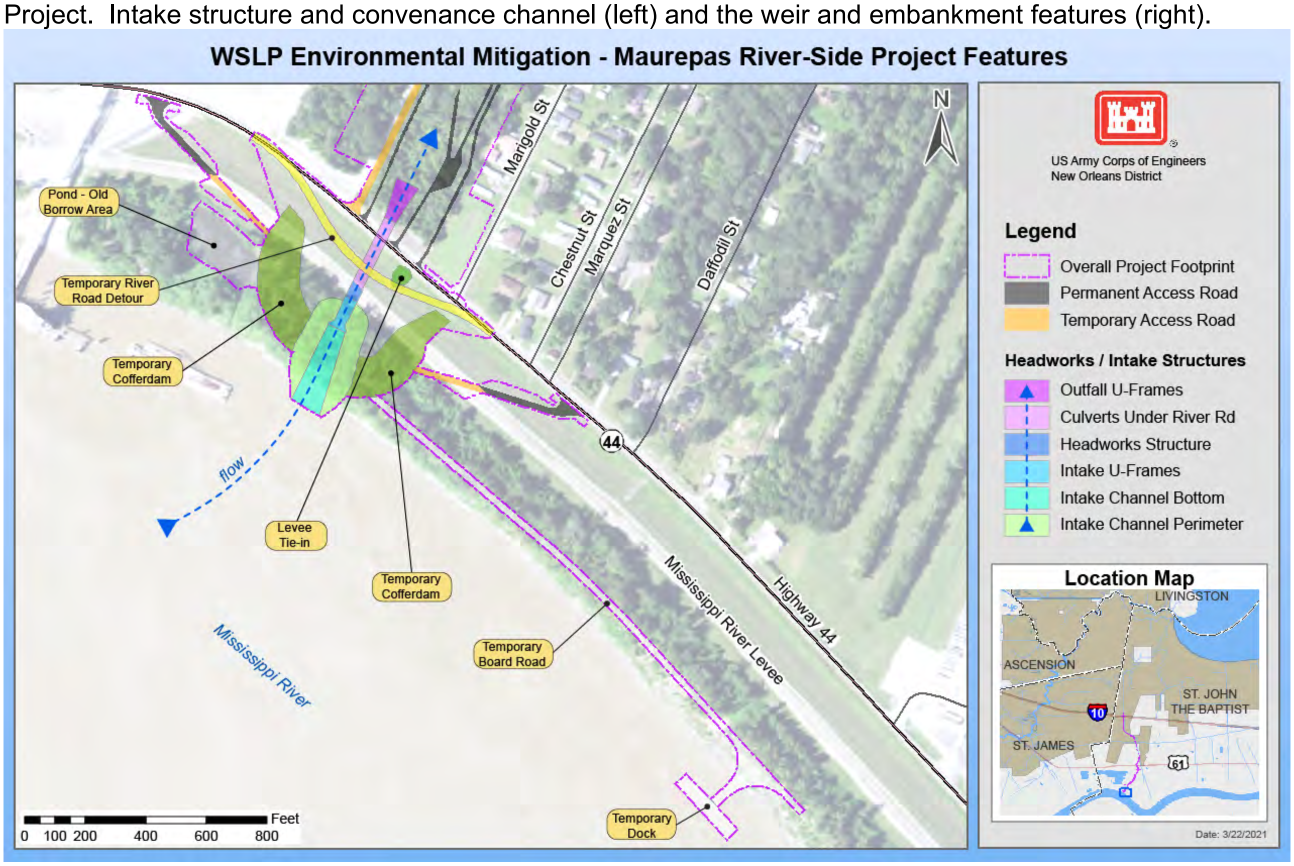

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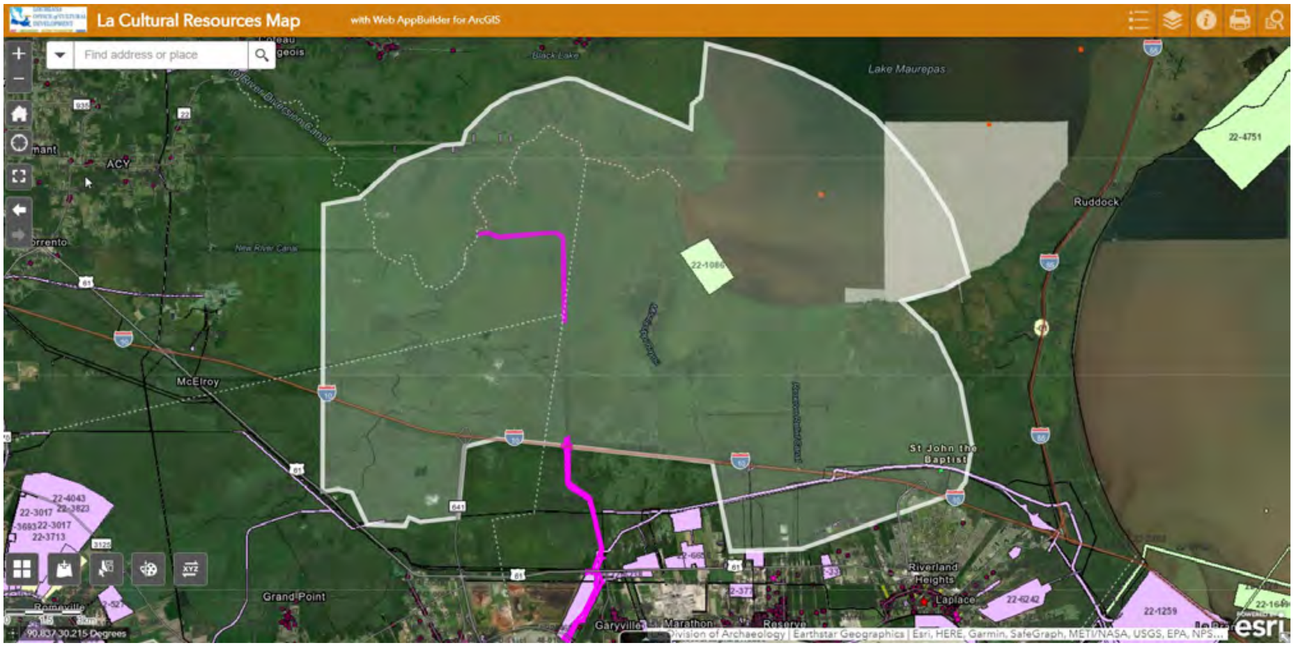

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DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 Leake Ave, New Orleans, LA 70118

October 19, 2021

Regional Planning and
Environment Division, South
Environmental Planning Branch
Attn: CEMVN-PDS-N

B. Cheryl Smith, Principal Chief
Jena Band of Choctaw Indians
P.O. Box 14
Jena, LA 71342

RE: **Section 106 Notification -** Addition of Maurepas Swamp Project (MSP) to Appendix B of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA).

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preliminary APE in Figure 1 and 5. The APE incorporates both direct effects (e.g., access, staging, and construction areas), indirect effects (e.g., visual), and areas of inundation (outflow area). The direct construction APE of the MSP is approximately 288.30 acres (116.67 hectares). The Indirect APE extends beyond the construction footprint for roughly 50 feet. The outflow area APE includes Maurepas Swamp and Lake Maurepas and is approximately 90,357 acres (36,566 hectares). The total APE, direct and indirect, is approximately 90,652.7 acres (36,686.12 hectares) (Figure 1 and 5). It is acknowledged that this APE is preliminary based on the state of development of the project. Should the APE need to be revised, CEMVN will follow provision II. D. 3. Of the BBA 18 Mitigation PA to proposed revisions.

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CEMVN identified historic properties within the project footprint, mitigation areas, and impact areas (collectively the APE) based on a review of the NRHP database, the Louisiana Division of Archaeology (LDOA) Louisiana Cultural Resources Map (LDOA Website), historic maps, pertinent regional and local cultural resources investigations, historic aerial photography, and other appropriate sources. This review identified 15 previous cultural resources surveys, 11 previously recorded archaeological sites, and three (3) previously recorded architectural resources within the MSP APE (Figure 5).

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A total of eleven (11) archaeological sites are present within the MSP APE. Two (2) of these sites are not eligible for the NRHP, 16SJ73 (Blind River Timber Rail) and 16SJB68 (Angelina Plantation, Note: Locus A of 16SJ68 is of unknown eligibility). Seven (7) sites are listed as unknown eligibility (16AN8, 16LV24, 16LV73, 16LV74, 16LV103, 16SJ72, and 16SJB4). These sites include four (4) prehistoric shell middens (16AN8, 16LV73, 16LV24, 16SJB4), 2 possible watercrafts/shipwrecks (16LV74, 16SJ72), one (1) railroad bridge (16SJ72), and the Amite River Diversion Canal (16LV103). Two (2) cemeteries are present within the APE (16SJ58, 16SJ61), both dating back to the Civil War.

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The proposed project is located approximately one (1) mile from the Garyville Historic District, a National Register Historic District (NRHD) listed in the NRHP in 1990. Tree coverage along the majority of LA-54 separates the Garyville Historic District from the proposed project. The proposed project is located west of LA-54 while the Garyville Historic District is located east of LA-54. No individual historic properties were identified as listed, or formally determined eligible for listing by the Keeper, in the NRHP within the project, mitigation, and impact areas. No previously recorded built resources are located

within the mitigation and impact areas.

Review of previous investigations revealed three built resources (Louisiana Historic Resource Inventory (LHRI) ID Number 48-01071, 48-01073, and 48-01089) within or adjacent to the project area that were individually documented in 1985. According to the LDOA Cultural Resources Map, these three resources are near River Road and the proposed headworks and intake structures. During the mid-1980's, many of the surveyed resources were identified by Post Office Box or only the street name. As a result, LHRI Numbers 48-01071, 48-01073, and 48-01089 do not have identifying street numbers and street names. Visual inspection via Google Street View suggests that these three (3) resources may have been demolished or their LHRI locations are plotted incorrectly on the LDOA Cultural Resources Map.

The Earnest Amann Subdivision borders the proposed project to the east. Marigold Street runs parallel to the proposed project footprint and was developed likely in the late 1950s with dwellings constructed on the east side of the street by the early 1960s (NETR 1961). A review of aerial photographs and historic USGS maps reveal that the east side of Marigold Street was fully developed by the early 1980s (NETR 1981). The west side of Marigold Street developed sometime after 1970 (NETR 1971). As a result, built resources 50 years of age or older are present adjacent to the proposed project area.

Assessment of the Undertaking's Potential to Effect Historic Properties

The exact impact assessment for this project is currently unknown but will be updated as the MSP develops, and consultation continues. This project includes ground disturbing activities involving access, staging, construction of structural features (intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, box culverts, and other features as described in Figures 1-2), and borrow fill. These activities may directly impact both known and undocumented cultural resources listed or eligible for listing in the NRHP not limited to: archaeological sites; historic built resources; cemeteries or other sites that may contain human remains, funerary objects, sacred objects, or objects of cultural patrimony; and TCPs; that exist both within the project footprint and associated areas in a way that will diminish the integrity of these property's location, design, setting, materials, workmanship, feeling, or association.

The MSP includes the introduction of new visual elements to the project area's viewshed that have the potential to indirectly impact known and previously undocumented cultural resources that may be listed or eligible for listing in the NRHP. These elements include a roughly 400 ft. long by 200 ft. wide intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, and other features as described in Figures 1-2. The introduction of new visual elements that are inconsistent with the historic or cultural character of these potential resources could indirectly diminish the integrity of the property's setting, feeling, or association and/or cause changes to the integrity of feeling or character associated with a historic resource or TCP.

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potentially indirectly effect three built resources (LHRI ID Number 48-01071, 48-01073, and 48-01089). Additionally, the proposed project could potentially indirectly affect built resources 50 years of age or older within the Earnest Amann Subdivision, which borders the proposed project to the east.

Based on the current understanding of the historic properties in the APE and the potential effects from direct and indirect causes, CEMVN will continue to consult as anticipated historic property identification surveys are completed and affect determination are made following the terms of the BBA 18 PA. The commitment to follow the procedures in the BBA 18 Mitigation PA will also be reflected in the WSLP SEIS and the Record of Decision.

If you have any questions or require additional information concerning this undertaking, please contact Ms. Ashley Fedoroff, archaeologist, at (601) 631-5278 or via e-mail Ashley.M.Fedoroff@usace.army.mil, Ms. Jill Enersen, Architectural Historian, at (504) 862-1741 or Jill.A.Enersen@usace.army.mil, or Mr. Jason Emery, Tribal Liaison, at (504) 862-2364 or via email Jason.A.Emery@usace.army.mil.

Sincerely,

MARSHALL K. HARPER
Chief, Environmental Planning Branch

Enclosures
1. BBA 18 Mitigation PA
2. 25 March 2021, Annual Report with project list to include WSLP Swamp Mitigation.

CC: File
An electronic copy of this letter with enclosures will be provided to Ms. Johnna Flynn , Tribal Historic Preservation Officer, Jena Band of Choctaw Indians, jflynn@jenachoctaw.org.

List of Recipients:
Alabama Coushatta Tribe of Texas
Chitimacha Tribe of Louisiana
Choctaw Nation of Oklahoma
Coushatta Tribe of Louisiana
Jena Band of Choctaw Indians
Mississippi Band of Choctaw Indians
Muscogee (Creek) Nation
Seminole Nation of Oklahoma
Tunica-Biloxi Tribe of Louisiana
Louisiana State Historic Preservation Office (SHPO)
Advisory Council of Historic Places (ACHP)

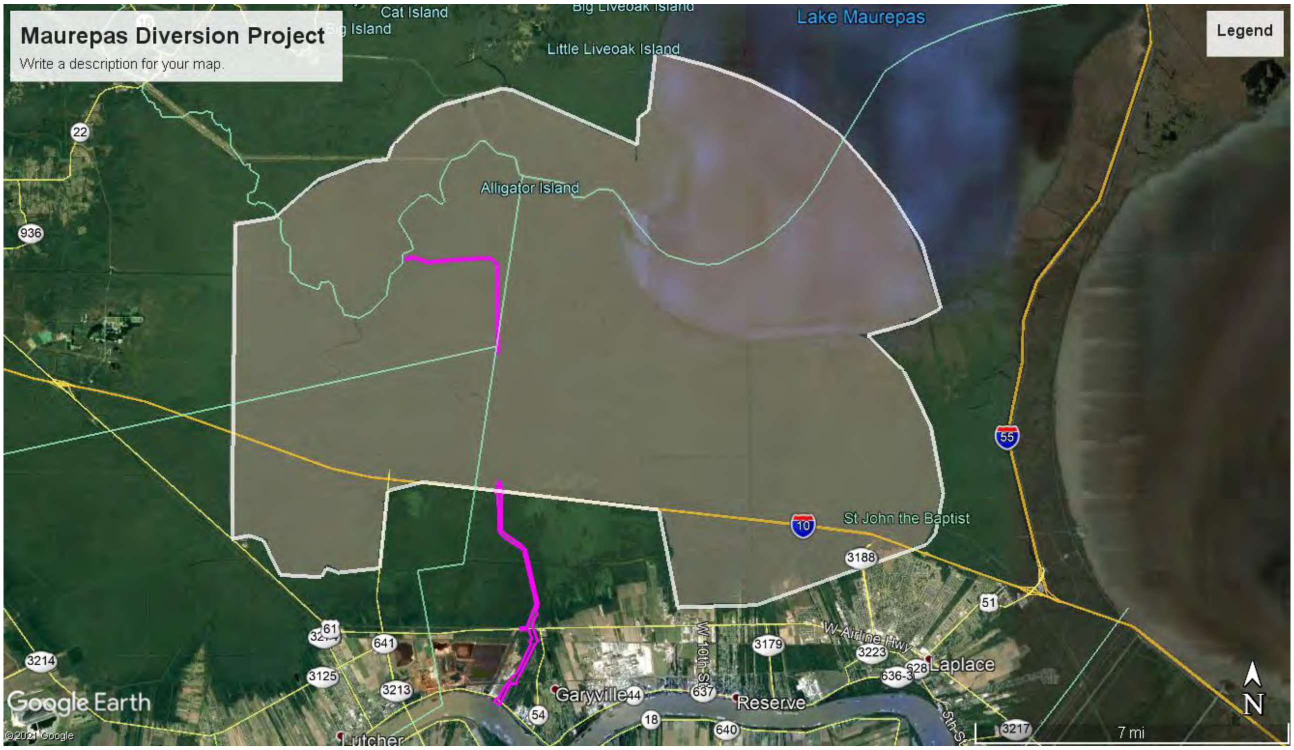

Figure 1. Overview of Maurepas Swamp Project APE: Direct Impact APE (pink) and Indirect Impact APE (white).

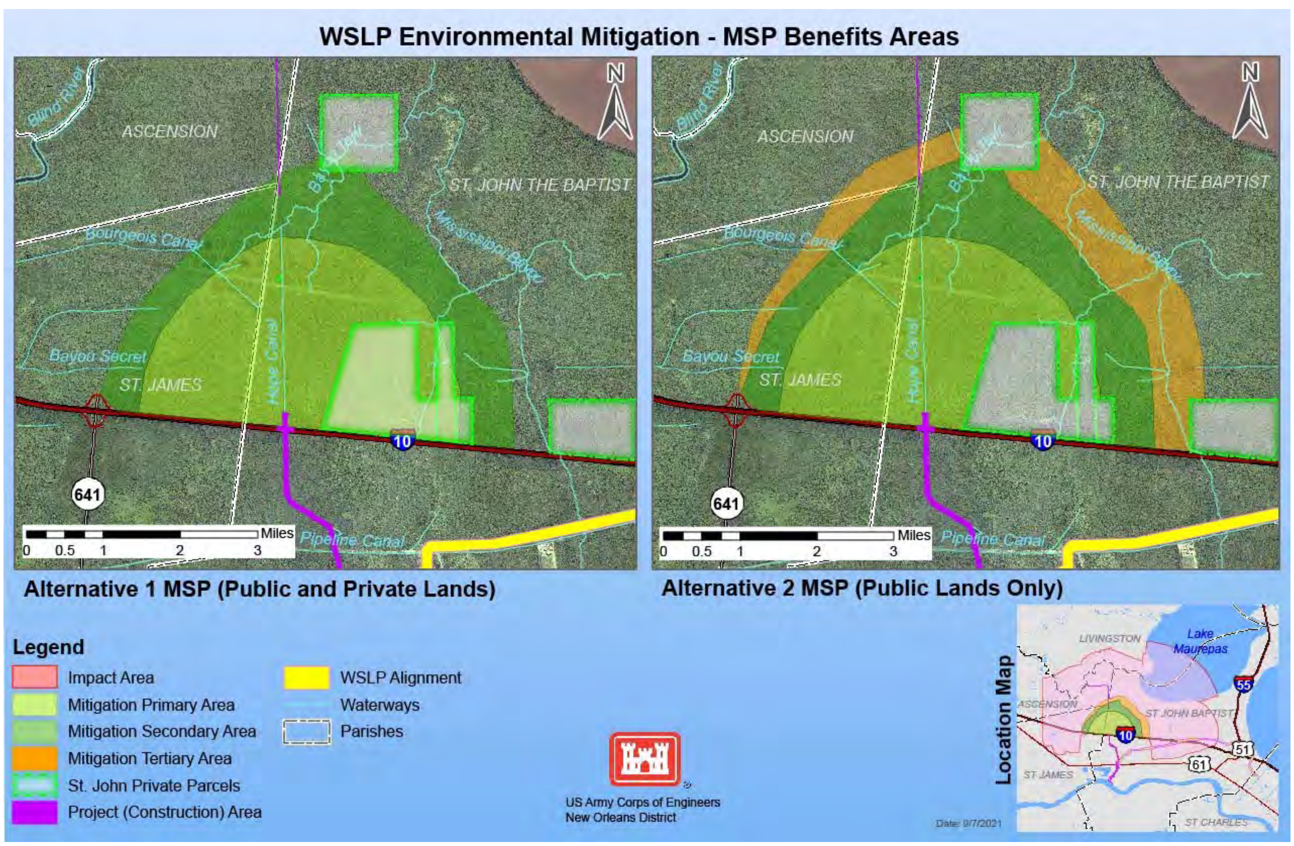

Figure 2. Detail of the Marurepas Swamp Project Mitigation Alternatives MSP 1 and MSP2.

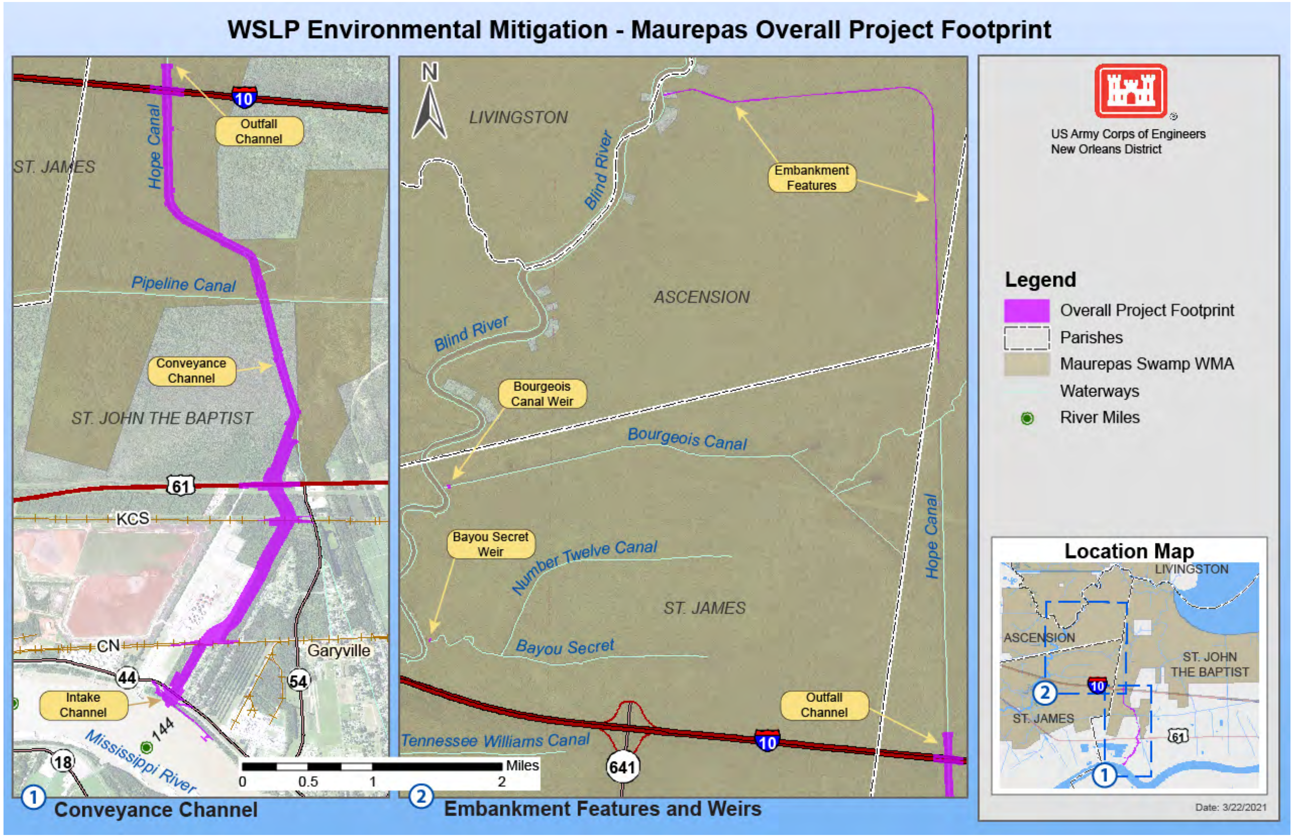

Figure 3. Detail of the construction features of for the diversion to facilitate the Maurepas Swamp Mitigation Project. Intake structure and convenance channel (left) and the weir and embankment features (right).

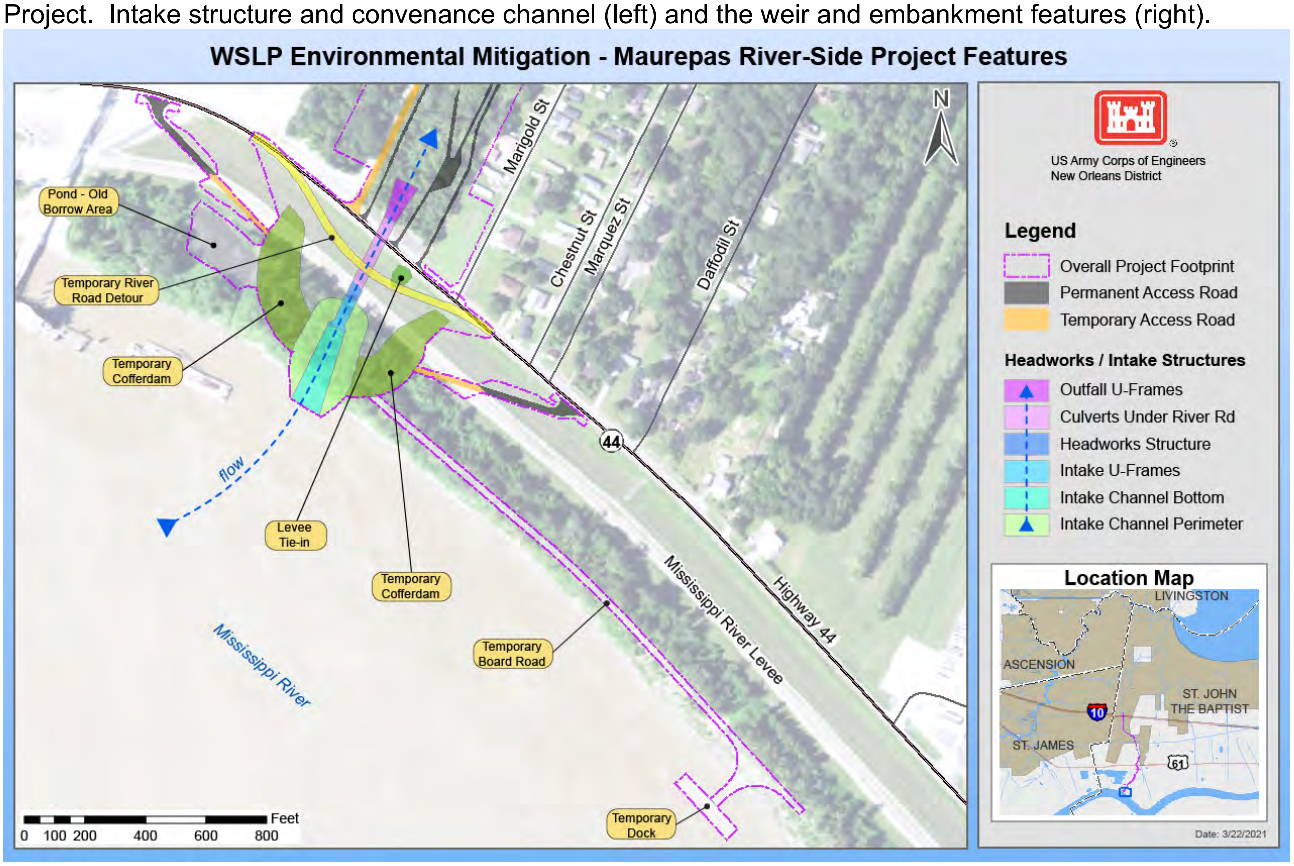

Figure 4 : Detail of the Intake Structure and appurtenant features.

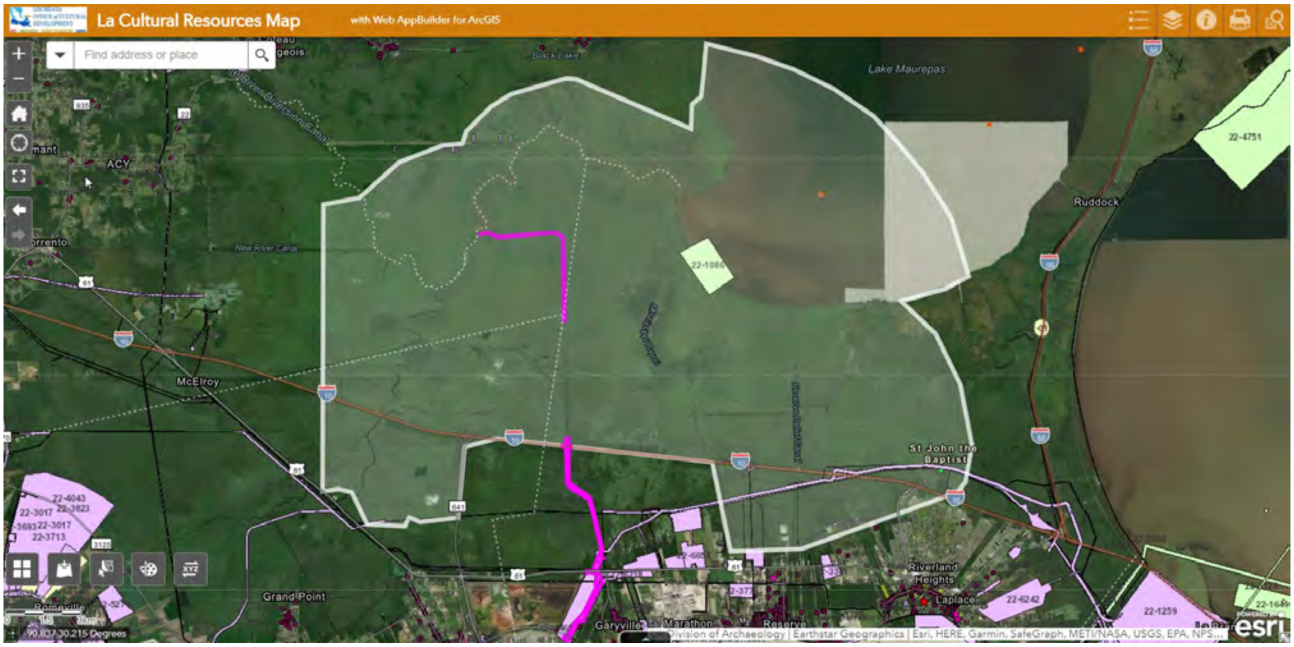

Figure 5: Maurepas Swamp Project APE: Direct Impact APE (pink) and Indirect Impact APE (white). LDOA Cultural Resources Map. Note that the conveyance channel area has been surveyed under LDOA Report # 22-3023.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 Leake Ave, New Orleans, LA 70118

October 19, 2021

Regional Planning and
Environment Division, South
Environmental Planning Branch
Attn: CEMVN-PDS-N

Cyrus Ben, Chief
Mississippi Band of Choctaw Indians
P.O. Box 6010
Choctaw, MS 39350

RE: **Section 106 Notification -** Addition of Maurepas Swamp Project (MSP) to Appendix B of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA).

Dear Chief Ben:

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative.

Background

Previously, CEMVN evaluated environmental impacts due to construction of the West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Project (WSLP Project) through a Supplemental Environmental Assessment (SEA) 576, which addressed mitigation for habitat impacts associated with each of the Bipartisan Budget Act (BBA) 18 construction projects (i.e., WSLP Project, Comite Project, and East Baton Rouge Project). The Finding of No Significant Impact (FONSI) for SEA 576 was signed by the CEMVN District Commander on April 4, 2020. Associated with this effort was the development and execution of the BBA 18 Habitat Mitigation PA to provide an alternative NHPA Section 106

process tailored to the construction of habitat mitigation projects (enclosed). As part of the public review process, the Non-Federal Sponsor, Louisiana's Coastal Protection Restoration Authority (CPRA), requested that CEMVN evaluate the Mississippi River Diversion into Maurepas Swamp [PO-29; Maurepas Swamp Project (MSP)], a proposed ecological restoration project that shares construction features with the WSLP Project, be considered as a mitigation alternative for impacts to swamp habitat associated with the construction of the WSLP Project.

In order to evaluate the proposed mitigation project in a manner similar to the other proposed mitigation projects, CEMVN is preparing a Supplemental Environmental Impact Statement to West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study (WSLP SEIS) to compare viable swamp mitigation alternatives within the Pontchartrain Basin. As part of this effort, CEMVN will be utilizing the currently executed BBA 18 Habitat Mitigation PA to conduct any additional necessary Historic Property identification, NRHP evaluation, consultation, and mitigation, as this mitigation project clear meets the intent of the PA after reviewing the preamble and the applicability description in Appendix B.

Initial notification was distributed to consulting parties as part of the annual report of activities on March 25, 2021, via email (enclosed). The Louisiana State Historic Preservation Office (LA SHPO) responded on March 25, 2021 saying, "the State Historic Preservation Office concurs that incorporating the WSLP Maurepas Diversion Habitat Management Site under the terms of the BBA-18 Habitat Mitigation Programmatic Agreement is appropriate."

Description of Undertaking- Maurepas Swamp Project (MSP)

Pursuant to Stipulation II. C., Defining the Undertaking, CEMVN is sharing the current designs for the plan and the initial historic property findings for this mitigation project. The proposed Maurepas Swamp Project (MSP) involves a freshwater diversion that would reconnect the Mississippi River to the Maurepas Swamp, strategically delivering nutrient-laden river water to restore the health of the dying Cypress-Tupelo Swamp. The project is proposed as a 2,000 cubic foot per second (cfs) freshwater diversion with the intake of the conveyance channel located on the West Bank of the Mississippi River in St. John the Baptist Parish, immediately west of Garyville, Louisiana, at River Mile 144 Above Head of Passes (AHP). The 300 ft wide construction corridor for the conveyance channel extends from LA 44 (River Road) northward. It extends northward for 5½ miles, terminating approximately 1,000 ft north of Interstate 10 (I-10) (Figure 1, 2 and 3).

The primary project features are located in St. John the Baptist Parish and are comprised of, but not limited to, the following elements:

- an intake channel from the Mississippi River; *(Figure 4, Figure 3)*
- an automated gate structure in the Mississippi River Levee (MRL); *(Figure 4)*
- a sedimentation basin; *(within the conveyance channel)*
- a 5.5-mile long open conveyance channel; *(Figure 4)*
- box culverts under River Road, Canadian National Railroad (CN), and Airline Highway; *(Figure4)*

- a bridge over the channel at Kansas City Southern Railroad (KCS); *(Figure 4)*
- 8 lateral discharge valves between Airline Highway and I-10 to carry flow from the conveyance channel to areas east and west of the channel (Figure 3);
- check valving on culverts underneath I-10 to mitigate southward backflow (Figure 3);
- reshaping the geometry of the existing Hope Canal channel under I-10 (Figure 3 and 2)
- embankment cuts in the existing ridge of an old railroad embankment; *(Figure 3)* and
- submerged rock rip-rap weirs in Bayou Secret and Bourgeois Canal; *(Figure 3)*

The intake channel is roughly 400 ft long by 200 ft wide, with a bottom depth at EL (-) 4 ft NAVD88 excavated into the batture to route flow from the Mississippi River into the diversion headworks. The channel will be lined with riprap to prevent scour. The primary function of the headworks structure is to convey flow from the intake channel underneath the Mississppi River Levee (MRL). It will be comprised of a multi-cell box culvert with vertical lift gates (sluice gates) (Figure 4).

The outlet for the conveyance channel is along the existing centerline of Hope Canal. The guide levee elevations from the Interstate 10 (I-10) bridges to the termination point gradually transition to existing grade. At that point the diverted water will overflow the canal banks and dissipate into the area above I-10, south of Lake Maurepas.

The diversion flow of 2,000 cfs generally spreads radially outwards as it enters the swamp north of I-10. Approximately, one-third flows westward through the swamp, one-third flows through Dutch Bayou and the remaining third flows eastward through the swamp. The westward flow enters Blind River and largely proceeds to Lake Maurepas. The eastward flow enters the Reserve Relief Canal and mostly proceeds to Lake Maurepas. Most of the swamp water is displaced by the introduced Mississippi River water (Figure 1,3, and 5). This spreading water is captured in the figures and is what accounts for this being a mitigation project for swamp habitat.

Required earthwork would consist of clearing, grubbing, excavation, and removal of earthen material for the project's conveyance channel and disposal at an approved disposal site. When possible, unsuitable excavated material could be utilized beneficially. If a borrow study in subsequent design phases indicates sufficient suitable material within the excavated material, the Contractor may elect to use that material on-site. Any material used on site would stay within the right-of-way (ROW) and would be used to construct features.

Additional earthwork outside of the conveyance channel will occur along the existing ridge of an old railroad embankment. 7.51 acres along the old railroad embankment will be cleared for equipment access. 5 individual areas along the embankment will be excavated to existing grade while all spoil will be placed in 20 individual areas along the embankment. It is anticipated that no material will be removed from the project area.

Area of Potential Effect (APE)

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Sincerely,

MARSHALL K. HARPER
Chief, Environmental Planning Branch

Enclosures
1. BBA 18 Mitigation PA
2. 25 March 2021, Annual Report with project list to include WSLP Swamp Mitigation.

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Chitimacha Tribe of Louisiana
Choctaw Nation of Oklahoma
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Jena Band of Choctaw Indians
Mississippi Band of Choctaw Indians
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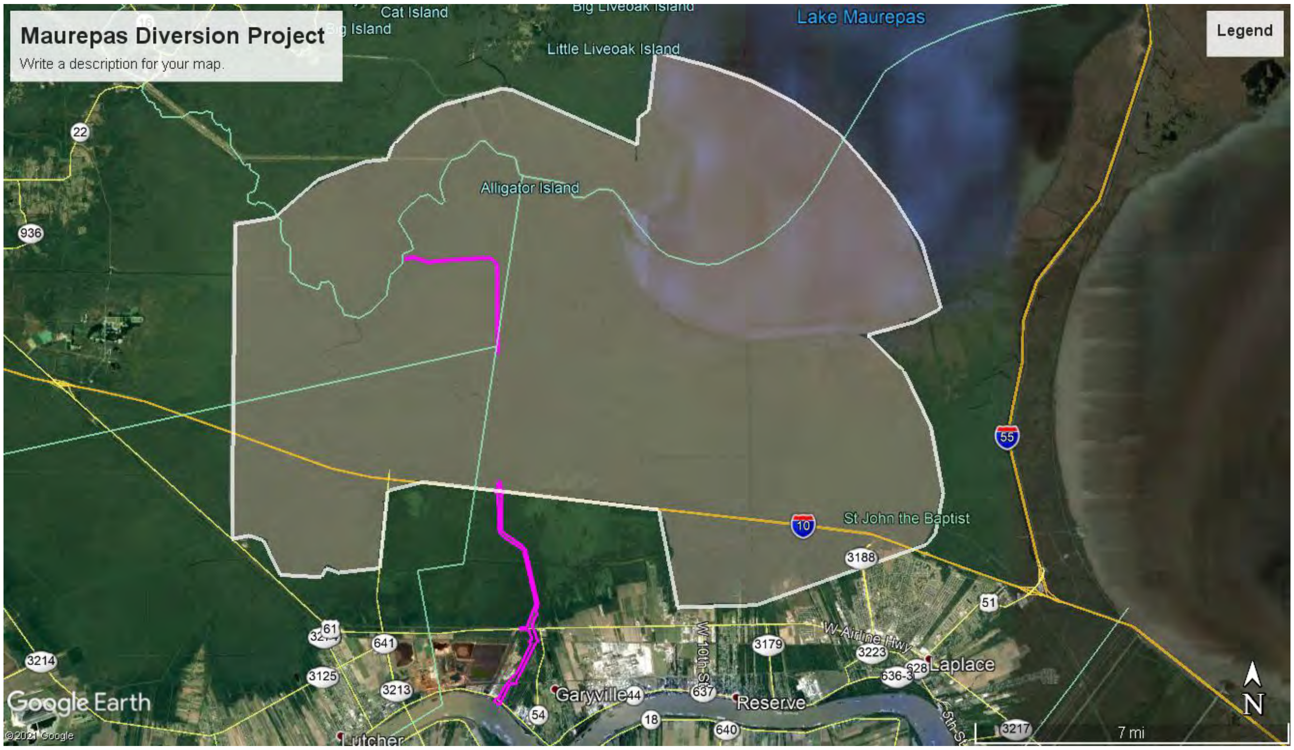

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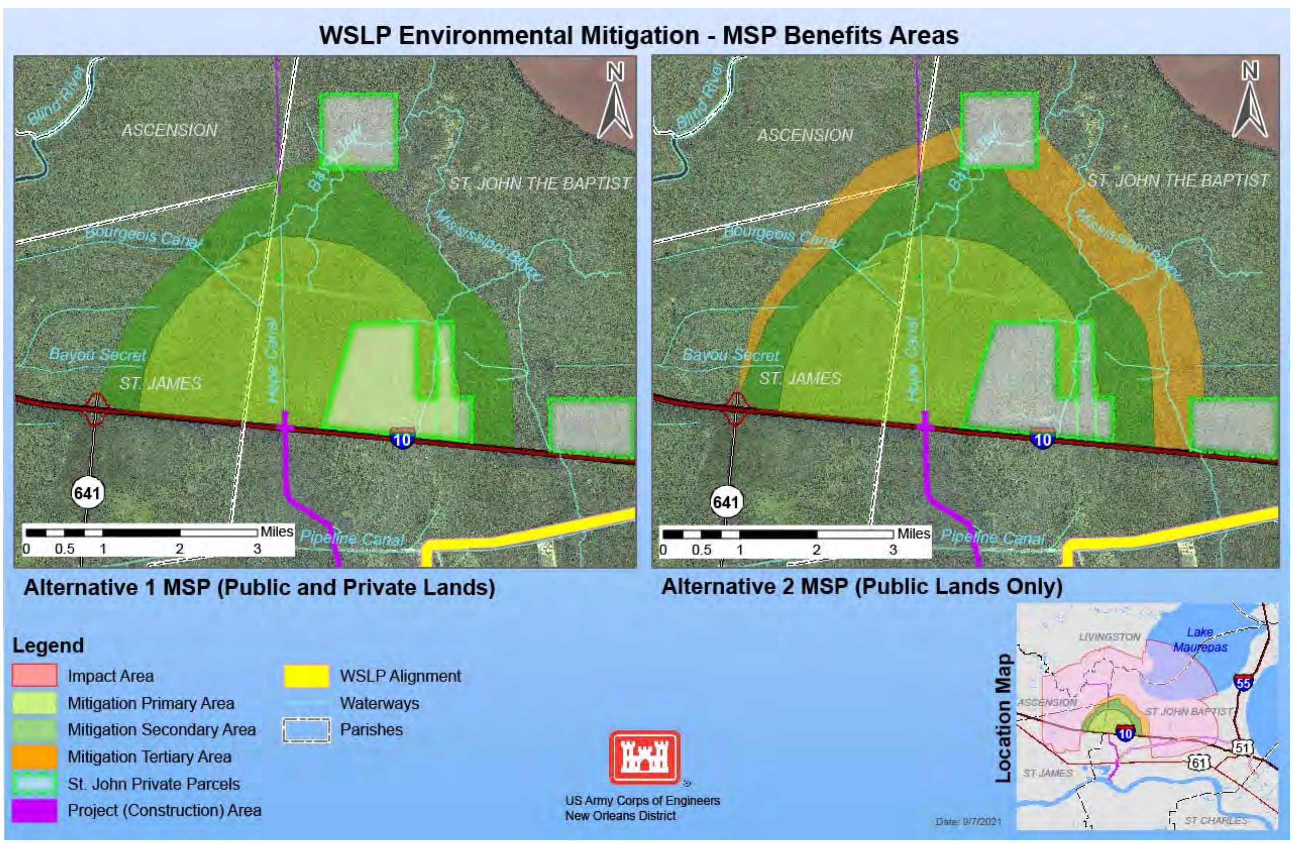

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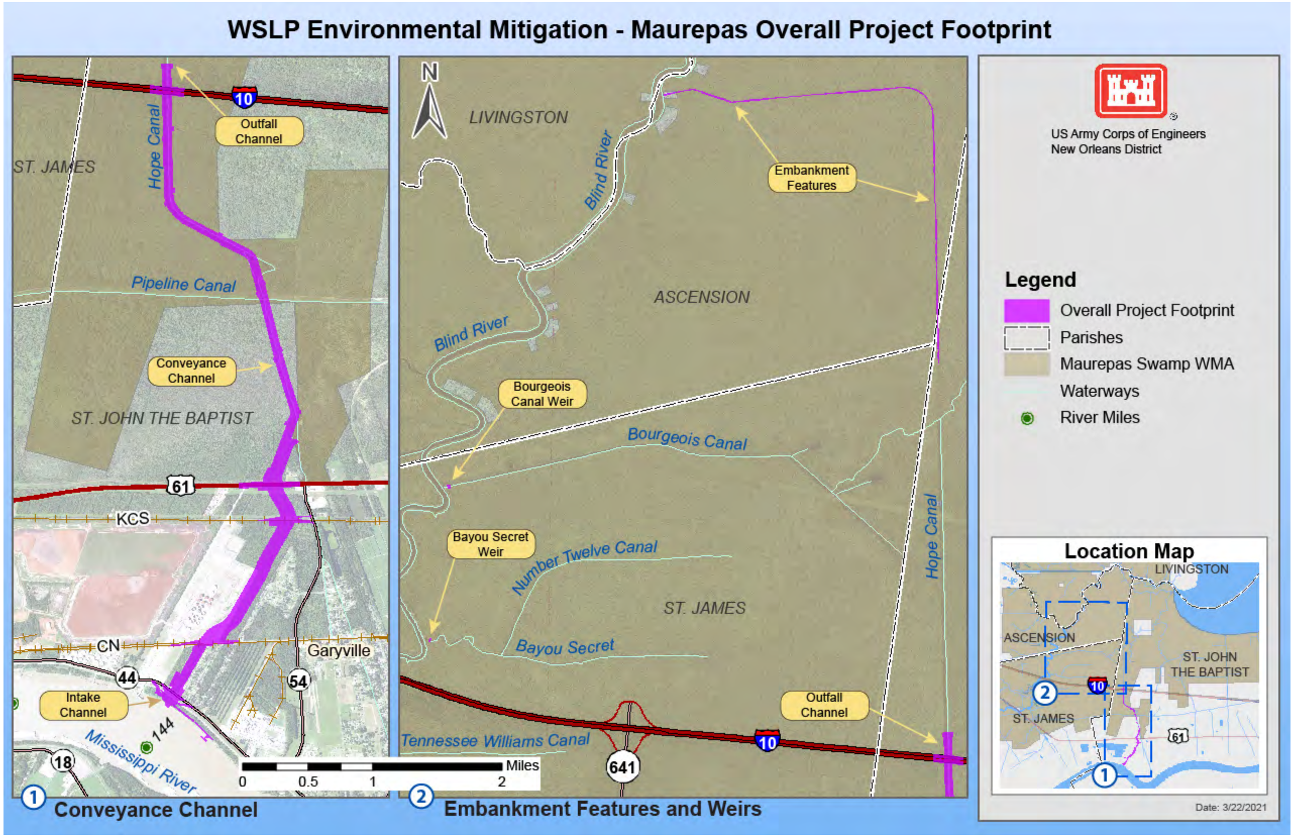

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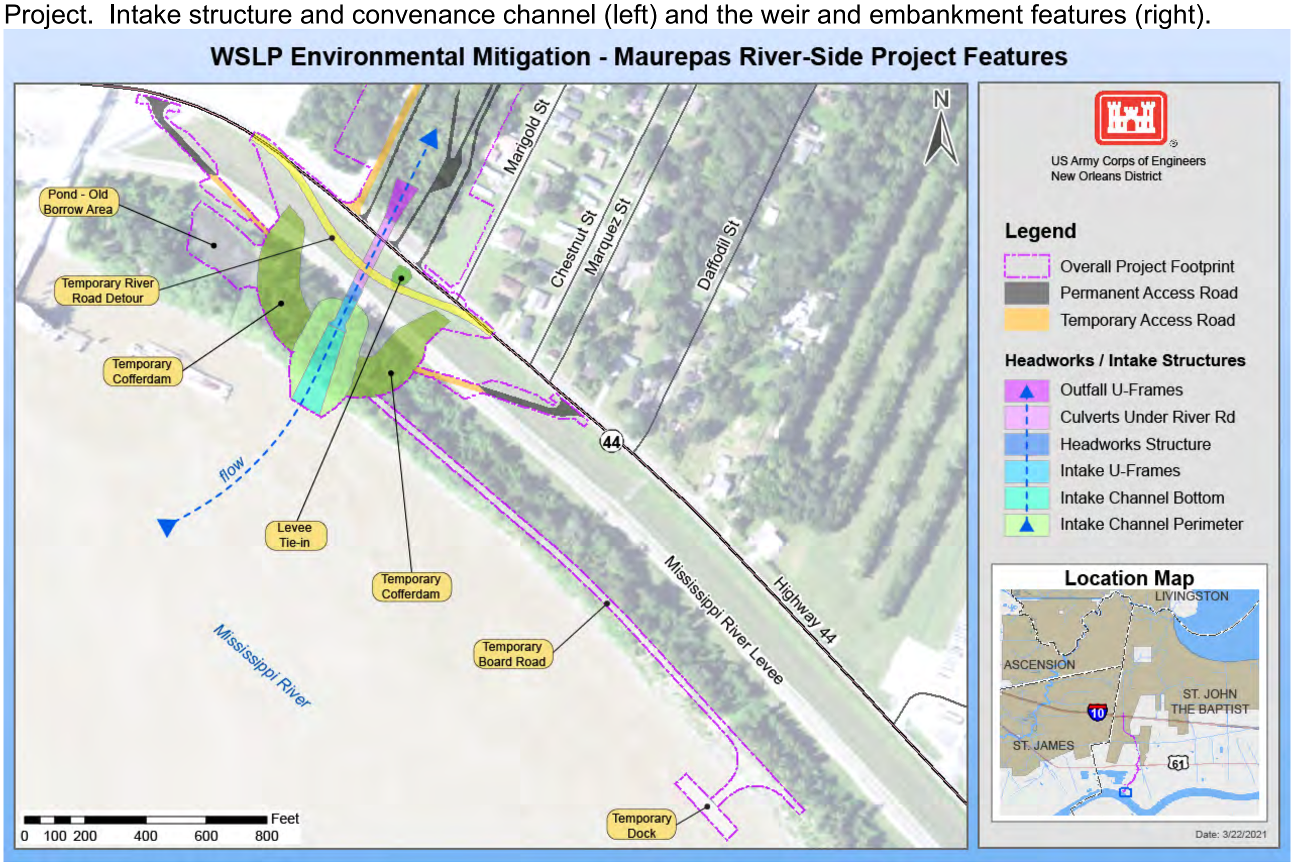

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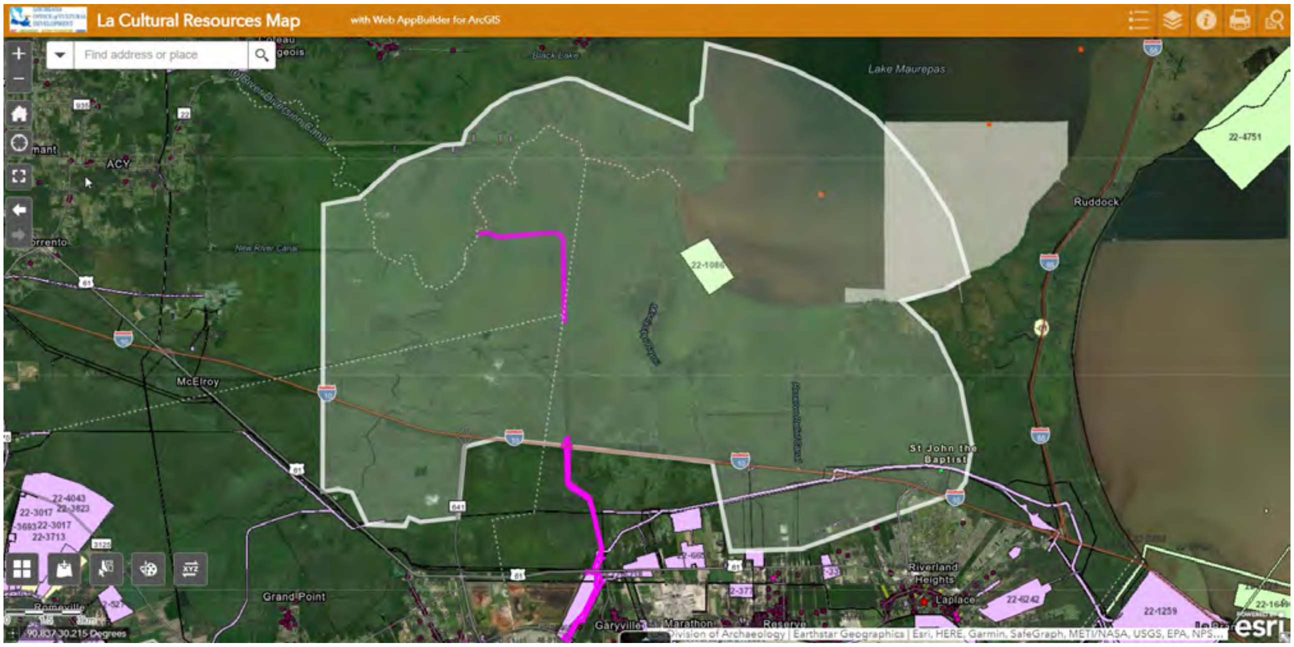

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DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 Leake Ave, New Orleans, LA 70118

October 19, 2021

Regional Planning and
Environment Division, South
Environmental Planning Branch
Attn: CEMVN-PDS-N

Mr. David Hill, Principal Chief
Muscogee (Creek) Nation
Attn: Historic and Cultural Preservation Office
P.O. Box 580
Okmulgee, OK 74447

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execution of the BBA 18 Habitat Mitigation PA to provide an alternative NHPA Section 106 process tailored to the construction of habitat mitigation projects (enclosed). As part of the public review process, the Non-Federal Sponsor, Louisiana's Coastal Protection Restoration Authority (CPRA), requested that CEMVN evaluate the Mississippi River Diversion into Maurepas Swamp [PO-29; Maurepas Swamp Project (MSP)], a proposed ecological restoration project that shares construction features with the WSLP Project, be considered as a mitigation alternative for impacts to swamp habitat associated with the construction of the WSLP Project.

In order to evaluate the proposed mitigation project in a manner similar to the other proposed mitigation projects, CEMVN is preparing a Supplemental Environmental Impact Statement to West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study (WSLP SEIS) to compare viable swamp mitigation alternatives within the Pontchartrain Basin. As part of this effort, CEMVN will be utilizing the currently executed BBA 18 Habitat Mitigation PA to conduct any additional necessary Historic Property identification, NRHP evaluation, consultation, and mitigation, as this mitigation project clear meets the intent of the PA after reviewing the preamble and the applicability description in Appendix B.

Initial notification was distributed to consulting parties as part of the annual report of activities on March 25, 2021, via email (enclosed). The Louisiana State Historic Preservation Office (LA SHPO) responded on March 25, 2021 saying, "the State Historic Preservation Office concurs that incorporating the WSLP Maurepas Diversion Habitat Management Site under the terms of the BBA-18 Habitat Mitigation Programmatic Agreement is appropriate."

Description of Undertaking- Maurepas Swamp Project (MSP)

Pursuant to Stipulation II. C., Defining the Undertaking, CEMVN is sharing the current designs for the plan and the initial historic property findings for this mitigation project. The proposed Maurepas Swamp Project (MSP) involves a freshwater diversion that would reconnect the Mississippi River to the Maurepas Swamp, strategically delivering nutrient-laden river water to restore the health of the dying Cypress-Tupelo Swamp. The project is proposed as a 2,000 cubic foot per second (cfs) freshwater diversion with the intake of the conveyance channel located on the West Bank of the Mississippi River in St. John the Baptist Parish, immediately west of Garyville, Louisiana, at River Mile 144 Above Head of Passes (AHP). The 300 ft wide construction corridor for the conveyance channel extends from LA 44 (River Road) northward. It extends northward for 5½ miles, terminating approximately 1,000 ft north of Interstate 10 (I-10) (Figure 1, 2 and 3).

The primary project features are located in St. John the Baptist Parish and are comprised of, but not limited to, the following elements:

- an intake channel from the Mississippi River; *(Figure 4, Figure 3)*
- an automated gate structure in the Mississippi River Levee (MRL); *(Figure 4)*
- a sedimentation basin; *(within the conveyance channel)*
- a 5.5-mile long open conveyance channel; *(Figure 4)*

- box culverts under River Road, Canadian National Railroad (CN), and Airline Highway; *(Figure4)*
- a bridge over the channel at Kansas City Southern Railroad (KCS); *(Figure 4)*
- 8 lateral discharge valves between Airline Highway and I-10 to carry flow from the conveyance channel to areas east and west of the channel (Figure 3);
- check valving on culverts underneath I-10 to mitigate southward backflow (Figure 3);
- reshaping the geometry of the existing Hope Canal channel under I-10 (Figure 3 and 2)
- embankment cuts in the existing ridge of an old railroad embankment; *(Figure 3)* and
- submerged rock rip-rap weirs in Bayou Secret and Bourgeois Canal; *(Figure 3)*

The intake channel is roughly 400 ft long by 200 ft wide, with a bottom depth at EL (-) 4 ft NAVD88 excavated into the batture to route flow from the Mississippi River into the diversion headworks. The channel will be lined with riprap to prevent scour. The primary function of the headworks structure is to convey flow from the intake channel underneath the Mississppi River Levee (MRL). It will be comprised of a multi-cell box culvert with vertical lift gates (sluice gates) (Figure 4).

The outlet for the conveyance channel is along the existing centerline of Hope Canal. The guide levee elevations from the Interstate 10 (I-10) bridges to the termination point gradually transition to existing grade. At that point the diverted water will overflow the canal banks and dissipate into the area above I-10, south of Lake Maurepas.

The diversion flow of 2,000 cfs generally spreads radially outwards as it enters the swamp north of I-10. Approximately, one-third flows westward through the swamp, one-third flows through Dutch Bayou and the remaining third flows eastward through the swamp. The westward flow enters Blind River and largely proceeds to Lake Maurepas. The eastward flow enters the Reserve Relief Canal and mostly proceeds to Lake Maurepas. Most of the swamp water is displaced by the introduced Mississippi River water (Figure 1,3, and 5). This spreading water is captured in the figures and is what accounts for this being a mitigation project for swamp habitat.

Required earthwork would consist of clearing, grubbing, excavation, and removal of earthen material for the project's conveyance channel and disposal at an approved disposal site. When possible, unsuitable excavated material could be utilized beneficially. If a borrow study in subsequent design phases indicates sufficient suitable material within the excavated material, the Contractor may elect to use that material on-site. Any material used on site would stay within the right-of-way (ROW) and would be used to construct features.

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Pursuant to Stipulation II. D. (1-4) of the BBA 18 Mitigation PA, CEMVN has defined a preliminary APE in Figure 1 and 5. The APE incorporates both direct effects (e.g., access, staging, and construction areas), indirect effects (e.g., visual), and areas of inundation (outflow area). The direct construction APE of the MSP is approximately 288.30 acres (116.67 hectares). The Indirect APE extends beyond the construction footprint for roughly 50 feet. The outflow area APE includes Maurepas Swamp and Lake Maurepas and is approximately 90,357 acres (36,566 hectares). The total APE, direct and indirect, is approximately 90,652.7 acres (36,686.12 hectares) (Figure 1 and 5). It is acknowledged that this APE is preliminary based on the state of development of the project. Should the APE need to be revised, CEMVN will follow provision II. D. 3. Of the BBA 18 Mitigation PA to proposed revisions.

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CEMVN identified historic properties within the project footprint, mitigation areas, and impact areas (collectively the APE) based on a review of the NRHP database, the Louisiana Division of Archaeology (LDOA) Louisiana Cultural Resources Map (LDOA Website), historic maps, pertinent regional and local cultural resources investigations, historic aerial photography, and other appropriate sources. This review identified 15 previous cultural resources surveys, 11 previously recorded archaeological sites, and three (3) previously recorded architectural resources within the MSP APE (Figure 5).

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A total of eleven (11) archaeological sites are present within the MSP APE. Two (2) of these sites are not eligible for the NRHP, 16SJ73 (Blind River Timber Rail) and 16SJB68 (Angelina Plantation, Note: Locus A of 16SJ68 is of unknown eligibility). Seven (7) sites are listed as unknown eligibility (16AN8, 16LV24, 16LV73, 16LV74, 16LV103, 16SJ72, and 16SJB4). These sites include four (4) prehistoric shell middens (16AN8, 16LV73, 16LV24, 16SJB4), 2 possible watercrafts/shipwrecks (16LV74, 16SJ72), one (1) railroad bridge (16SJ72), and the Amite River Diversion Canal (16LV103). Two (2) cemeteries are present within the APE (16SJ58, 16SJ61), both dating back to the Civil War.

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Architectural

The proposed project is located approximately one (1) mile from the Garyville Historic District, a National Register Historic District (NRHD) listed in the NRHP in 1990. Tree coverage along the majority of LA-54 separates the Garyville Historic District from the proposed project. The proposed project is located west of LA-54 while the Garyville Historic District is located east of LA-54. No individual historic properties were identified as

listed, or formally determined eligible for listing by the Keeper, in the NRHP within the project, mitigation, and impact areas. No previously recorded built resources are located within the mitigation and impact areas.

Review of previous investigations revealed three built resources (Louisiana Historic Resource Inventory (LHRI) ID Number 48-01071, 48-01073, and 48-01089) within or adjacent to the project area that were individually documented in 1985. According to the LDOA Cultural Resources Map, these three resources are near River Road and the proposed headworks and intake structures. During the mid-1980’s, many of the surveyed resources were identified by Post Office Box or only the street name. As a result, LHRI Numbers 48-01071, 48-01073, and 48-01089 do not have identifying street numbers and street names. Visual inspection via Google Street View suggests that these three (3) resources may have been demolished or their LHRI locations are plotted incorrectly on the LDOA Cultural Resources Map.

The Earnest Amann Subdivision borders the proposed project to the east. Marigold Street runs parallel to the proposed project footprint and was developed likely in the late 1950s with dwellings constructed on the east side of the street by the early 1960s (NETR 1961). A review of aerial photographs and historic USGS maps reveal that the east side of Marigold Street was fully developed by the early 1980s (NETR 1981). The west side of Marigold Street developed sometime after 1970 (NETR 1971). As a result, built resources 50 years of age or older are present adjacent to the proposed project area.

Assessment of the Undertaking’s Potential to Effect Historic Properties

The exact impact assessment for this project is currently unknown but will be updated as the MSP develops, and consultation continues. This project includes ground disturbing activities involving access, staging, construction of structural features (intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, box culverts, and other features as described in Figures 1-2), and borrow fill. These activities may directly impact both known and undocumented cultural resources listed or eligible for listing in the NRHP not limited to: archaeological sites; historic built resources; cemeteries or other sites that may contain human remains, funerary objects, sacred objects, or objects of cultural patrimony; and TCPs; that exist both within the project footprint and associated areas in a way that will diminish the integrity of these property’s location, design, setting, materials, workmanship, feeling, or association.

The MSP includes the introduction of new visual elements to the project area’s viewshed that have the potential to indirectly impact known and previously undocumented cultural resources that may be listed or eligible for listing in the NRHP. These elements include a roughly 400 ft. long by 200 ft. wide intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, and other features as described in Figures 1-2. The introduction of new visual elements that are inconsistent with the historic or cultural character of these potential resources could indirectly diminish the integrity of the property’s setting, feeling, or association and/or cause changes to the integrity of feeling or character associated with a historic resource or TCP.

The proposed project is located approximately one mile from the Garyville Historic District, a NRHD listed in the NRHP in 1990. No indirect effects to the Garyville Historic

District would occur due to tree coverage along the majority of LA-54 which separates the Garyville Historic District from the proposed project. However, the proposed project could potentially indirectly effect three built resources (LHRI ID Number 48-01071, 48-01073, and 48-01089). Additionally, the proposed project could potentially indirectly affect built resources 50 years of age or older within the Earnest Amann Subdivision, which borders the proposed project to the east.

Based on the current understanding of the historic properties in the APE and the potential effects from direct and indirect causes, CEMVN will continue to consult as anticipated historic property identification surveys are completed and affect determination are made following the terms of the BBA 18 PA. The commitment to follow the procedures in the BBA 18 Mitigation PA will also be reflected in the WSLP SEIS and the Record of Decision.

If you have any questions or require additional information concerning this undertaking, please contact Ms. Ashley Fedoroff, archaeologist, at (601) 631-5278 or via e-mail Ashley.M.Fedoroff@usace.army.mil, Ms. Jill Enersen, Architectural Historian, at (504) 862-1741 or Jill.A.Enersen@usace.army.mil, or Mr. Jason Emery, Tribal Liaison, at (504) 862-2364 or via email Jason.A.Emery@usace.army.mil.

Sincerely,

MARSHALL K. HARPER
Chief, Environmental Planning Branch

Enclosures

1. BBA 18 Mitigation PA
2. 25 March 2021, Annual Report with project list to include WSLP Swamp Mitigation.

CC: File

An electronic copy of this letter with enclosures will be provided to Ms. Corain Lowe-Zepeda, Tribal Historic Preservation Officer, Muscogee (Creek) Nation, section106@mcn-nsn.gov.

List of Recipients:
Alabama Coushatta Tribe of Texas
Chitimacha Tribe of Louisiana
Choctaw Nation of Oklahoma
Coushatta Tribe of Louisiana
Jena Band of Choctaw Indians
Mississippi Band of Choctaw Indians
Muscogee (Creek) Nation
Seminole Nation of Oklahoma
Tunica-Biloxi Tribe of Louisiana

Louisiana State Historic Preservation Office (SHPO)
Advisory Council of Historic Places (ACHP)

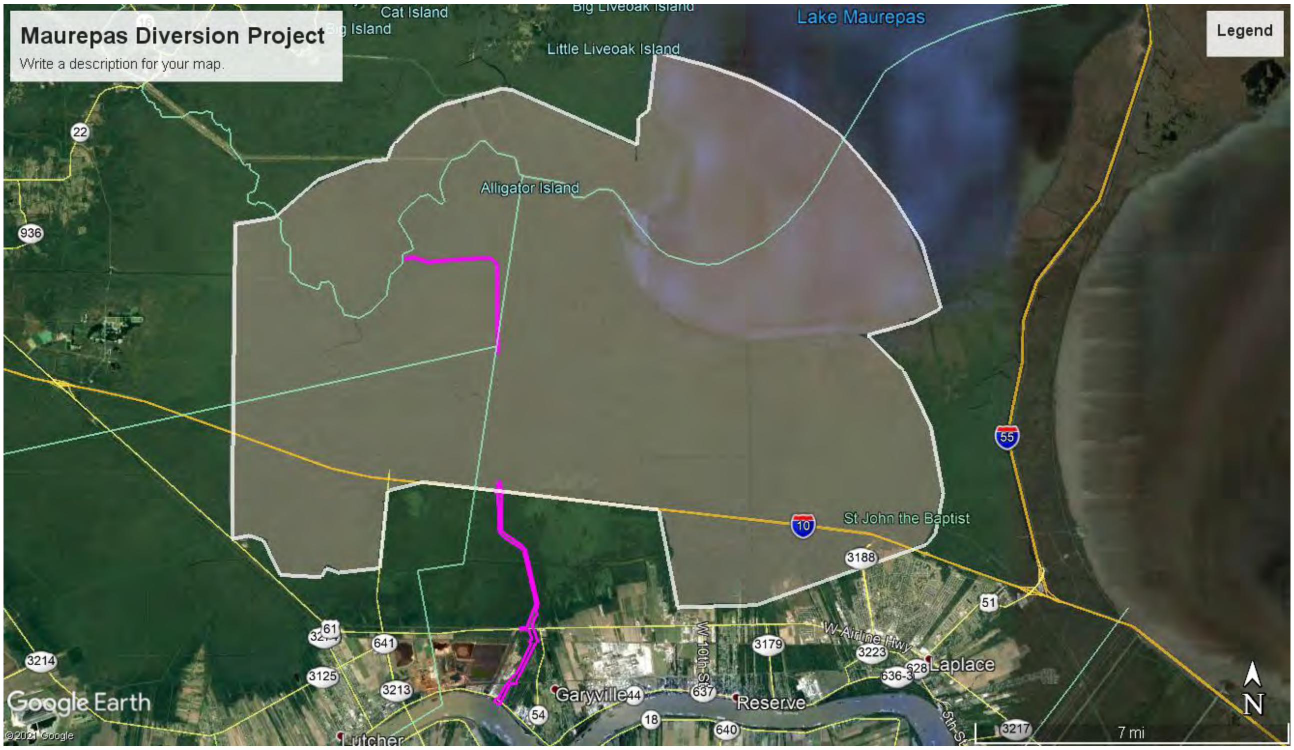

Figure 1. Overview of Maurepas Swamp Project APE: Direct Impact APE (pink) and Indirect Impact APE (white).

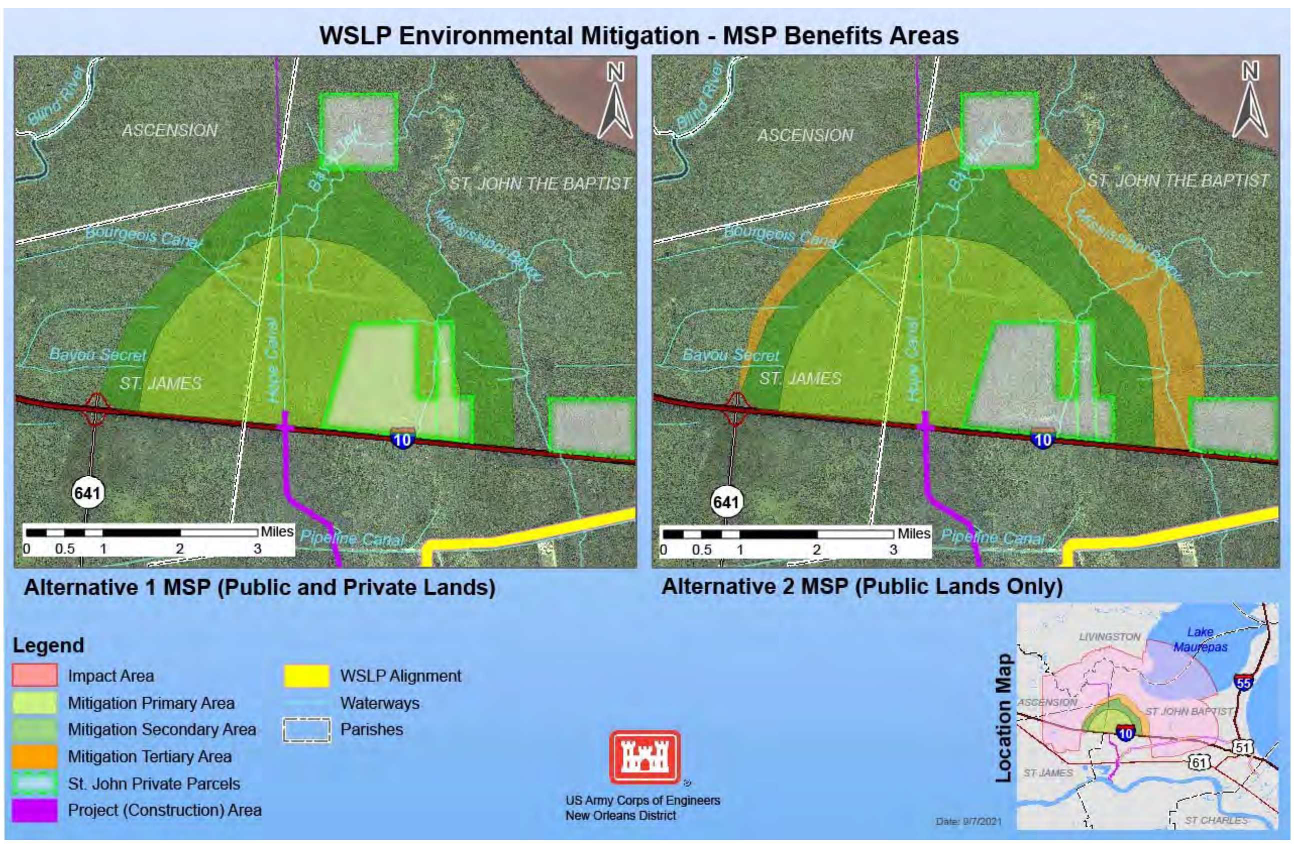

Figure 2. Detail of the Marurepas Swamp Project Mitigation Alternatives MSP 1 and MSP2.

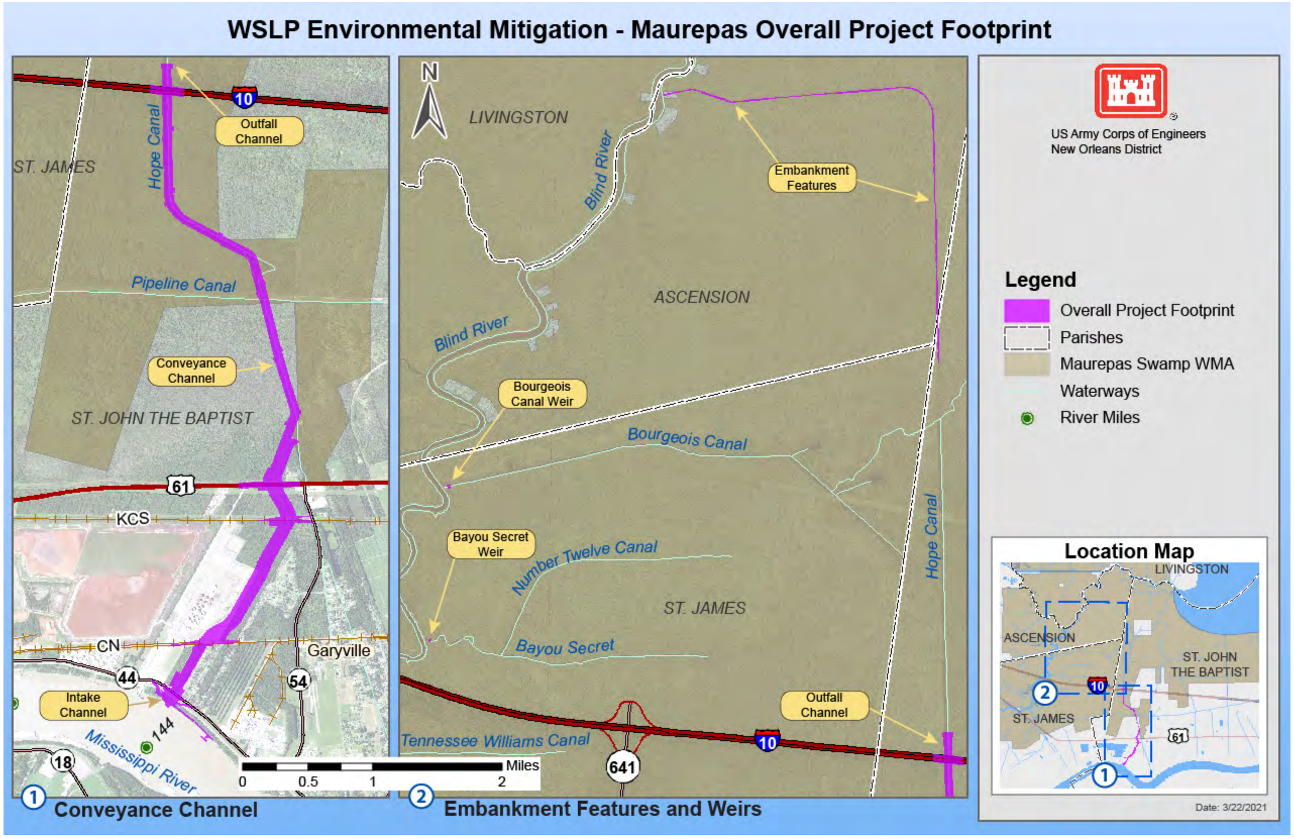

Figure 3. Detail of the construction features of for the diversion to facilitate the Maurepas Swamp Mitigation Project. Intake structure and convenance channel (left) and the weir and embankment features (right).

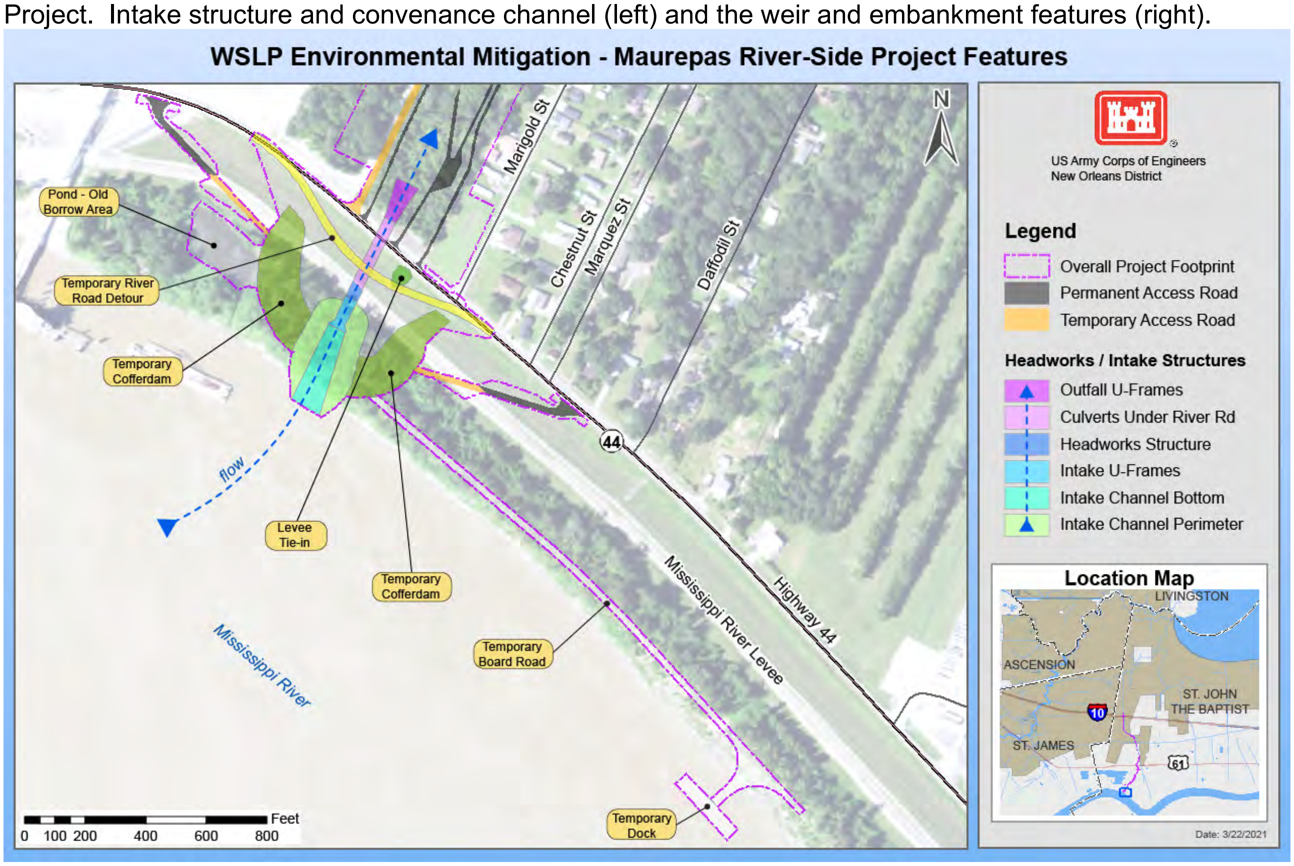

Figure 4 : Detail of the Intake Structure and appurtenant features.

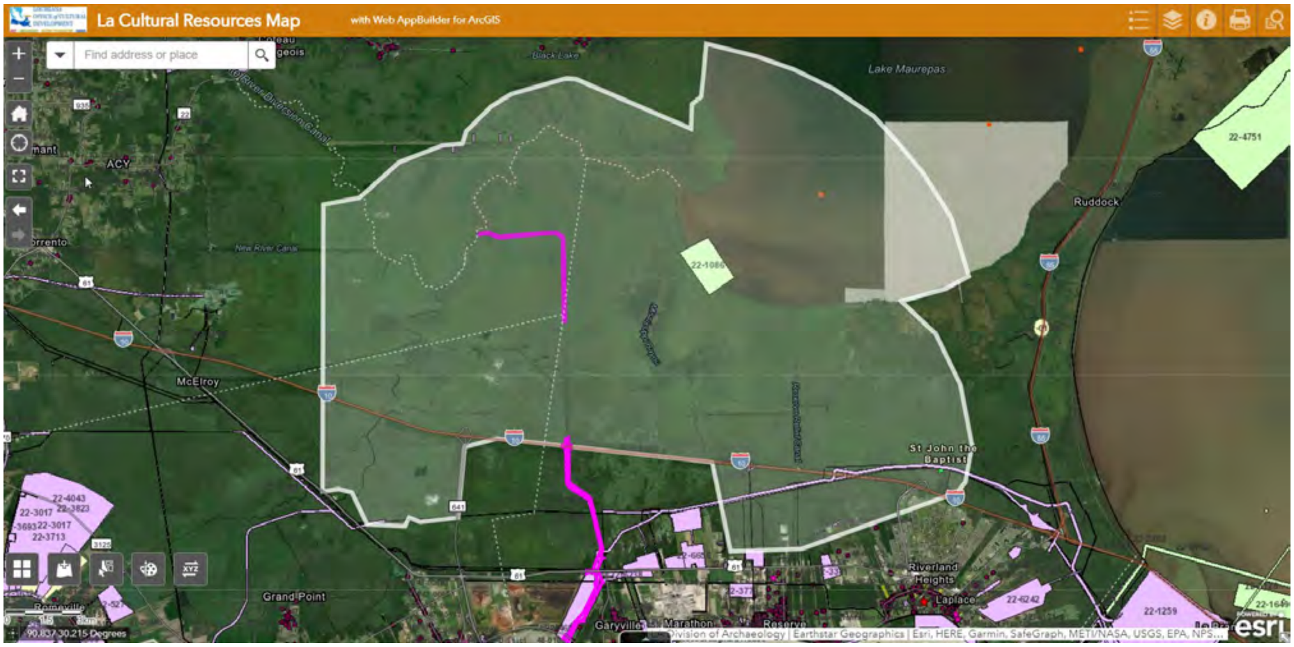

Figure 5: Maurepas Swamp Project APE: Direct Impact APE (pink) and Indirect Impact APE (white). LDOA Cultural Resources Map. Note that the conveyance channel area has been surveyed under LDOA Report # 22-3023.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 Leake Ave, New Orleans, LA 70118

October 19, 2021

Regional Planning and
Environment Division, South
Environmental Planning Branch
Attn: CEMVN-PDS-N

Greg Chilcoat, Principal Chief
Seminole Nation of Oklahoma
P.O. Box 1498
Wewoka, OK 74884

RE: **Section 106 Notification -** Addition of Maurepas Swamp Project (MSP) to Appendix B of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA).

Dear Principal Chief Chilcoat:

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative.

Background

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If you have any questions or require additional information concerning this undertaking, please contact Ms. Ashley Fedoroff, archaeologist, at (601) 631-5278 or via e-mail Ashley.M.Fedoroff@usace.army.mil, Ms. Jill Enersen, Architectural Historian, at (504) 862-1741 or Jill.A.Enersen@usace.army.mil, or Mr. Jason Emery, Tribal Liaison, at (504) 862-2364 or via email Jason.A.Emery@usace.army.mil.

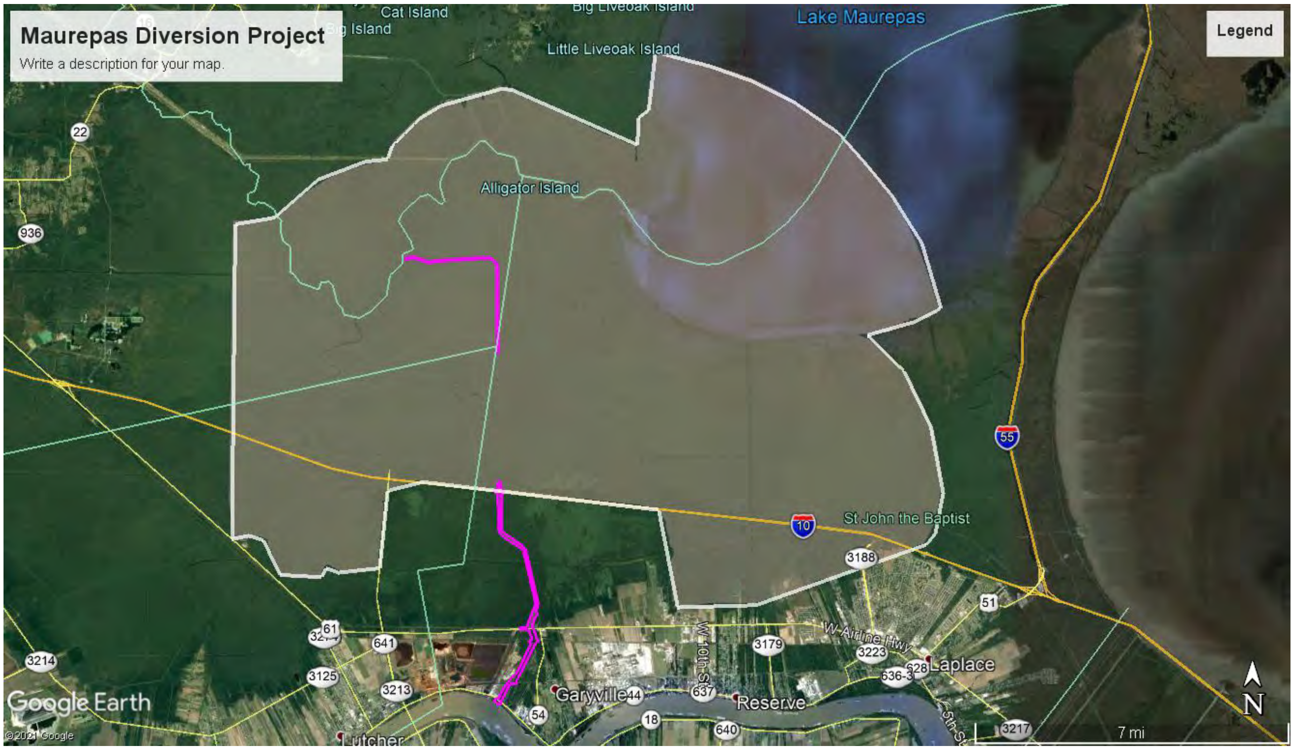
Sincerely,

MARSHALL K. HARPER
Chief, Environmental Planning Branch

Enclosures
1. BBA 18 Mitigation PA
2. 25 March 2021, Annual Report with project list to include WSLP Swamp Mitigation.

CC: File
An electronic copy of this letter with enclosures will be provided to Mr. David Franks, Tribal Historic Preservation Officer, Seminole Nation of Oklahoma, franks.d@sno-nsn.gov.

List of Recipients:
Alabama Coushatta Tribe of Texas
Chitimacha Tribe of Louisiana
Choctaw Nation of Oklahoma
Coushatta Tribe of Louisiana
Jena Band of Choctaw Indians
Mississippi Band of Choctaw Indians
Muscogee (Creek) Nation
Seminole Nation of Oklahoma
Tunica-Biloxi Tribe of Louisiana
Louisiana State Historic Preservation Office (SHPO)
Advisory Council of Historic Places (ACHP)



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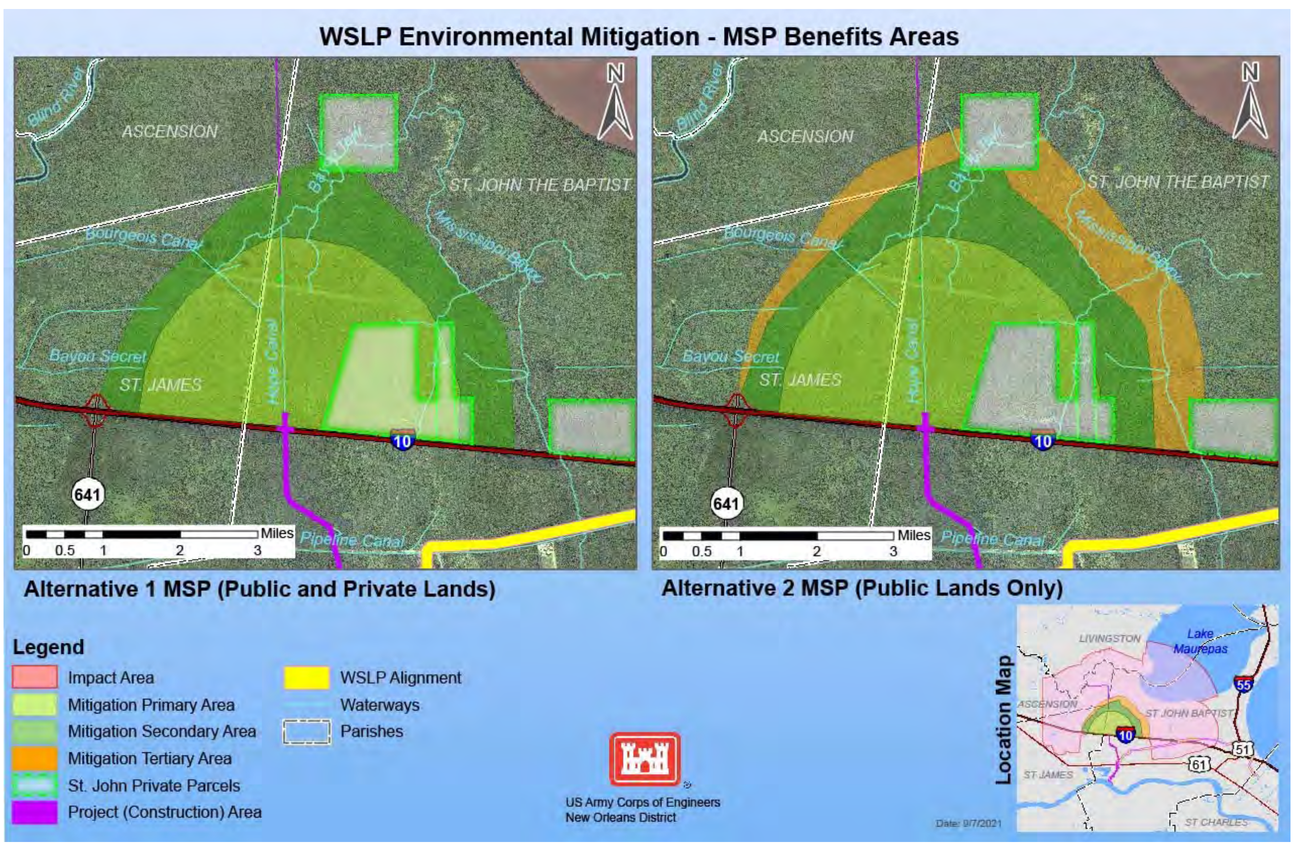

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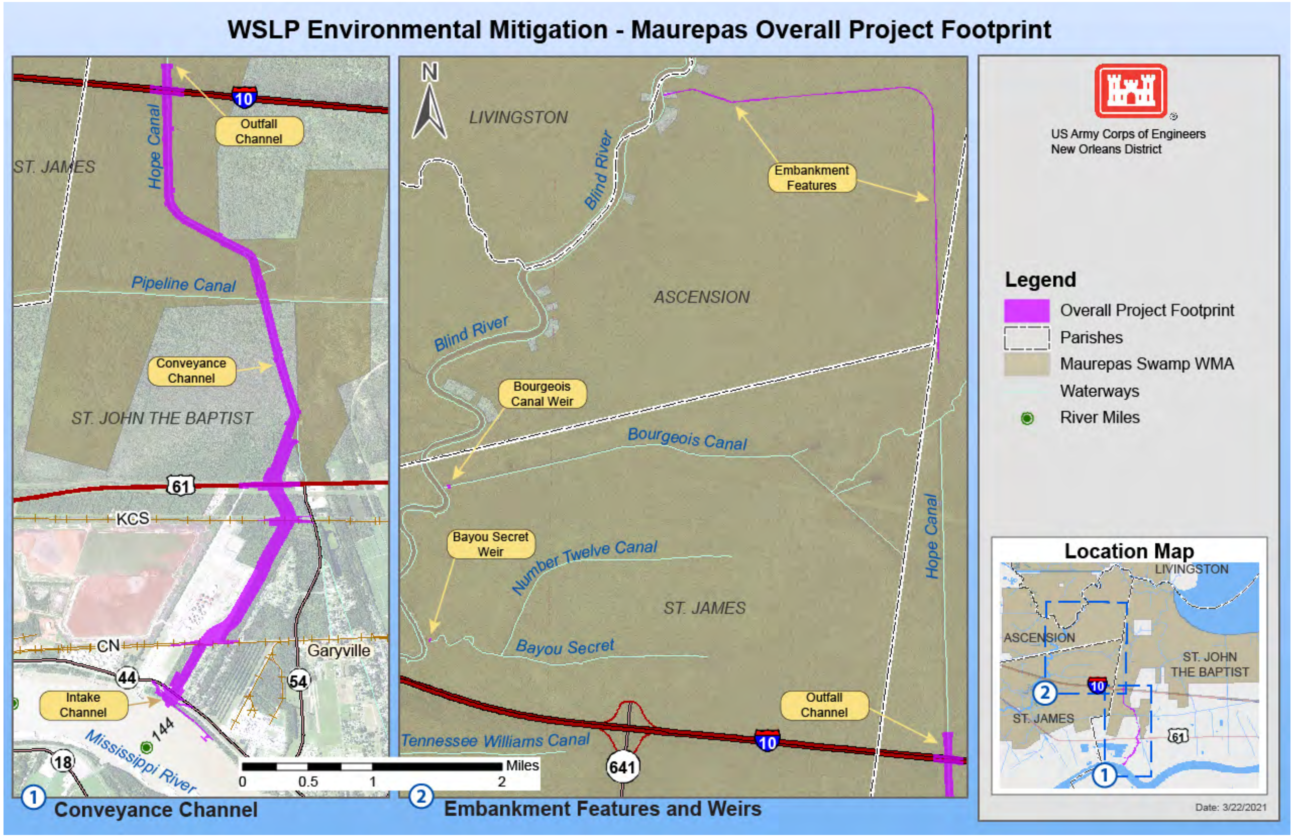

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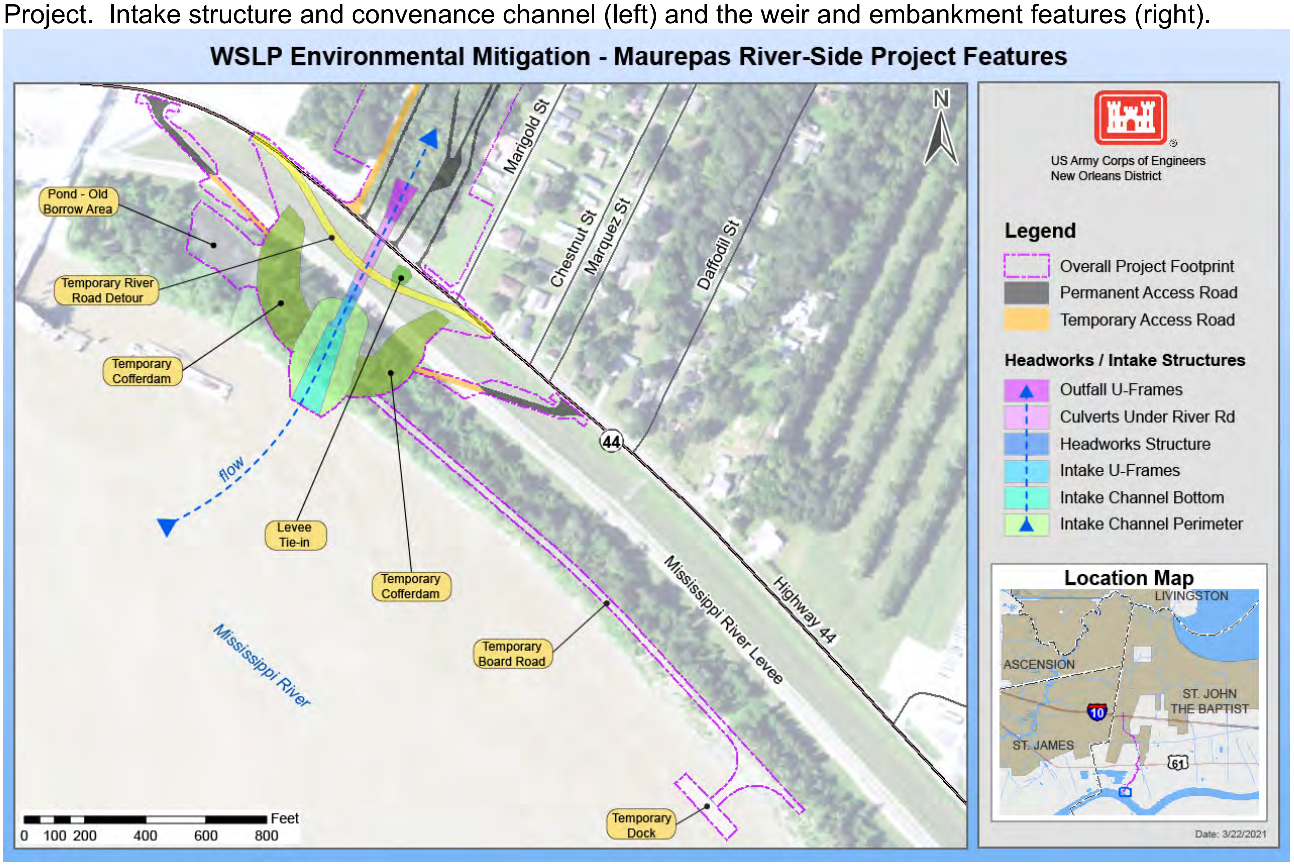

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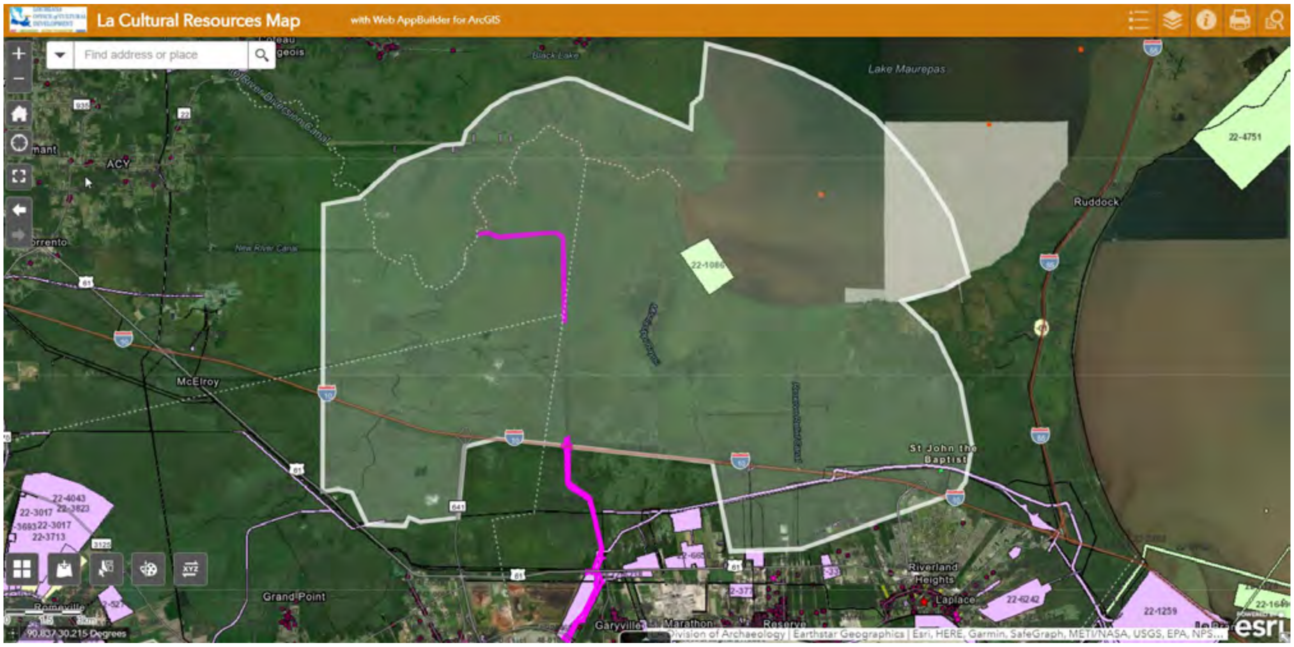

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DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 Leake Ave, New Orleans, LA 70118

October 19, 2021

Regional Planning and
Environment Division, South
Environmental Planning Branch
Attn: CEMVN-PDS-N

Joey Barbry, Chairman
Tunica-Biloxi Tribe of Louisiana
P.O. Box 1589
Marksville, LA 71351

RE: Section 106 Notification - Addition of Maurepas Swamp Project (MSP) to Appendix B of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA).

Dear Chairman Barbry:

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative.

Background

Previously, CEMVN evaluated environmental impacts due to construction of the West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Project (WSLP Project) through a Supplemental Environmental Assessment (SEA) 576, which addressed mitigation for habitat impacts associated with each of the Bipartisan Budget Act (BBA) 18 construction projects (i.e., WSLP Project, Comite Project, and East Baton Rouge Project). The Finding of No Significant Impact (FONSI) for SEA 576 was signed by the CEMVN District Commander on April 4, 2020. Associated with this effort was the development and execution of the BBA 18 Habitat Mitigation PA to provide an alternative NHPA Section 106

process tailored to the construction of habitat mitigation projects (enclosed). As part of the public review process, the Non-Federal Sponsor, Louisiana's Coastal Protection Restoration Authority (CPRA), requested that CEMVN evaluate the Mississippi River Diversion into Maurepas Swamp [PO-29; Maurepas Swamp Project (MSP)], a proposed ecological restoration project that shares construction features with the WSLP Project, be considered as a mitigation alternative for impacts to swamp habitat associated with the construction of the WSLP Project.

In order to evaluate the proposed mitigation project in a manner similar to the other proposed mitigation projects, CEMVN is preparing a Supplemental Environmental Impact Statement to West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study (WSLP SEIS) to compare viable swamp mitigation alternatives within the Pontchartrain Basin. As part of this effort, CEMVN will be utilizing the currently executed BBA 18 Habitat Mitigation PA to conduct any additional necessary Historic Property identification, NRHP evaluation, consultation, and mitigation, as this mitigation project clear meets the intent of the PA after reviewing the preamble and the applicability description in Appendix B.

Initial notification was distributed to consulting parties as part of the annual report of activities on March 25, 2021, via email (enclosed). The Louisiana State Historic Preservation Office (LA SHPO) responded on March 25, 2021 saying, "the State Historic Preservation Office concurs that incorporating the WSLP Maurepas Diversion Habitat Management Site under the terms of the BBA-18 Habitat Mitigation Programmatic Agreement is appropriate."

Description of Undertaking- Maurepas Swamp Project (MSP)

Pursuant to Stipulation II. C., Defining the Undertaking, CEMVN is sharing the current designs for the plan and the initial historic property findings for this mitigation project. The proposed Maurepas Swamp Project (MSP) involves a freshwater diversion that would reconnect the Mississippi River to the Maurepas Swamp, strategically delivering nutrient-laden river water to restore the health of the dying Cypress-Tupelo Swamp. The project is proposed as a 2,000 cubic foot per second (cfs) freshwater diversion with the intake of the conveyance channel located on the West Bank of the Mississippi River in St. John the Baptist Parish, immediately west of Garyville, Louisiana, at River Mile 144 Above Head of Passes (AHP). The 300 ft wide construction corridor for the conveyance channel extends from LA 44 (River Road) northward. It extends northward for 5½ miles, terminating approximately 1,000 ft north of Interstate 10 (I-10) (Figure 1, 2 and 3).

The primary project features are located in St. John the Baptist Parish and are comprised of, but not limited to, the following elements:

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- an automated gate structure in the Mississippi River Levee (MRL); *(Figure 4)*
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The intake channel is roughly 400 ft long by 200 ft wide, with a bottom depth at EL (-) 4 ft NAVD88 excavated into the batture to route flow from the Mississippi River into the diversion headworks. The channel will be lined with riprap to prevent scour. The primary function of the headworks structure is to convey flow from the intake channel underneath the Mississppi River Levee (MRL). It will be comprised of a multi-cell box culvert with vertical lift gates (sluice gates) (Figure 4).

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Additional earthwork outside of the conveyance channel will occur along the existing ridge of an old railroad embankment. 7.51 acres along the old railroad embankment will be cleared for equipment access. 5 individual areas along the embankment will be excavated to existing grade while all spoil will be placed in 20 individual areas along the embankment. It is anticipated that no material will be removed from the project area.

Area of Potential Effect (APE)

Pursuant to Stipulation II. D. (1-4) of the BBA 18 Mitigation PA, CEMVN has defined a

preliminary APE in Figure 1 and 5. The APE incorporates both direct effects (e.g., access, staging, and construction areas), indirect effects (e.g., visual), and areas of inundation (outflow area). The direct construction APE of the MSP is approximately 288.30 acres (116.67 hectares). The Indirect APE extends beyond the construction footprint for roughly 50 feet. The outflow area APE includes Maurepas Swamp and Lake Maurepas and is approximately 90,357 acres (36,566 hectares). The total APE, direct and indirect, is approximately 90,652.7 acres (36,686.12 hectares) (Figure 1 and 5). It is acknowledged that this APE is preliminary based on the state of development of the project. Should the APE need to be revised, CEMVN will follow provision II. D. 3. Of the BBA 18 Mitigation PA to proposed revisions.

Historic Property Identification and Evaluation Efforts

CEMVN identified historic properties within the project footprint, mitigation areas, and impact areas (collectively the APE) based on a review of the NRHP database, the Louisiana Division of Archaeology (LDOA) Louisiana Cultural Resources Map (LDOA Website), historic maps, pertinent regional and local cultural resources investigations, historic aerial photography, and other appropriate sources. This review identified 15 previous cultural resources surveys, 11 previously recorded archaeological sites, and three (3) previously recorded architectural resources within the MSP APE (Figure 5).

Archaeological

A total of eleven (11) archaeological sites are present within the MSP APE. Two (2) of these sites are not eligible for the NRHP, 16SJ73 (Blind River Timber Rail) and 16SJB68 (Angelina Plantation, Note: Locus A of 16SJ68 is of unknown eligibility). Seven (7) sites are listed as unknown eligibility (16AN8, 16LV24, 16LV73, 16LV74, 16LV103, 16SJ72, and 16SJB4). These sites include four (4) prehistoric shell middens (16AN8, 16LV73, 16LV24, 16SJB4), 2 possible watercrafts/shipwrecks (16LV74, 16SJ72), one (1) railroad bridge (16SJ72), and the Amite River Diversion Canal (16LV103). Two (2) cemeteries are present within the APE (16SJ58, 16SJ61), both dating back to the Civil War.

Fifteen (15) previous cultural surveys have been performed within the MSP APE. Most of these surveys did not discover existing cultural resources within the MSP APE. A total of nine (9) surveys occurred near or in the Angelina Plantation site (16SJB68). They are 22-3023, 22-3793, 22-4288, 22-4571, 22-4571-1, 22-4571-2, 22-4690, 22-5431, 22-6238. A Phase I Cultural Resources Survey of the River Reintroduction Corridor, Maurepas Swamp (PO-29), St. John the Baptist Parish, Louisiana was performed by Coastal Environments, Inc. in 2008, and included the proposed footprint of the Maurepas Diversion Canal corridor from Interstate-10 to the Mississippi River (Wells 2008; 22-3023). No eligible archaeological sites were recorded as a result of this survey.

Architectural

The proposed project is located approximately one (1) mile from the Garyville Historic District, a National Register Historic District (NRHD) listed in the NRHP in 1990. Tree coverage along the majority of LA-54 separates the Garyville Historic District from the proposed project. The proposed project is located west of LA-54 while the Garyville Historic District is located east of LA-54. No individual historic properties were identified as listed, or formally determined eligible for listing by the Keeper, in the NRHP within the project, mitigation, and impact areas. No previously recorded built resources are located

within the mitigation and impact areas.

Review of previous investigations revealed three built resources (Louisiana Historic Resource Inventory (LHRI) ID Number 48-01071, 48-01073, and 48-01089) within or adjacent to the project area that were individually documented in 1985. According to the LDOA Cultural Resources Map, these three resources are near River Road and the proposed headworks and intake structures. During the mid-1980’s, many of the surveyed resources were identified by Post Office Box or only the street name. As a result, LHRI Numbers 48-01071, 48-01073, and 48-01089 do not have identifying street numbers and street names. Visual inspection via Google Street View suggests that these three (3) resources may have been demolished or their LHRI locations are plotted incorrectly on the LDOA Cultural Resources Map.

The Earnest Amann Subdivision borders the proposed project to the east. Marigold Street runs parallel to the proposed project footprint and was developed likely in the late 1950s with dwellings constructed on the east side of the street by the early 1960s (NETR 1961). A review of aerial photographs and historic USGS maps reveal that the east side of Marigold Street was fully developed by the early 1980s (NETR 1981). The west side of Marigold Street developed sometime after 1970 (NETR 1971). As a result, built resources 50 years of age or older are present adjacent to the proposed project area.

Assessment of the Undertaking’s Potential to Effect Historic Properties

The exact impact assessment for this project is currently unknown but will be updated as the MSP develops, and consultation continues. This project includes ground disturbing activities involving access, staging, construction of structural features (intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, box culverts, and other features as described in Figures 1-2), and borrow fill. These activities may directly impact both known and undocumented cultural resources listed or eligible for listing in the NRHP not limited to: archaeological sites; historic built resources; cemeteries or other sites that may contain human remains, funerary objects, sacred objects, or objects of cultural patrimony; and TCPs; that exist both within the project footprint and associated areas in a way that will diminish the integrity of these property’s location, design, setting, materials, workmanship, feeling, or association.

The MSP includes the introduction of new visual elements to the project area’s viewshed that have the potential to indirectly impact known and previously undocumented cultural resources that may be listed or eligible for listing in the NRHP. These elements include a roughly 400 ft. long by 200 ft. wide intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, and other features as described in Figures 1-2. The introduction of new visual elements that are inconsistent with the historic or cultural character of these potential resources could indirectly diminish the integrity of the property’s setting, feeling, or association and/or cause changes to the integrity of feeling or character associated with a historic resource or TCP.

The proposed project is located approximately one mile from the Garyville Historic District, a NRHD listed in the NRHP in 1990. No indirect effects to the Garyville Historic District would occur due to tree coverage along the majority of LA-54 which separates the Garyville Historic District from the proposed project. However, the proposed project could

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Chief, Environmental Planning Branch

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Choctaw Nation of Oklahoma
Coushatta Tribe of Louisiana
Jena Band of Choctaw Indians
Mississippi Band of Choctaw Indians
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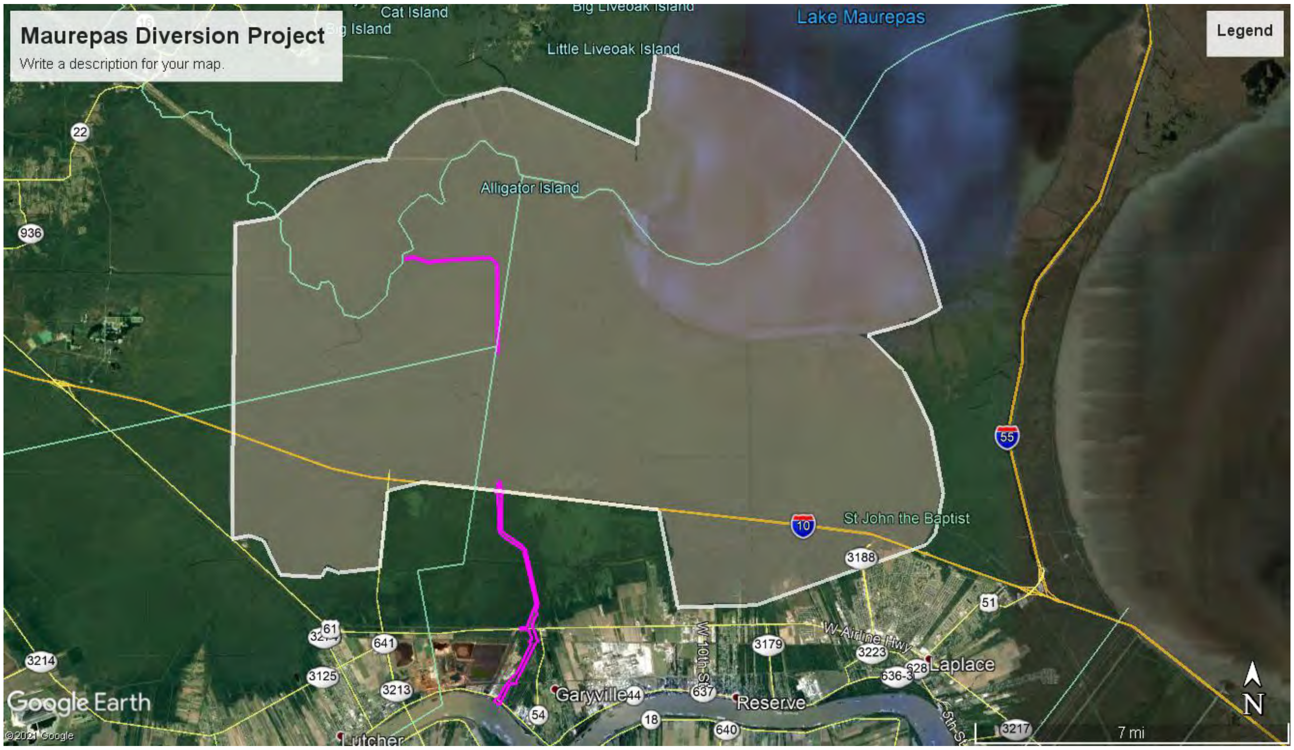

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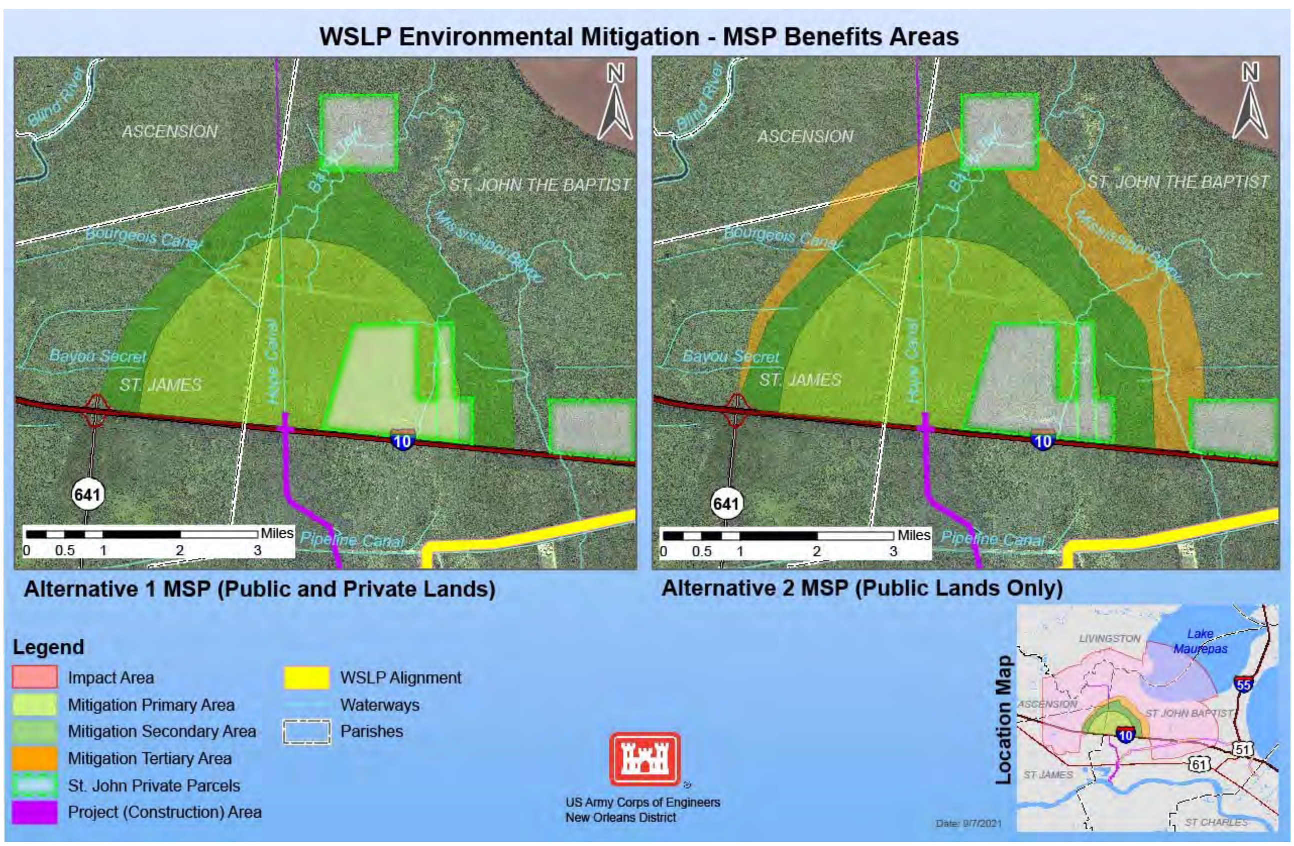

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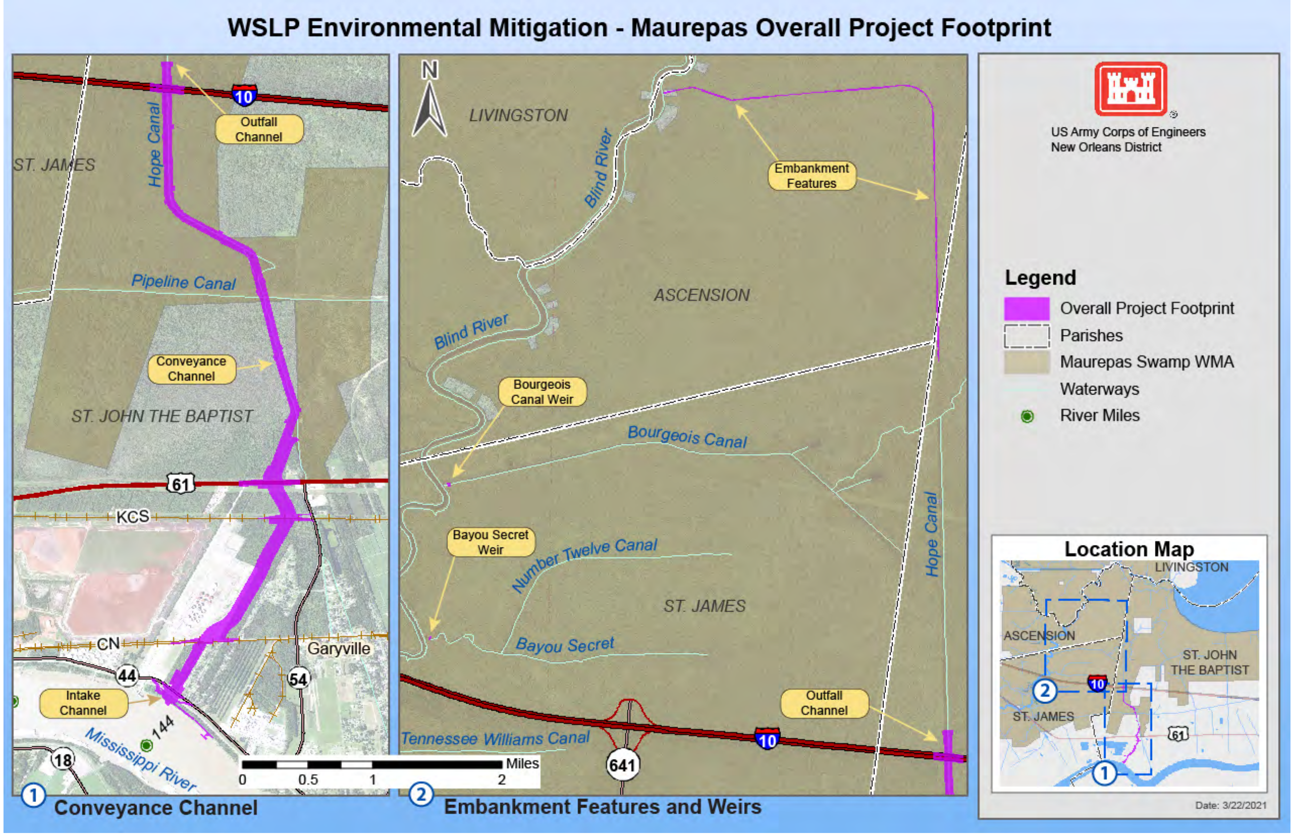

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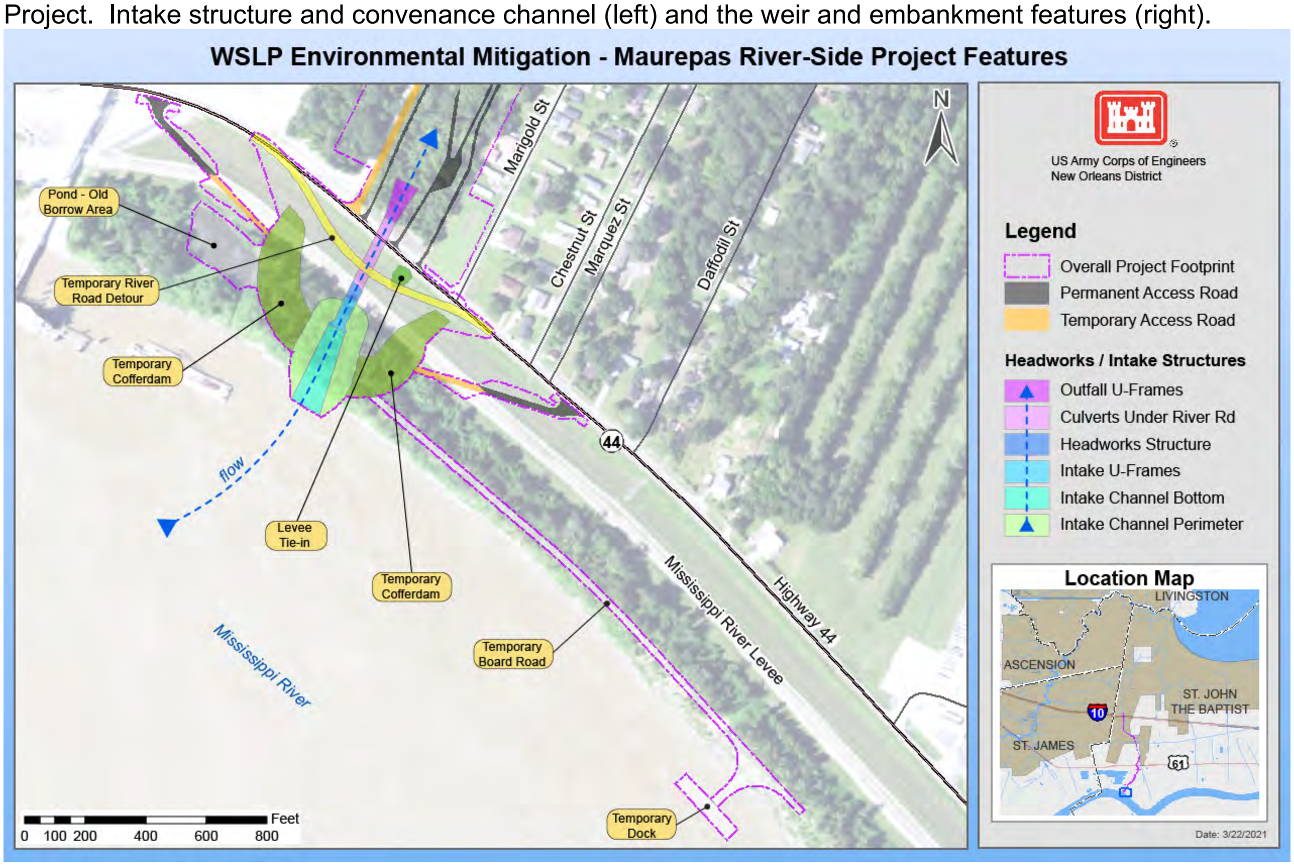

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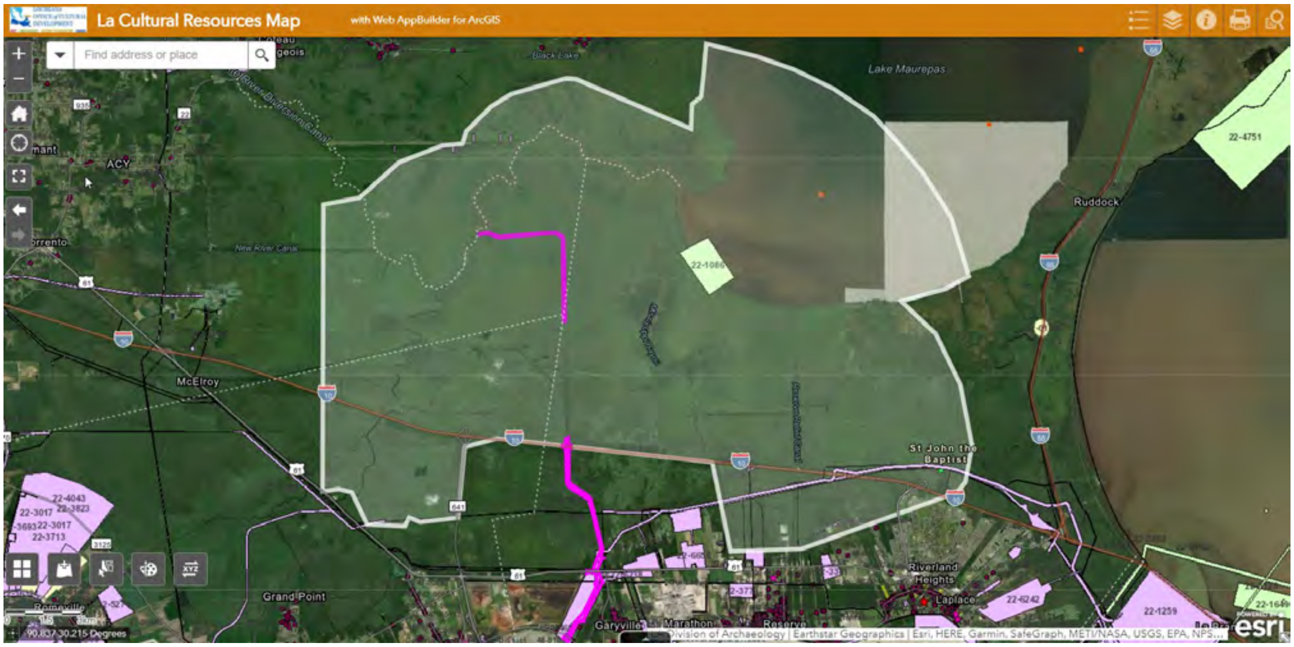

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DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 Leake Ave, New Orleans, LA 70118

October 19, 2021

Regional Planning and
Environment Division, South
Environmental Planning Branch
Attn: CEMVN-PDS-N

Kristin Sanders, SHPO
LA State Historic Preservation Officer
P.O. Box 44247
Baton Rouge, LA 70804-4241

RE: **Section 106 Notification -** Addition of Maurepas Swamp Project (MSP) to Appendix B of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA).

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CEMVN identified historic properties within the project footprint, mitigation areas, and impact areas (collectively the APE) based on a review of the NRHP database, the Louisiana Division of Archaeology (LDOA) Louisiana Cultural Resources Map (LDOA Website), historic maps, pertinent regional and local cultural resources investigations, historic aerial photography, and other appropriate sources. This review identified 15 previous cultural resources surveys, 11 previously recorded archaeological sites, and three (3) previously recorded architectural resources within the MSP APE (Figure 5).

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A total of eleven (11) archaeological sites are present within the MSP APE. Two (2) of these sites are not eligible for the NRHP, 16SJ73 (Blind River Timber Rail) and 16SJB68 (Angelina Plantation, Note: Locus A of 16SJ68 is of unknown eligibility). Seven (7) sites are listed as unknown eligibility (16AN8, 16LV24, 16LV73, 16LV74, 16LV103, 16SJ72, and 16SJB4). These sites include four (4) prehistoric shell middens (16AN8, 16LV73, 16LV24, 16SJB4), 2 possible watercrafts/shipwrecks (16LV74, 16SJ72), one (1) railroad bridge (16SJ72), and the Amite River Diversion Canal (16LV103). Two (2) cemeteries are present within the APE (16SJ58, 16SJ61), both dating back to the Civil War.

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The proposed project is located approximately one (1) mile from the Garyville Historic District, a National Register Historic District (NRHD) listed in the NRHP in 1990. Tree coverage along the majority of LA-54 separates the Garyville Historic District from the proposed project. The proposed project is located west of LA-54 while the Garyville Historic District is located east of LA-54. No individual historic properties were identified as listed, or formally determined eligible for listing by the Keeper, in the NRHP within the project, mitigation, and impact areas. No previously recorded built resources are located

within the mitigation and impact areas.

Review of previous investigations revealed three built resources (Louisiana Historic Resource Inventory (LHRI) ID Number 48-01071, 48-01073, and 48-01089) within or adjacent to the project area that were individually documented in 1985. According to the LDOA Cultural Resources Map, these three resources are near River Road and the proposed headworks and intake structures. During the mid-1980’s, many of the surveyed resources were identified by Post Office Box or only the street name. As a result, LHRI Numbers 48-01071, 48-01073, and 48-01089 do not have identifying street numbers and street names. Visual inspection via Google Street View suggests that these three (3) resources may have been demolished or their LHRI locations are plotted incorrectly on the LDOA Cultural Resources Map.

The Earnest Amann Subdivision borders the proposed project to the east. Marigold Street runs parallel to the proposed project footprint and was developed likely in the late 1950s with dwellings constructed on the east side of the street by the early 1960s (NETR 1961). A review of aerial photographs and historic USGS maps reveal that the east side of Marigold Street was fully developed by the early 1980s (NETR 1981). The west side of Marigold Street developed sometime after 1970 (NETR 1971). As a result, built resources 50 years of age or older are present adjacent to the proposed project area.

Assessment of the Undertaking’s Potential to Effect Historic Properties

The exact impact assessment for this project is currently unknown but will be updated as the MSP develops, and consultation continues. This project includes ground disturbing activities involving access, staging, construction of structural features (intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, box culverts, and other features as described in Figures 1-2), and borrow fill. These activities may directly impact both known and undocumented cultural resources listed or eligible for listing in the NRHP not limited to: archaeological sites; historic built resources; cemeteries or other sites that may contain human remains, funerary objects, sacred objects, or objects of cultural patrimony; and TCPs; that exist both within the project footprint and associated areas in a way that will diminish the integrity of these property’s location, design, setting, materials, workmanship, feeling, or association.

The MSP includes the introduction of new visual elements to the project area’s viewshed that have the potential to indirectly impact known and previously undocumented cultural resources that may be listed or eligible for listing in the NRHP. These elements include a roughly 400 ft. long by 200 ft. wide intake channel, temporary cofferdam, intake U-frames, headworks structure, levees, floodgates, and other features as described in Figures 1-2. The introduction of new visual elements that are inconsistent with the historic or cultural character of these potential resources could indirectly diminish the integrity of the property’s setting, feeling, or association and/or cause changes to the integrity of feeling or character associated with a historic resource or TCP.

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potentially indirectly effect three built resources (LHRI ID Number 48-01071, 48-01073, and 48-01089). Additionally, the proposed project could potentially indirectly affect built resources 50 years of age or older within the Earnest Amann Subdivision, which borders the proposed project to the east.

Based on the current understanding of the historic properties in the APE and the potential effects from direct and indirect causes, CEMVN will continue to consult as anticipated historic property identification surveys are completed and affect determination are made following the terms of the BBA 18 PA. The commitment to follow the procedures in the BBA 18 Mitigation PA will also be reflected in the WSLP SEIS and the Record of Decision.

If you have any questions or require additional information concerning this undertaking, please contact Ms. Ashley Fedoroff, archaeologist, at (601) 631-5278 or via e-mail Ashley.M.Fedoroff@usace.army.mil, Ms. Jill Enersen, Architectural Historian, at (504) 862-1741 or Jill.A.Enersen@usace.army.mil, or Mr. Jason Emery, Tribal Liaison, at (504) 862-2364 or via email Jason.A.Emery@usace.army.mil.

Sincerely,

MARSHALL K. HARPER
Chief, Environmental Planning Branch

Enclosures
1. BBA 18 Mitigation PA
2. 25 March 2021, Annual Report with project list to include WSLP Swamp Mitigation.

CC: File
An electronic copy of this letter with enclosures will be provided to the Section 106 Inbox, section106@crt.la.gov.

List of Recipients:
Alabama Coushatta Tribe of Texas
Chitimacha Tribe of Louisiana
Choctaw Nation of Oklahoma
Coushatta Tribe of Louisiana
Jena Band of Choctaw Indians
Mississippi Band of Choctaw Indians
Muscogee (Creek) Nation
Seminole Nation of Oklahoma
Tunica-Biloxi Tribe of Louisiana
Louisiana State Historic Preservation Office (SHPO)
Advisory Council of Historic Places (ACHP)

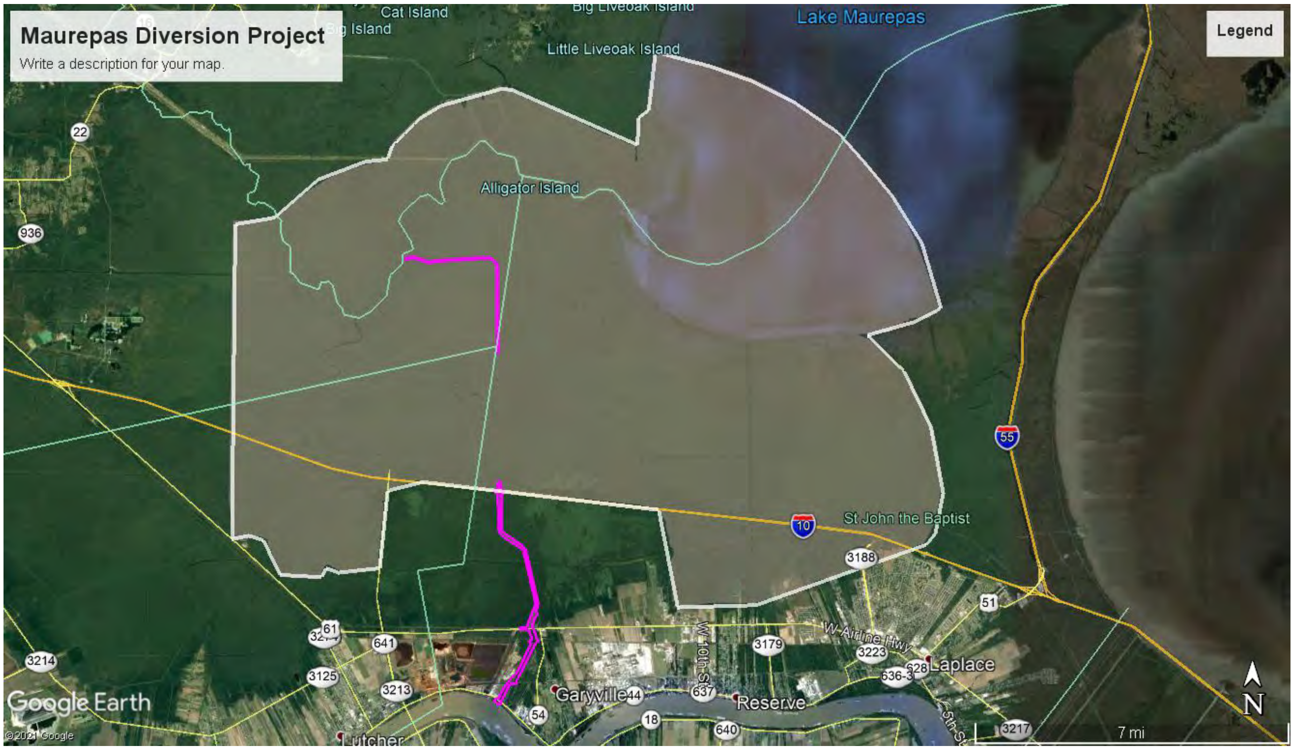

Figure 1. Overview of Maurepas Swamp Project APE: Direct Impact APE (pink) and Indirect Impact APE (white).

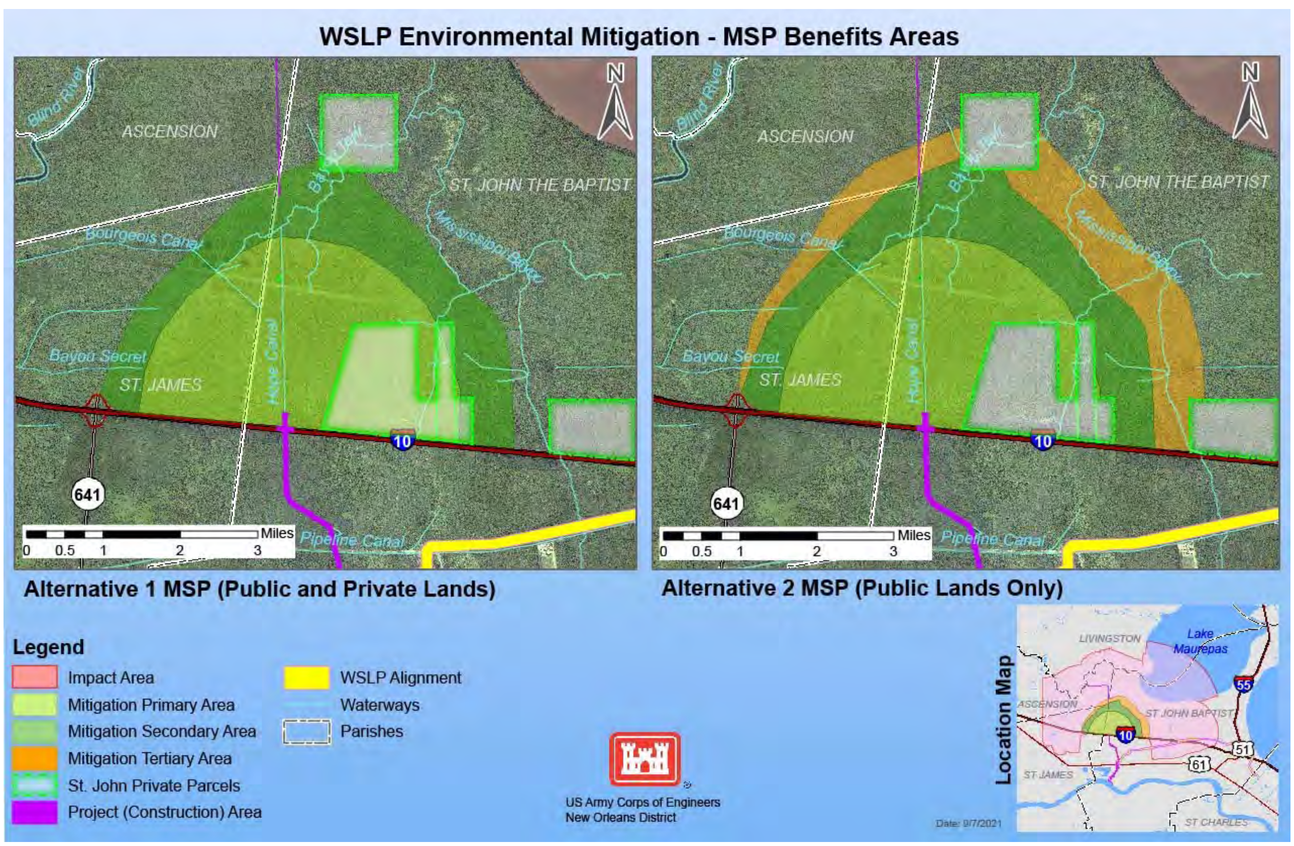

Figure 2. Detail of the Marurepas Swamp Project Mitigation Alternatives MSP 1 and MSP2.

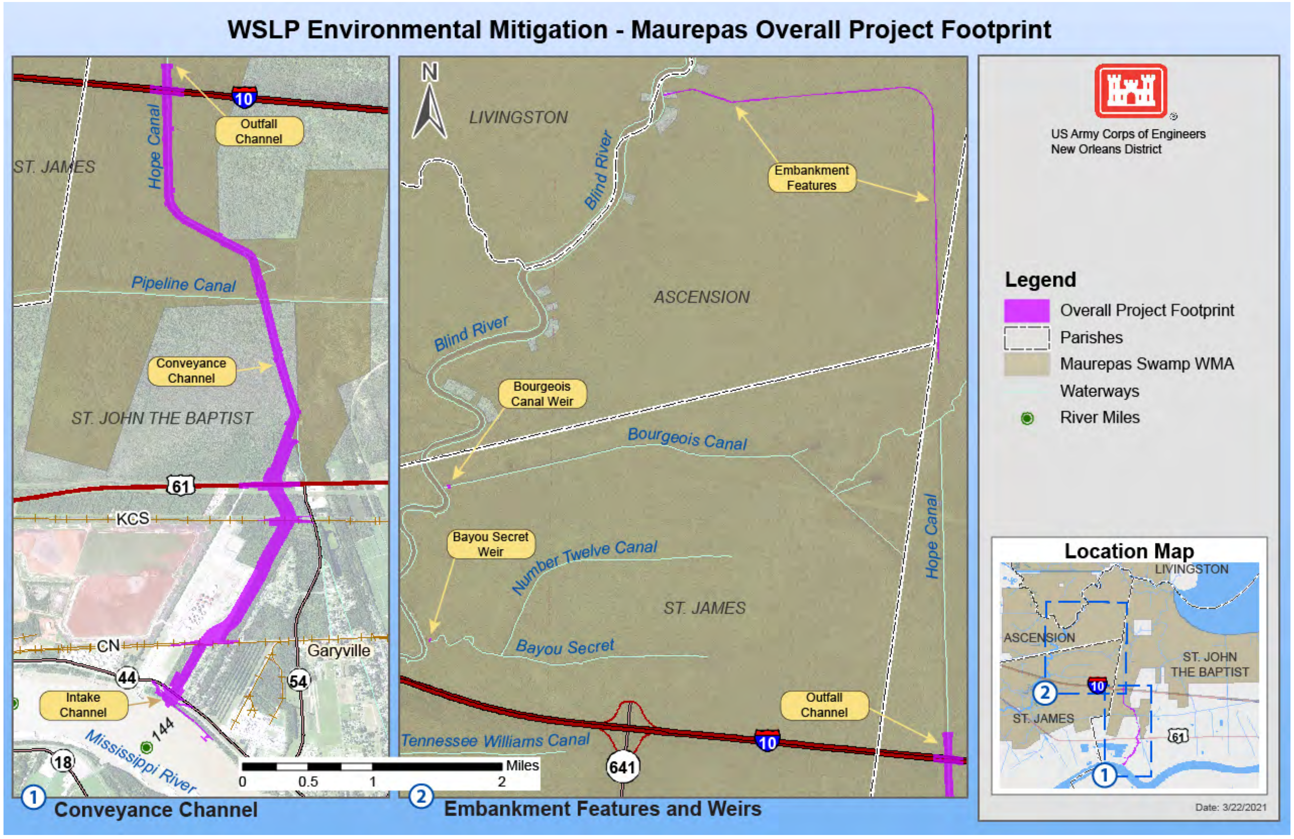

Figure 3. Detail of the construction features of for the diversion to facilitate the Maurepas Swamp Mitigation Project. Intake structure and convenance channel (left) and the weir and embankment features (right).

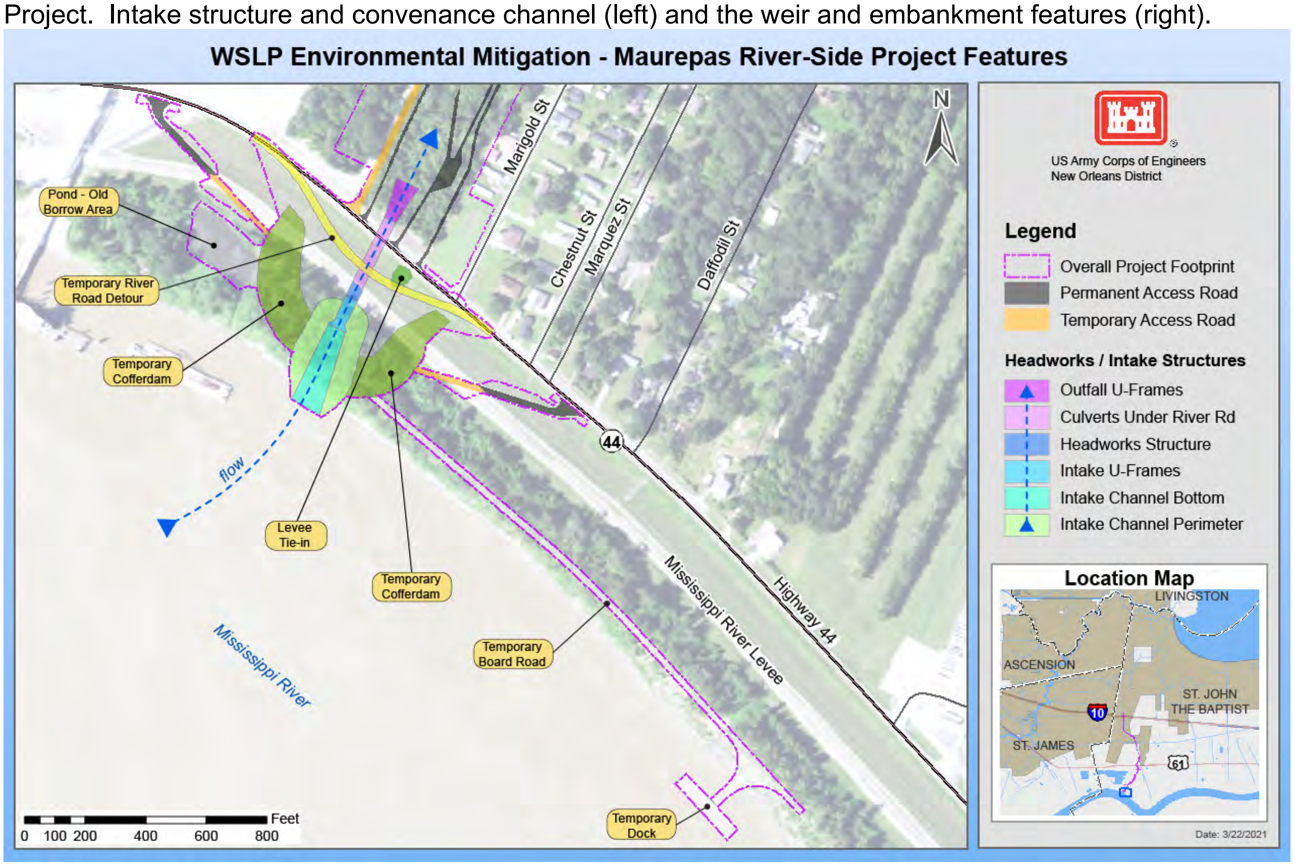

Figure 4 : Detail of the Intake Structure and appurtenant features.

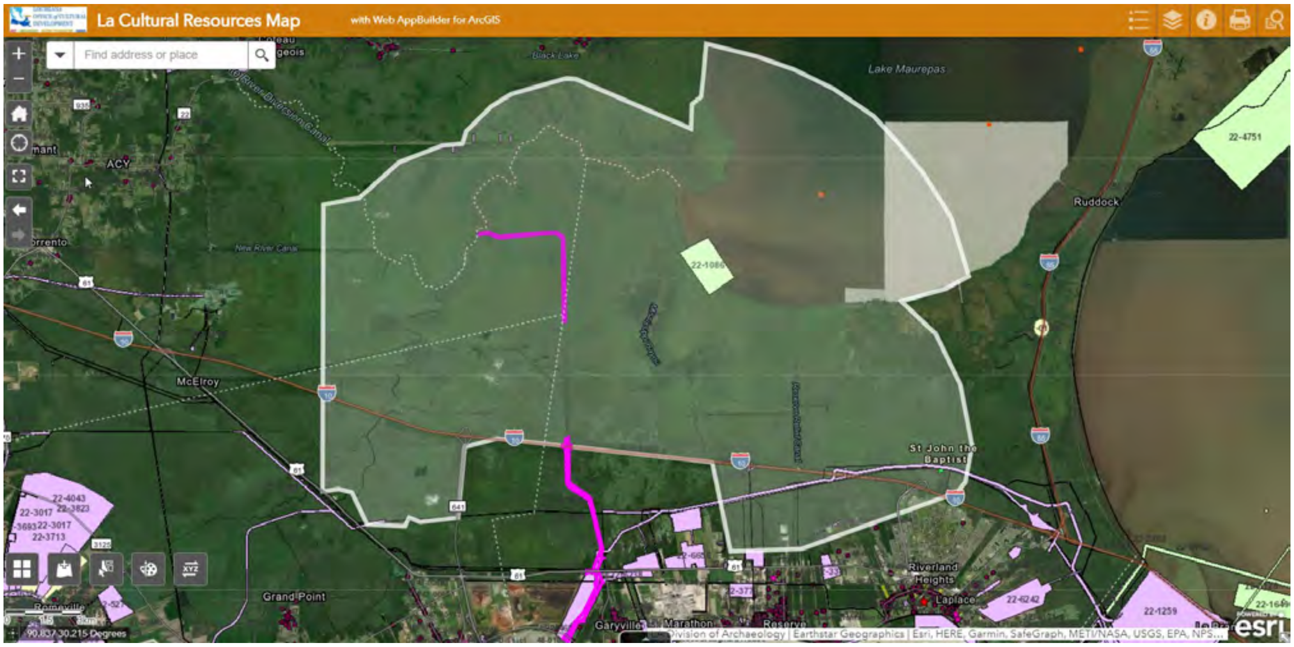

Figure 5: Maurepas Swamp Project APE: Direct Impact APE (pink) and Indirect Impact APE (white). LDOA Cultural Resources Map. Note that the conveyance channel area has been surveyed under LDOA Report # 22-3023.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
7400 Leake Ave, New Orleans, LA 70118

October 19, 2021

Regional Planning and
Environment Division, South
Environmental Planning Branch
Attn: CEMVN-PDS-N

Reid Nelson, Chairman
Office of Federal Agency Programs
Advisory Council on Historic Preservation
401 F. Street NW, Suite 308
Washington, DC 20001-2637

RE: **Section 106 Notification -** Addition of Maurepas Swamp Project (MSP) to Appendix B of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA).

Dear Mr. Nelson:

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative.

Background

Previously, CEMVN evaluated environmental impacts due to construction of the West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Project (WSLP Project) through a Supplemental Environmental Assessment (SEA) 576, which addressed mitigation for habitat impacts associated with each of the Bipartisan Budget Act (BBA) 18 construction projects (i.e., WSLP Project, Comite Project, and East Baton Rouge Project). The Finding of No Significant Impact (FONSI) for SEA 576 was signed by the CEMVN District Commander on April 4, 2020. Associated with this effort was the development and

execution of the BBA 18 Habitat Mitigation PA to provide an alternative NHPA Section 106 process tailored to the construction of habitat mitigation projects (enclosed). As part of the public review process, the Non-Federal Sponsor, Louisiana's Coastal Protection Restoration Authority (CPRA), requested that CEMVN evaluate the Mississippi River Diversion into Maurepas Swamp [PO-29; Maurepas Swamp Project (MSP)], a proposed ecological restoration project that shares construction features with the WSLP Project, be considered as a mitigation alternative for impacts to swamp habitat associated with the construction of the WSLP Project.

In order to evaluate the proposed mitigation project in a manner similar to the other proposed mitigation projects, CEMVN is preparing a Supplemental Environmental Impact Statement to West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study (WSLP SEIS) to compare viable swamp mitigation alternatives within the Pontchartrain Basin. As part of this effort, CEMVN will be utilizing the currently executed BBA 18 Habitat Mitigation PA to conduct any additional necessary Historic Property identification, NRHP evaluation, consultation, and mitigation, as this mitigation project clear meets the intent of the PA after reviewing the preamble and the applicability description in Appendix B.

Initial notification was distributed to consulting parties as part of the annual report of activities on March 25, 2021, via email (enclosed). The Louisiana State Historic Preservation Office (LA SHPO) responded on March 25, 2021 saying, "the State Historic Preservation Office concurs that incorporating the WSLP Maurepas Diversion Habitat Management Site under the terms of the BBA-18 Habitat Mitigation Programmatic Agreement is appropriate."

Description of Undertaking- Maurepas Swamp Project (MSP)

Pursuant to Stipulation II. C., Defining the Undertaking, CEMVN is sharing the current designs for the plan and the initial historic property findings for this mitigation project. The proposed Maurepas Swamp Project (MSP) involves a freshwater diversion that would reconnect the Mississippi River to the Maurepas Swamp, strategically delivering nutrient-laden river water to restore the health of the dying Cypress-Tupelo Swamp. The project is proposed as a 2,000 cubic foot per second (cfs) freshwater diversion with the intake of the conveyance channel located on the West Bank of the Mississippi River in St. John the Baptist Parish, immediately west of Garyville, Louisiana, at River Mile 144 Above Head of Passes (AHP). The 300 ft wide construction corridor for the conveyance channel extends from LA 44 (River Road) northward. It extends northward for 5½ miles, terminating approximately 1,000 ft north of Interstate 10 (I-10) (Figure 1, 2 and 3).

The primary project features are located in St. John the Baptist Parish and are comprised of, but not limited to, the following elements:

- an intake channel from the Mississippi River; *(Figure 4, Figure 3)*
- an automated gate structure in the Mississippi River Levee (MRL); *(Figure 4)*
- a sedimentation basin; *(within the conveyance channel)*
- a 5.5-mile long open conveyance channel; *(Figure 4)*

- box culverts under River Road, Canadian National Railroad (CN), and Airline Highway; *(Figure4)*
- a bridge over the channel at Kansas City Southern Railroad (KCS); *(Figure 4)*
- 8 lateral discharge valves between Airline Highway and I-10 to carry flow from the conveyance channel to areas east and west of the channel (Figure 3);
- check valving on culverts underneath I-10 to mitigate southward backflow (Figure 3);
- reshaping the geometry of the existing Hope Canal channel under I-10 (Figure 3 and 2)
- embankment cuts in the existing ridge of an old railroad embankment; *(Figure 3)* and
- submerged rock rip-rap weirs in Bayou Secret and Bourgeois Canal; *(Figure 3)*

The intake channel is roughly 400 ft long by 200 ft wide, with a bottom depth at EL (-) 4 ft NAVD88 excavated into the batture to route flow from the Mississippi River into the diversion headworks. The channel will be lined with riprap to prevent scour. The primary function of the headworks structure is to convey flow from the intake channel underneath the Mississppi River Levee (MRL). It will be comprised of a multi-cell box culvert with vertical lift gates (sluice gates) (Figure 4).

The outlet for the conveyance channel is along the existing centerline of Hope Canal. The guide levee elevations from the Interstate 10 (I-10) bridges to the termination point gradually transition to existing grade. At that point the diverted water will overflow the canal banks and dissipate into the area above I-10, south of Lake Maurepas.

The diversion flow of 2,000 cfs generally spreads radially outwards as it enters the swamp north of I-10. Approximately, one-third flows westward through the swamp, one-third flows through Dutch Bayou and the remaining third flows eastward through the swamp. The westward flow enters Blind River and largely proceeds to Lake Maurepas. The eastward flow enters the Reserve Relief Canal and mostly proceeds to Lake Maurepas. Most of the swamp water is displaced by the introduced Mississippi River water (Figure 1,3, and 5). This spreading water is captured in the figures and is what accounts for this being a mitigation project for swamp habitat.

Required earthwork would consist of clearing, grubbing, excavation, and removal of earthen material for the project's conveyance channel and disposal at an approved disposal site. When possible, unsuitable excavated material could be utilized beneficially. If a borrow study in subsequent design phases indicates sufficient suitable material within the excavated material, the Contractor may elect to use that material on-site. Any material used on site would stay within the right-of-way (ROW) and would be used to construct features.

Additional earthwork outside of the conveyance channel will occur along the existing ridge of an old railroad embankment. 7.51 acres along the old railroad embankment will be cleared for equipment access. 5 individual areas along the embankment will be excavated to existing grade while all spoil will be placed in 20 individual areas along the embankment. It is anticipated that no material will be removed from the project area.

Area of Potential Effect (APE)

Pursuant to Stipulation II. D. (1-4) of the BBA 18 Mitigation PA, CEMVN has defined a preliminary APE in Figure 1 and 5. The APE incorporates both direct effects (e.g., access, staging, and construction areas), indirect effects (e.g., visual), and areas of inundation (outflow area). The direct construction APE of the MSP is approximately 288.30 acres (116.67 hectares). The Indirect APE extends beyond the construction footprint for roughly 50 feet. The outflow area APE includes Maurepas Swamp and Lake Maurepas and is approximately 90,357 acres (36,566 hectares). The total APE, direct and indirect, is approximately 90,652.7 acres (36,686.12 hectares) (Figure 1 and 5). It is acknowledged that this APE is preliminary based on the state of development of the project. Should the APE need to be revised, CEMVN will follow provision II. D. 3. Of the BBA 18 Mitigation PA to proposed revisions.

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A total of eleven (11) archaeological sites are present within the MSP APE. Two (2) of these sites are not eligible for the NRHP, 16SJ73 (Blind River Timber Rail) and 16SJB68 (Angelina Plantation, Note: Locus A of 16SJ68 is of unknown eligibility). Seven (7) sites are listed as unknown eligibility (16AN8, 16LV24, 16LV73, 16LV74, 16LV103, 16SJ72, and 16SJB4). These sites include four (4) prehistoric shell middens (16AN8, 16LV73, 16LV24, 16SJB4), 2 possible watercrafts/shipwrecks (16LV74, 16SJ72), one (1) railroad bridge (16SJ72), and the Amite River Diversion Canal (16LV103). Two (2) cemeteries are present within the APE (16SJ58, 16SJ61), both dating back to the Civil War.

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Sincerely,

MARSHALL K. HARPER
Chief, Environmental Planning Branch

Enclosures
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2. 25 March 2021, Annual Report with project list to include WSLP Swamp Mitigation.

CC: File
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List of Recipients:
Alabama Coushatta Tribe of Texas
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Choctaw Nation of Oklahoma
Coushatta Tribe of Louisiana
Jena Band of Choctaw Indians
Mississippi Band of Choctaw Indians
Muscogee (Creek) Nation
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Tunica-Biloxi Tribe of Louisiana
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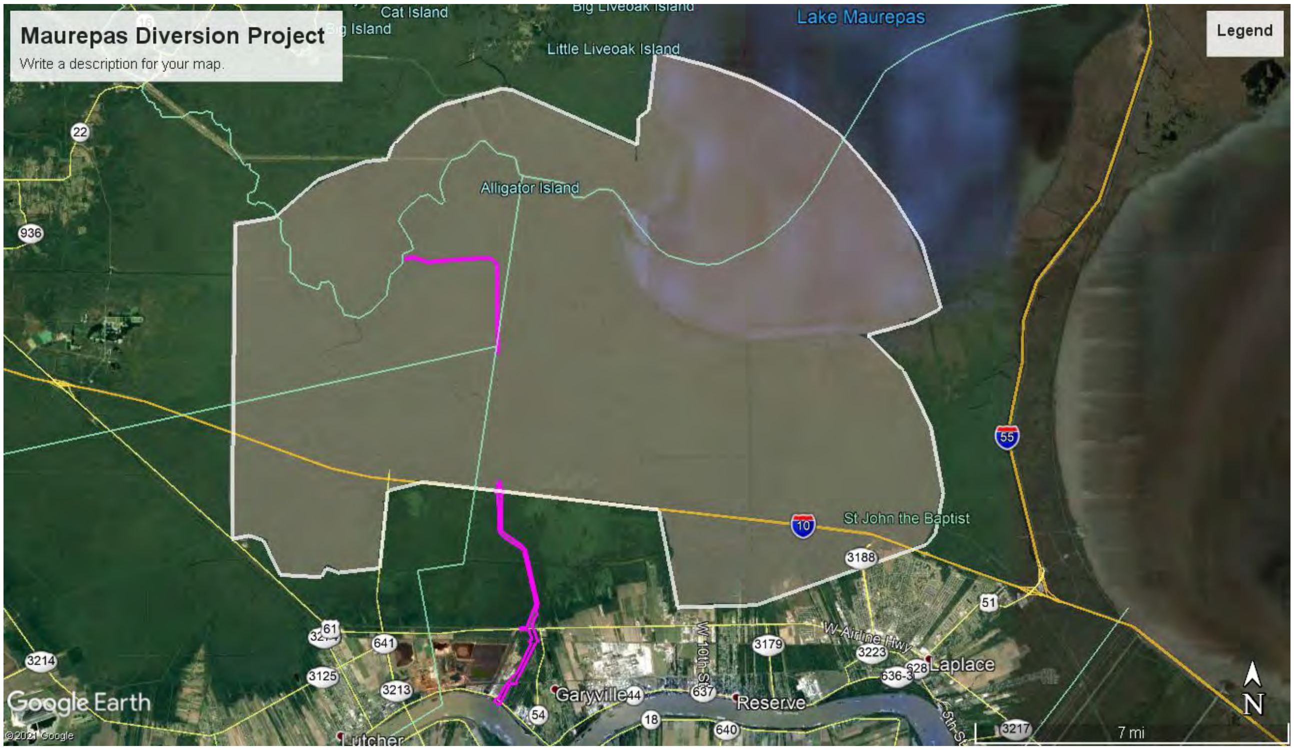

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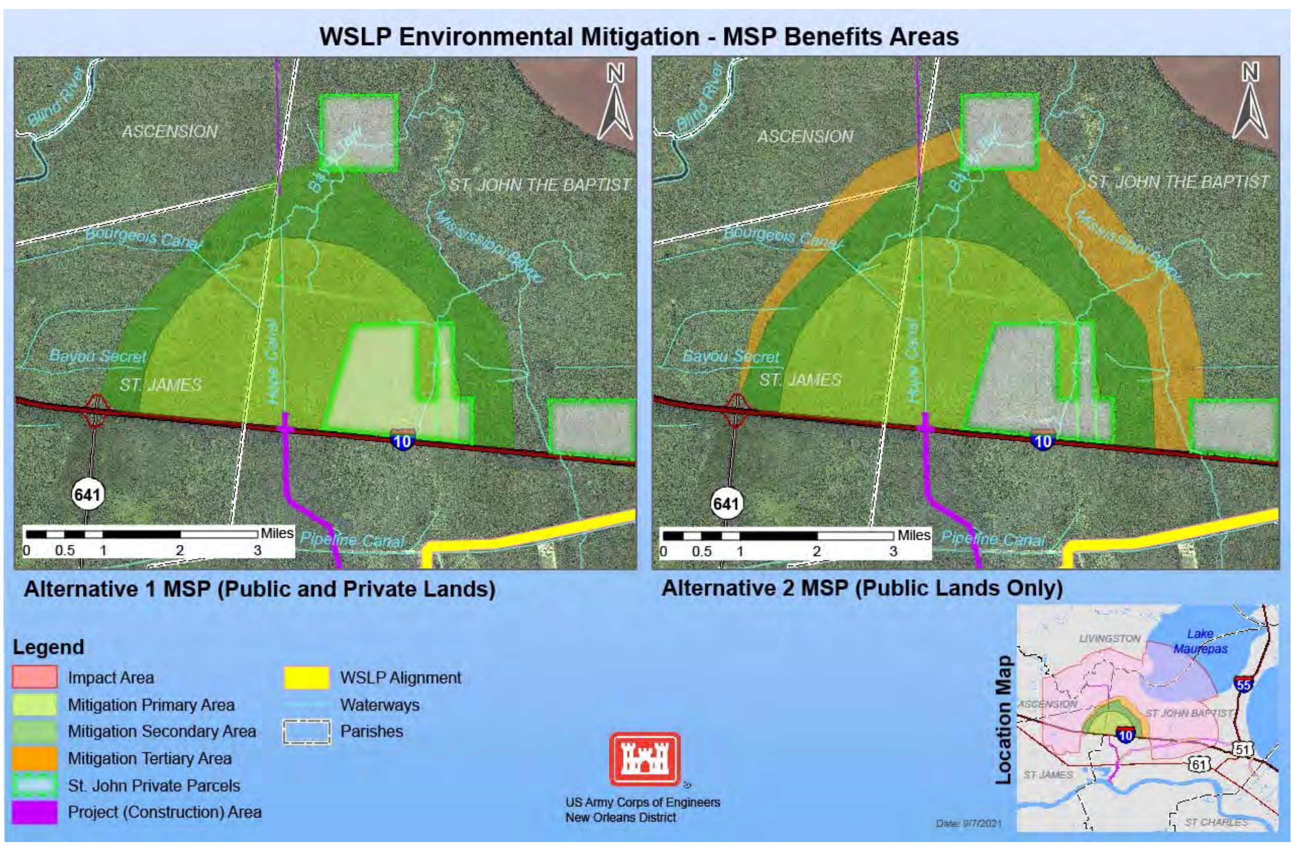

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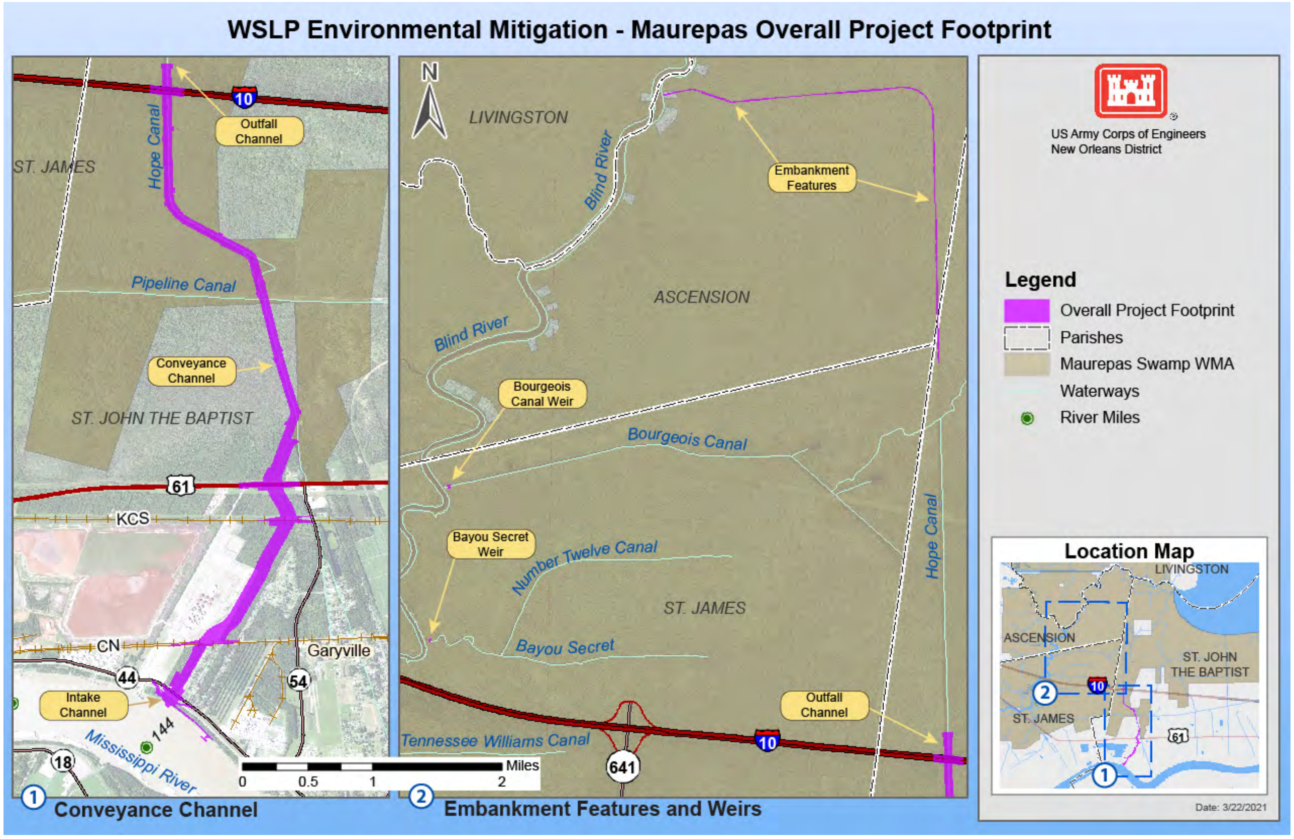

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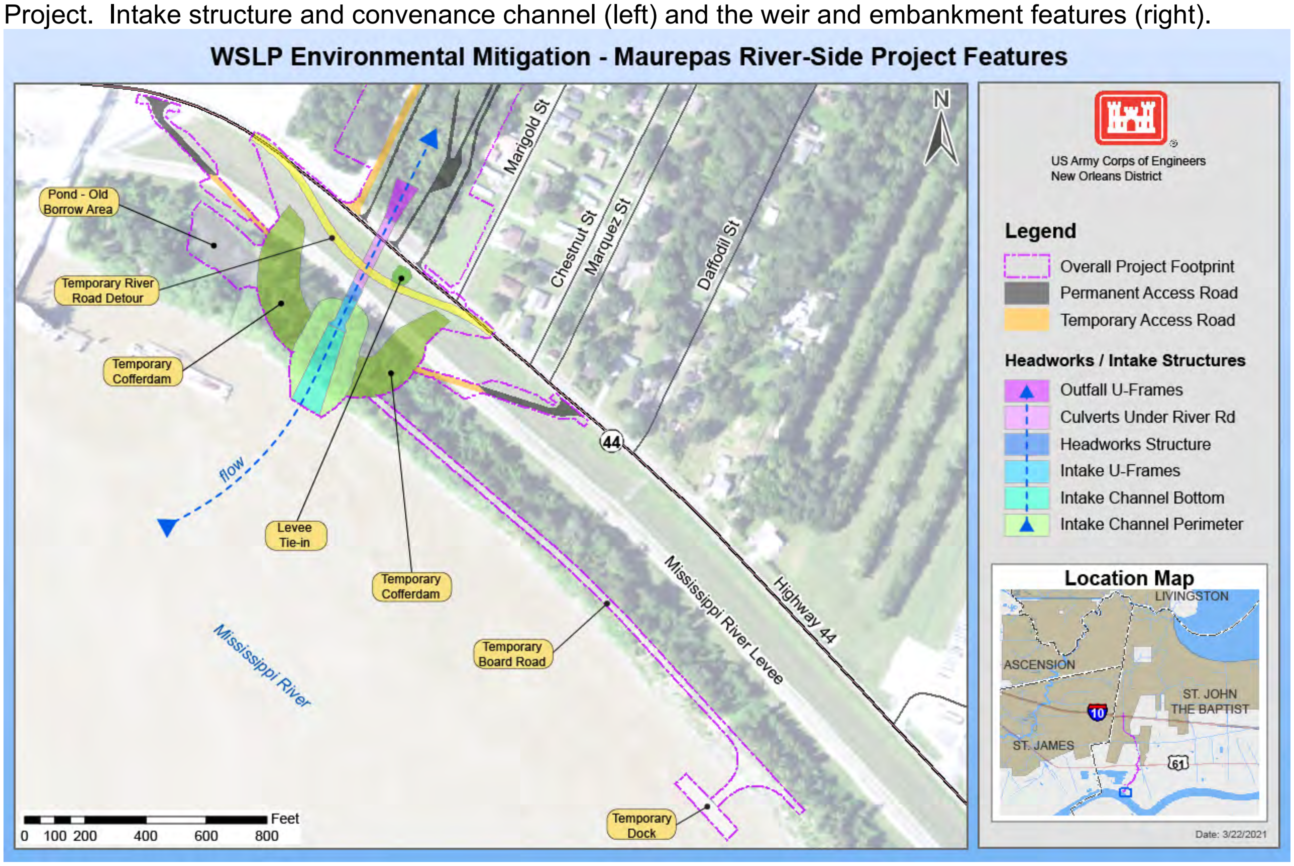

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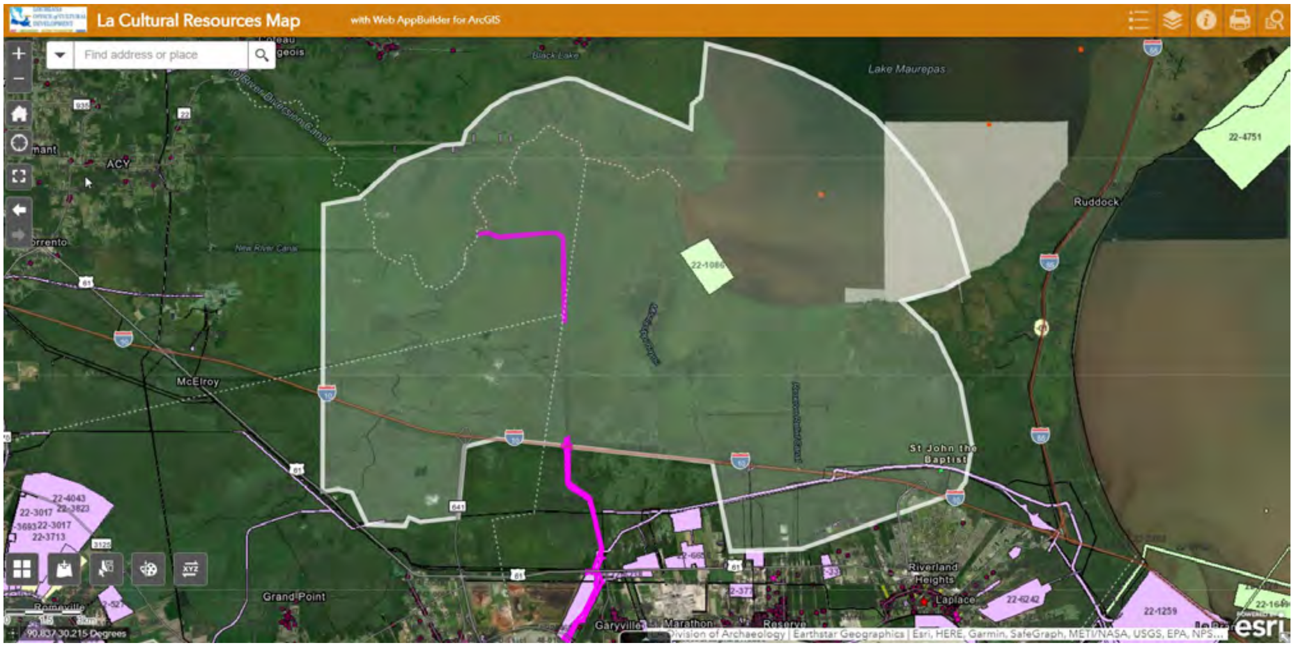

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AQ-1.2: SEIS to WSLP Project Coordination Letter Responses

From: David Franks
To: Fedoroff, Ashley M CIV USARMY CEMVN (USA)
Subject: [Non-DoD Source] RE: BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification
Date: Tuesday, October 19, 2021 4:39:02 PM

The Seminole Nation of Oklahoma has no objections or concerns to the Maurepas Swamp Project Addition.

David Frank, DIRECTOR
P.O BOX 1498
WEWOKA, OKLAHOMA 74848

405.220.0289 (C)
405.234.5218 (O)

Historic Preservation Office

-To inspire and empower tribal members for success-

From: Fedoroff, Ashley M CIV USARMY CEMVN (USA) [mailto:Ashley.M.Fedoroff@usace.army.mil]
Sent: Tuesday, October 19, 2021 4:08 PM
To: David Franks <Franks.D@sno-nsn.gov>
Cc: Emery, Jason A CIV USARMY CEMVN (USA) <Jason.A.Emery@usace.army.mil>; Enersen, Jill A CIV USARMY CEMVN (USA) <Jill.A.Enersen@usace.army.mil>; Williams, Eric M CIV USARMY CEMVN (USA) <Eric.M.Williams@usace.army.mil>
Subject: BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification

Dear Mr. Franks,

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative. Please see the attached letter of notification and the 2 enclosures for more information.

If you have any questions or require additional information concerning this undertaking, please contact Ms. Ashley Fedoroff, archaeologist, at (601) 631-5278 or via e-mail Ashley.M.Fedoroff@usace.army.mil, Ms. Jill Enersen, Architectural Historian, at (504) 862-1741 or

Jill.A.Enersen@usace.army.mil, or Mr. Jason Emery, Tribal Liaison, at (504) 862-2364 or via email Jason.A.Emery@usace.army.mil.

Respectfully,
Ashley

Ashley M. Fedoroff, MA, MPH
Archaeologist
Cultural & Social Resources Section (CEMVN-PDS-N)
U.S. Army Corps of Engineers
Vicksburg District Regional Planning and Environment Division, South
ashley.m.fedoroff@usace.army.mil
601.631.5278

From:	Alexa Didio
To:	Fedoroff, Ashley M CIV USARMY CEMVN (USA)
Subject:	[Non-DoD Source] RE: BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification
Date:	Wednesday, November 10, 2021 2:45:06 PM
Attachments:	image001.png

Dear Ms. Fedoroff,

Regarding the above-mentioned project, the Jena Band of Choctaw Indians THPO hereby concurs with he determination of No Adverse Effect. Should any inadvertent discoveries of anticipated impacts occur, please contact all Tribes with interest in this area. Thank you

Sincerely,

Alexa DiDio
Assistant THPO, Cultural Deaprtment
Jena Band of Choctaw Indians
Phone: 318-992-1205

From: Fedoroff, Ashley M CIV USARMY CEMVN (USA) <Ashley.M.Fedoroff@usace.army.mil>
Sent: Friday, November 5, 2021 8:36 AM
To: Alexa Didio <ADidio@jenachoctaw.org>
Subject: RE: BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification

Good Morning Alexa,

I took some screenshots and put them in PDFs for you. I also attached the JPEGs for you in case those are helpful too. I've included a zoomed out and zoomed in aerial views, topo view, and an overlay on the LA SHPO cultural map. For some reason the indirect impact area (white polygon) wouldn't show up on the topo view no matter what color I made it.

I'm pretty terrible at making maps so if these don't work well, let me know and I'll ask someone smarter than me to help.

Respectfully,
Ashley

Ashley M. Fedoroff, MA, MPH
Archaeologist
Cultural & Social Resources Section (CEMVN-PDS-N)
U.S. Army Corps of Engineers
Vicksburg District Regional Planning and Environment Division, South
ashley.m.fedoroff@usace.army.mil
601.631.5278

From: Alexa Didio <ADidio@jenachoctaw.org>
Sent: Thursday, November 4, 2021 8:57 AM
To: Fedoroff, Ashley M CIV USARMY CEMVN (USA) <Ashley.M.Fedoroff@usace.army.mil>
Subject: [Non-DoD Source] RE: BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification

Good morning Ms. Fedoroff,

I'm trying to make sure I give prompt responses, but I am not able to open the files that you have sent me. Is there anyway you can send me PDFs?

Sincerely,

Alexa DiDio
Assistant THPO, Cultural Deaprtment
Jena Band of Choctaw Indians
Phone: 318-992-1205

From: Fedoroff, Ashley M CIV USARMY CEMVN (USA) <Ashley.M.Fedoroff@usace.army.mil>
Sent: Thursday, October 28, 2021 3:13 PM
To: Alexa Didio <ADidio@jenachoctaw.org>
Cc: Emery, Jason A CIV USARMY CEMVN (USA) <Jason.A.Emery@usace.army.mil>
Subject: RE: BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification

Dear Ms. DiDio,

Thank you for your reply. I've attached 3 kmzs of the Maurepas Swamp Project APE. The pink polygons reference direct impact areas while the white polygon indicates potential indirect impact areas (i.e. flooding from diversion output). These kmzs represent the largest anticipated impact area; anticipated impacts to cultural resources for MSP-1 and MSP-2 alternatives are the same. We recognize there are previously recorded cultural resources in the potential impact area. For any areas not previously surveyed, CEMVN will follow the guidelines in pursuant of the BBA 18 Habitat Mitigation PA for any necessary future cultural investigations or mitigations.

We will make sure to add you to our contact list. Thank you for letting us know. For clarification, should future emails be sent exclusively to you, or to you and Johnna?

Respectfully,
Ashley

Ashley M. Fedoroff, MA, MPH
Archaeologist
Cultural & Social Resources Section (CEMVN-PDS-N)
U.S. Army Corps of Engineers

Vicksburg District Regional Planning and Environment Division, South
ashley.m.fedoroff@usace.army.mil
601.631.5278

From: Alexa Didio <ADidio@jenachoctaw.org>
Sent: Monday, October 25, 2021 9:28 AM
To: Fedoroff, Ashley M CIV USARMY CEMVN (USA) <Ashley.M.Fedoroff@usace.army.mil>
Subject: [Non-DoD Source] RE: BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification

Dear Ms. Federoff,

Regarding the above-mentioned projects, if you could send the four corners of each project, that would be greatly appreciated. We have some concerns with sites being close and we want to be extra thorough with our determinations before sending them.

For future reference, all projects taking place in Louisiana need to be sent to me at this email. Thank you.

Sincerely,

Alexa DiDio
Assistant THPO, Cultural Deaprtment
Jena Band of Choctaw Indians
Phone: 318-992-1205

From: Johnna Flynn <jflynn@jenachoctaw.org>
Sent: Thursday, October 21, 2021 10:54 AM
To: Alexa Didio <ADidio@jenachoctaw.org>
Subject: FW: BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification

Johnna Flynn
THPO/Cultural Director
Jena Band of Choctaw Indians
P.O. Box 14
Jena, LA 71342
(Ph) 318-992-1205
jflynn@jenachoctaw.org

From: Fedoroff, Ashley M CIV USARMY CEMVN (USA) <Ashley.M.Fedoroff@usace.army.mil>
Sent: Tuesday, October 19, 2021 3:56 PM
To: Johnna Flynn <jflynn@jenachoctaw.org>
Cc: Emery, Jason A CIV USARMY CEMVN (USA) <Jason.A.Emery@usace.army.mil>; Enersen, Jill A CIV USARMY CEMVN (USA) <Jill.A.Enersen@usace.army.mil>; Williams, Eric M CIV USARMY CEMVN (USA) <Eric.M.Williams@usace.army.mil>
Subject: BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification

Dear Ms. Flynn,

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative. Please see the attached letter of notification and the 2 enclosures for more information.

If you have any questions or require additional information concerning this undertaking, please contact Ms. Ashley Fedoroff, archaeologist, at (601) 631-5278 or via e-mail Ashley.M.Fedoroff@usace.army.mil, Ms. Jill Enersen, Architectural Historian, at (504) 862-1741 or Jill.A.Enersen@usace.army.mil, or Mr. Jason Emery, Tribal Liaison, at (504) 862-2364 or via email Jason.A.Emery@usace.army.mil.

Respectfully,
Ashley

Ashley M. Fedoroff, MA, MPH
Archaeologist
Cultural & Social Resources Section (CEMVN-PDS-N)
U.S. Army Corps of Engineers
Vicksburg District Regional Planning and Environment Division, South
ashley.m.fedoroff@usace.army.mil
601.631.5278

From:	Chris Daniel
To:	Fedoroff, Ashley M CIV USARMY CEMVN (USA)
Cc:	Emery, Jason A CIV USARMY CEMVN (USA); Enersen, Jill A CIV USARMY CEMVN (USA); Williams, Eric M CIV USARMY CEMVN (USA)
Subject:	[Non-DoD Source] RE: (External)BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification
Date:	Tuesday, October 26, 2021 9:09:17 AM

Ashley,

Thank you for the notification by the Corps of Engineers of its intent to add the Maurepas Swamp Project to the BBA 18 Habitat Mitigation PA. Pursuant to the PA's terms (IV.A.2) modifications, additions, or deletions to the appendices may occur at the request of CEMVN or another Signatory or Invited Signatory who has signed the PA. The ACHP is not a signatory to the PA and at this time has no comments on the proposed addition. In the future, the Corps can refrain from including us on such notifications. However, should the addition be accepted and Corps determine the project will result in an adverse effect and it proposes to utilize a Project-Specific Memorandum of Agreement consistent with Stipulation II.G.3, please notify the ACHP at that time. Please use the ACHP's Electronic Section 106 Documentation Submittal System (e106) to notify us formally of an adverse effect finding. All the information can be found on our site at: https://www.achp.gov/e106-email-form

Christopher Daniel (he/him/his)
Program Analyst
Advisory Council on Historic Preservation
202.517.0223 (Office & Mobile)
cdaniel@achp.gov

From: Fedoroff, Ashley M CIV USARMY CEMVN (USA) [mailto:Ashley.M.Fedoroff@usace.army.mil]
Sent: Tuesday, October 19, 2021 4:39 PM
To: e106; Chris Daniel
Cc: Emery, Jason A CIV USARMY CEMVN (USA); Enersen, Jill A CIV USARMY CEMVN (USA); Williams, Eric M CIV USARMY CEMVN (USA)
Subject: (External)BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification

Dear Council,

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative. Please see the attached letter of notification and the 2 enclosures for more information.

If you have any questions or require additional information concerning this undertaking, please contact Ms. Ashley Fedoroff, archaeologist, at (601) 631-5278 or via e-mail Ashley.M.Fedoroff@usace.army.mil, Ms. Jill Enersen, Architectural Historian, at (504) 862-1741 or

Jill.A.Enersen@usace.army.mil, or Mr. Jason Emery, Tribal Liaison, at (504) 862-2364 or via email Jason.A.Emery@usace.army.mil.

Respectfully,
Ashley

Ashley M. Fedoroff, MA, MPH
Archaeologist
Cultural & Social Resources Section (CEMVN-PDS-N)
U.S. Army Corps of Engineers
Vicksburg District Regional Planning and Environment Division, South
ashley.m.fedoroff@usace.army.mil
601.631.5278

From:	Lindsey Bilyeu
To:	Fedoroff, Ashley M CIV USARMY CEMVN (USA)
Subject:	[Non-DoD Source] RE: BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification
Date:	Thursday, November 18, 2021 4:05:23 PM

Ashley,

The Choctaw Nation of Oklahoma thanks the USACE, Vicksburg District, for the correspondence regarding the above referenced project. It appears that we never executed a signature for the agreement. I will have this agreement reviewed by our legal department and get a signature back to you. In the meantime, could you please provide me the GIS shapefiles of the project area so that we may determine if there are any Choctaw sites in the APE?

If you have any questions, please contact me.

Thank you,

Lindsey D. Bilyeu, MS
Senior Section 106 Reviewer
Choctaw Nation of Oklahoma
Historic Preservation Department
Office: (580) 642-8377
Cell: (580) 740-9624

From: Fedoroff, Ashley M CIV USARMY CEMVN (USA) <Ashley.M.Fedoroff@usace.army.mil>
Sent: Tuesday, October 19, 2021 3:51 PM
To: Ian Thompson <ithompson@choctawnation.com>; Lindsey Bilyeu <lbilyeu@choctawnation.com>
Cc: Emery, Jason A CIV USARMY CEMVN (USA) <Jason.A.Emery@usace.army.mil>; Enersen, Jill A CIV USARMY CEMVN (USA) <Jill.A.Enersen@usace.army.mil>; Williams, Eric M CIV USARMY CEMVN (USA) <Eric.M.Williams@usace.army.mil>
Subject: BBA 18 Habitat Mitigation PA - Maurepas Swamp Project Addition Notification

Dear Dr. Thompson and Ms. Bilyeu,

The U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) is notifying the consulting parties to the BBA 18 Habitat Mitigation PA that it is adding an additional swamp mitigation project to those already under consideration per Appendix B of the document, providing rational for doing so, and sharing currently available information about this proposed mitigation alternative. Please see the attached letter of notification and the 2 enclosures for more information.

If you have any questions or require additional information concerning this undertaking, please contact Ms. Ashley Fedoroff, archaeologist, at (601) 631-5278 or via e-mail

Ashley.M.Fedoroff@usace.army.mil, Ms. Jill Enersen, Architectural Historian, at (504) 862-1741 or Jill.A.Enersen@usace.army.mil, or Mr. Jason Emery, Tribal Liaison, at (504) 862-2364 or via email Jason.A.Emery@usace.army.mil.

Respectfully,
Ashley

Ashley M. Fedoroff, MA, MPH
Archaeologist
Cultural & Social Resources Section (CEMVN-PDS-N)
U.S. Army Corps of Engineers
Vicksburg District Regional Planning and Environment Division, South
ashley.m.fedoroff@usace.army.mil
601.631.5278

AQ-2 ITEM 2: BBA 18 HABITAT MITIGATION PA

PROGRAMMATIC AGREEMENT AMONG THE U.S. ARMY CORPS OF ENGINEERS, NEW ORLEANS DISTRICT; AMITE RIVER BASIN COMMISSION; EAST BATON ROUGE PARISH; LOUISIANA COASTAL PROTECTION AND RESTORATION AUTHORITY; LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT; PONTCHARTRAIN LEVEE DISTRICT; LOUISIANA STATE HISTORIC PRESERVATION OFFICER OF THE DEPARTMENT OF CULTURE, RECREATION & TOURISM; AND CHOCTAW NATION OF OKLAHOMA; REGARDING THE BIPARTISAN BUDGET ACT OF 2018 COMPENSATORY HABITAT MITIGATION PROGRAM FOR THE COMITE RIVER DIVERSION, EAST BATON ROUGE PARISH WATERSHED FLOOD RISK MANAGEMENT, AND WEST SHORE LAKE PONTCHARTRAIN HURRICANE AND STORM DAMAGE RISK REDUCTION PROJECTS IN LOUISIANA

WHEREAS, the U.S. Army Corps of Engineers (USACE), New Orleans District (CEMVN) is conducting the present Compensatory Mitigation Program (BBA Mitigation Program; Undertaking) for the Comite River Diversion (Comite), East Baton Rouge Parish Watershed Flood Risk Management (EBR), and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction (WSLP) Projects (Appendix A) with funding from the Bipartisan Budget Act of 2018 (BBA; Pub. L. 115-123), signed into law February 9, 2018. The Comite, EBR, and WSLP projects were previously authorized by other legislation; and

WHEREAS, the purpose of the BBA Mitigation Program is to compensate for habitat losses to be incurred during construction of the Comite, EBR, and WSLP, projects. Generally and to the extent possible, the mitigation projects will be implemented in the same coastal basin where the project impacts occur. The Comite Project is located in East Baton Rouge Parish, Louisiana. The EBR project is located in East Baton Rouge Parish, Louisiana. The WSLP project is located in southeast Louisiana, on the east-bank of the Mississippi River, in St. Charles, St. John the Baptist, and St. James Parishes. Presently, the mitigation projects need to compensate for two (2) habitat categories: Bottomland Hardwoods (BLH)-Wet and Swamp. Some of the construction projects are currently undergoing re-design; therefore, the impacts and mitigation needs could change; and

WHEREAS, CEMVN is the lead federal agency for purposes of the National Environmental Policy Act of 1969 (NEPA) and its implementing regulations, set out at 40 CFR parts 1500-1508 (43 FR 55978), "Section 106" of the National Historic Preservation Act (NHPA) [54 U.S.C. § 300101 et seq.], as amended (54 U.S.C. § 306108), and its implementing regulations, set out at 36 Code of Federal Regulations (CFR) Part 800, and in accordance with 36 CFR § 800.2(a)(2) and 800.8; and

WHEREAS, the Non-Federal Sponsors (NFS) for the Comite project are the Louisiana Department of Transportation and Development (LA DOTD) and the Amite River Basin Commission (ARBC). The NFS for the EBR project is East Baton Rouge Parish (EBRP). The NFS for the WSLP project are the Louisiana Coastal Protection and Restoration Authority (CPRA) and the Pontchartrain Levee District (PLD); and

WHEREAS, CEMVN has determined that implementing the BBA Mitigation Program may result in multiple Undertakings, as defined by 54 U.S.C. § 300320 and 36 CFR § 800.16(y), that may affect properties listed in or eligible for listing on the National Register of Historic Places (NRHP) pursuant to 36 CFR Part 60 (historic properties) and/or properties having religious and cultural significance to Tribes including sites that may contain human remains and/or associated cultural items; and

WHEREAS, because the scope and programmatic nature of the BBA Mitigation Program makes it unreasonable to fully identify historic properties or determine the effects of these Undertakings at the present time, CEMVN has concluded that a phased process to conduct identification and evaluation of historic properties (36 CFR § 800.4(b)(2)) and for application of the criteria of adverse effect (800.5(a)(3)), is an appropriate and necessary approach for the agency to meet the requirements of Section 106; and

WHEREAS, as the federal agency cannot fully determine how these Undertakings may affect historic properties, the location of historic properties, or their significance and character, CEMVN has elected to negotiate a Programmatic Agreement (PA) in consultation with stakeholders, as provided for in 36 CFR § 800.14(b)(1)(ii), to govern the implementation of this Program and fulfill its obligations under Section 106 of the NHPA including the resolution of adverse effects for these Undertakings; and

WHEREAS, in this PA, “Signatories” is defined in 36 CFR § 800.6(c)(1), “Invited Signatories” is defined in 36 CFR § 800.6(c)(2), and “Concurring Party” is defined in 36 CFR § 800.6(c)(3); and

WHEREAS, a Consulting Party will be recognized by CEMVN as a Signatory, Invited Signatory, or a Concurring Party starting on the date the Consulting Party signs this PA as a Signatory, Invited Signatory, or Concurring Party and provides CEMVN with a record of this signature; and

WHEREAS, in accordance with 36 CFR § 800.6(c)(1), a Signatory has the authority to execute, amend, or terminate the PA; and

Whereas, in accordance with 36 CFR § 800.6(c)(2), Invited Signatories who sign this PA are signatories with the authority to execute, amend, or terminate the PA; and

WHEREAS, in accordance with 36 CFR § 800.6(c)(3), a Concurring Party is a Consulting Party invited to concur in the PA but who does not have the authority to amend or terminate the PA; and

WHEREAS, in accordance with 36 C.F.R. § 800.6(a)(1), the Advisory Council on Historic Preservation (ACHP) has been provided the required documentation and invited to participate in this PA. On September 30, 2019, the ACHP provided written notice that it has chosen not to participate in the consultation; and

WHEREAS, pursuant to 36 C.F.R. § 800.6(b)(1), CEMVN has consulted with the Louisiana State Historic Preservation Officer of the Department of Culture, Recreation and Tourism (SHPO) regarding its intent to develop this PA and invited the SHPO to participate. SHPO accepted on July 31, 2019, and is a Signatory to this PA; and

WHEREAS, CEMVN has consulted with the NFS regarding the potential effects of the Undertakings on historic properties, and as the proponents of the Undertakings, are Invited Signatories to this PA; and

WHEREAS, CEMVN recognizes that the Alabama-Coushatta Tribe of Texas (ACTT), the Caddo Nation of Oklahoma (CN), the Choctaw Nation of Oklahoma (CNO), the Coushatta Tribe of Louisiana (CT), the Chitimacha Tribe of Louisiana (CTL), the Jena Band of Choctaw Indians (JBCI), the Mississippi Band of Choctaw Indians (MBCI), the Muscogee (Creek) Nation (MCN), the Seminole Nation of Oklahoma (SNO), the Seminole Tribe of Florida (STF), and the Tunica-Biloxi Tribe of Louisiana (TBTL) (collectively referenced as "Tribes"), may have sites of religious and cultural significance on or off Tribal Lands [as defined in 36 CFR § 800.16(x)] that may be affected by these Undertakings, and in meeting its Federal trust responsibility, CEMVN engaged in government-to-government consultation with Tribes via letter on July 03, 2019, and July 23, 2019. Pursuant to 36 CFR § 800.2 (c)(2)(ii)(E), and in consideration of the confidentiality of information, CEMVN has invited the Tribes to enter into an PA that specifies how CEMVN will carry out Section 106 responsibilities for these Undertakings; and

WHEREAS, the ACTT, CN, CNO, CT, CTL, JBCI, MBCI, MCN, SNO, STF, and TBTL have assumed the responsibilities of the SHPO with respect to its/their Tribal lands through appointment of a Tribal Historic Preservation Officer (THPO) in accordance with Section 101 of the NHPA and CEMVN will consult with the appropriate THPO in lieu of the SHPO for Undertakings occurring on or affecting its/their Tribal lands; and

WHEREAS, as of the date of this Agreement, no Tribes(s) have expressly declined to enter into this Agreement as a signatory party; and

WHEREAS, on August 08, 2019, the CNO submitted a written response to CEMVN's July 23, 2019, letter requesting to be a Consulting Party and is a Concurring Party to this PA.

WHEREAS, CEMVN may invite additional Tribes that have sites of religious and cultural significance to enter into the terms of this Agreement as Invited Signatories or Concurring Parties in accordance with 36 CFR § 800.14(f), and nothing in this Agreement prevents a Tribe from entering into a separate PA or other agreement with CEMVN; and

WHEREAS, the terms of this PA shall not apply to Undertakings on or affecting Tribal lands without prior execution of the PA by the affected Tribe; and

WHEREAS, on July 02, 2019, CEMVN posted a NHPA/NEPA Public Notice on the designated project website: (https://www.mvn.usace.army.mil/About/Projects/BBA-2018/Mitigation/) for a (15)-day comment period requesting the public's input concerning: 1) the proposed Undertaking and its potential to significantly affect historic properties; 2) assistance in identifying any relevant parties who may have an interest in participating in this consultation, and; 3) CEMVN's proposal to develop a PA pursuant to 36 CFR § 800.14(b). No comments were received; and

WHEREAS, for the review of specific Undertakings under this PA, CEMVN may invite other agencies, organizations, and individuals to participate as Consulting Parties; and

WHEREAS, Consultation among all Signatories, Invited Signatories, and Concurring Parties to this PA will continue throughout the implementation of the PA. Consultation is mutual, meaningful dialogue regarding the fulfillment of this PA, the process of Section 106 compliance, and the treatment of historic properties that may be affected by CEMVN Undertakings; and

NOW, THEREFORE, CEMVN, SHPO, (Signatories), LA DOTD, ARBC, EBRP, CPRA, and PLD (Invited Signatories), and CNO (Concurring Party) agree that the Undertakings resulting from the BBA Mitigation Program shall be administered in accordance with the with the following stipulations in order to take into account the effects of the Undertakings on historic properties and to satisfy CEMVN's responsibilities under Section 106 of the NHPA for all resulting BBA Mitigation Undertakings:

STIPULATIONS

To the extent of its legal authority, and in coordination with other Signatories, Invited Signatories, and Concurring Parties, CEMVN will implement the following measures:

I. GENERAL

A. Applicability

1. If another Federal program or Federal agency has approved an Undertaking that lies wholly or partly within the BBA Mitigation Program APE within the past five (5)-years, and no new substantial information has been revealed, then Section 106 consultation and review is concluded for that portion of the BBA APE within this previous Undertaking provided that CEMVN:

    a) Confirms that the Area of Potential Effects (APE) and effect [as defined by 36 CFR § 800.16(i)] of its Undertaking are the same as that of the Undertaking reviewed by the previous agency, and;

    b) Determines that the previous agency complied with Section 106, including Tribal consultation, appropriately and;

    c) Adopts the findings and determinations of the previous agency.

2. CEMVN will document these findings in its project file in order to confirm that the requirements of Section 106 have been satisfied. Should CEMVN, in consultation with SHPO and participating Tribes, determine that the previous Section 106 review was insufficient or involved interagency disagreements about eligibility, effect, and/or resolution of adverse effects, CEMVN will conduct additional Section 106 consultation in accordance with the terms of this PA.

3. CEMVN has determined that the following types of activities have limited or no potential to affect historic properties and CEMVN has no further Section 106 responsibilities with regards to them, pursuant to 36 CFR § 800.3(a)(1):

   a) Administrative actions such as personnel actions, travel, procurement of services, supplies (including vehicles and equipment) for the support of day-to-day operational activities.

   b) Providing funding for planning, studies, and design and engineering costs that involve no commitment of resources other than staffing and associated funding.

   c) Funding the administrative action of acquiring properties, including the real estate transactions and transfers.

   d) Surveying, monitoring, data gathering, and reporting in support of planning activities (e.g., soil survey testing, conducting geotechnical boring investigations or other geophysical and engineering activities) provided that such testing is shifted to avoid impacts to known cultural resources and that soil survey and geotechnical testing of sediment utilizes hand-dug test pits, hand probes, cores, and/or augers. If heavy equipment (i.e., backhoes, tractors, excavators, etc.) will be used as part of the testing process, then the activities are considered to have potential to affect historic properties. Under such circumstances, Section 106 consultation will be required in accordance with Stipulation II.E.1.

   e) Demarcation of project areas and resources (e.g., cultural sites, wetlands, threatened and endangered species habitat).

B. Timeframes and Communications

1. All references to time periods in this PA are in calendar days. If a review period included in this PA ends on a Saturday, Sunday, or State/Federal holiday, the review period will be extended until the next business day. Any electronic communication forwarding plans or other documents for review under the terms of the PA that is sent after 4:00 pm Central Time will be deemed to have been received by the reviewing party on the next business day. E-mail comments submitted by a Signatory, Invited Signatory, or Concurring Party for review under this PA are timely if they are received at any time on the last day of a review period. Responses sent by U.S. mail will be accepted as timely if they are postmarked by the last day allowed for the review.

2. CEMVN will provide the Signatories, Invited Signatories, and Concurring Parties with the opportunity to review and comment on various documents and reports as specified under the terms of the PA. Determinations or reviews that have been completed by CEMVN under the terms of this PA prior to the signature of a Signatory, Invited

Signatory, or Concurring Party will not be reconsidered because the Consulting Party did not have the opportunity to review and comment.

3. The Signatories, Invited Signatories, and Concurring Parties may send and accept official notices, comments, requests for further information and documentation, and other communications required by this PA by electronic mail (e-mail). If the size of an e-mail message is unusually large or an e-mail is returned to a sender because its size prevents delivery, the sender will contact the recipient(s) and determine alternative methods to deliver the information.

4. Time sensitive information that is not sent by e-mail should be sent by overnight mail, courier, or be hand-delivered and the timeframe for its review will be measured by the date the delivery is signed for by the individual recipient, agency, or organization representing the Signatory, Invited Signatory, or Concurring Party.

5. Due to the varied nature of Undertakings, the individual response times to CEMVN's requests for comment or concurrence will vary. These response times are contingent upon CEMVN ensuring that its findings and determinations are made by *Qualified Staff* as defined in Stipulation II.A.1(a) and supported by documentation as required by 36 CFR § 800.11(d) and 36 CFR § 800.11(e), and consistent with CEMVN guidance.

6. The response time for each request for comment or concurrence shall be a maximum of thirty (30)-days, unless otherwise stipulated in this PA or agreed to on a case-by-case basis.

7. The failure of any Signatory, Invited Signatory, or Concurring Party to comment or concur on CEMVN's finding or determination within an agreed upon timeframe, will be treated by CEMVN as non-objection, and CEMVN may proceed to the next step in the consultation process without taking additional steps to seek comments from that party.

C. Points of Contact

1. The Signatories, Invited Signatories, and Concurring Parties of this PA will each designate a primary and secondary point of contact (see Appendix A). The primary contact is the contact to which all formal correspondence is sent. If the individual designated as the primary point of contact is not available, communications shall be directed to the secondary contact.

2. It is the responsibility of each Signatory, Invited Signatory, and Concurring Party to inform CEMVN of any changes in the name, address, e-mail address, or phone number of the point-of-contact. Such changes shall not require an amendment to this PA. CEMVN will forward this information to the other Consulting Parties by e-mail. The failure by any party to this PA to notify CEMVN of changes to their point-of-contact's

information shall not be grounds for asserting that notice of a proposed action was not received.

D. Confidentiality

1. In accordance with 36 CFR § 800.6(a)(5), if an Indian Tribe requests that specific information shared with CEMVN be kept confidential, or if the agency official believes that there are other reasons to withhold information, CEMVN will comply to the extent allowed by law.

2. CEMVN will safeguard information about historic properties provided by SHPO and/or sites of traditional, religious, and/or cultural importance to Tribes, including location information or non-public information provided by SHPO/Tribes to assist in the identification of such properties, to the extent allowed by Section 304 of NHPA (54 U.S.C. § 307103), and other applicable laws. In accordance with Stipulation II.A.1(a) only *Qualified Staff* will be afforded access to protected historic property information.

3. CEMVN will provide to all Consulting Parties the documentation specified in 36 CFR § 800.11 subject to the confidentiality provisions of 36 CFR § 800.11(c) and such other documentation as may be developed during consultation to resolve adverse effects.

E. Roles and Responsibilities of the Signatories

1. CEMVN:

    a) Will not authorize implementation of an individual Undertaking until Section 106 review is completed pursuant to this PA.

    b) Will notify and consult with the SHPO, Tribes, and other Consulting Parties, as appropriate. Consultations may include face-to-face meetings, as well as communications by U.S. mail, e-mail, facsimile, and/or telephone. Times and places of meetings, as well as an agenda for meetings, will be developed with mutual acceptance and done in a timely manner.

    c) Will consult with any Tribe on a government-to-government basis in recognition of their sovereign status, whether a signatory to this PA or not, throughout any activity or Undertaking that might affect historic properties; particularly in regards to sites that may have traditional, religious, and/or cultural importance to Tribes. In meeting its Federal trust responsibility, CEMVN alone will conduct all government-to-government consultation with Tribes.

    d) Will be responsible for determining the APE, identifying historic properties located within the APE, providing NRHP eligibility determinations, and findings of effect, in consultation with SHPO, Tribes, and other Consulting Parties.

e) Will ensure all Cultural Resources review is conducted by staff meeting the *Professional Standards* as outlined in Stipulation II.A.1(c).

f) Will ensure that all documentation generated as part of the NHPA process resulting from these Undertakings will be consistent with applicable *Standards* (Stipulation II.A.1(b)) and confidentiality provisions outlined in Stipulation I.D.

g) Will provide to the appropriate NFS, a written record of all stipulations and conditions pursuant to this agreement regarding the subject real property that the NFS has jurisdiction over and ensure that they are understood. Additionally, CEMVN will provide the NFS with guidance on the treatment of any historic properties, if applicable.

h) Will provide the other Signatories and ACHP with an annual report for each year that this PA is in effect as outlined in Stipulation IV.E.1.

2. SHPO/THPO(s):

a) Will coordinate with CEMVN, to identify Consulting Parties, including any communities, organizations, or individuals that may have an interest in a specific Undertaking and its effects on historic properties.

b) Will review CEMVN's determination of the APE, NRHP eligibility, findings of effect, and respond within timeframes required by this PA.

c) Upon request, SHPO will provide CEMVN and/or its designee(s) with available information about historic properties (such as access to site files, GIS data, survey information, geographic areas of concern). Only *Qualified Staff* and/or designee(s) will be afforded access to protected historic property information.

d) For CEMVN Undertakings on Tribal lands or affecting properties of religious and cultural significance, and where no tribe-specific consultation agreements or protocols are in place, CEMVN will consult with affected Tribes in accordance with 36 CFR Part 800. In determining the specific Tribes affected, CEMVN will first establish that it is a type of Undertaking with potential to affect historic properties with religious and cultural significance and may consult with SHPO, Tribes, any State Tribal Agency, and access the National Park Service (NPS) Native American Consultation Database, the list of Tribal Areas of Interest in the State of Louisiana, http://www.crt.state.la.us/Assets/OCD/archaeology/nativeamericancontacts/NatAmContacts.pdf, or other tools to identify geographic Tribal interests.

e) Will participate in reviews of Undertakings and consultation meetings as needed and any other roles appropriate to the completion of the goals of this PA. In those instances where consultation with SHPO/THPO(s) has occurred, CEMVN will document any decisions that were reached in its project file.

f) Will review the annual report provided by CEMVN and will recommend any actions or revisions to be considered; including updates to the appendices in accordance with Stipulation IV.E.2.

g) Will participate in meetings convened by CEMVN or any other Signatory, Invited Signatory, or Concurring Party to review the effectiveness of this PA.

3. NFS:

a) Will coordinate with CEMVN, to identify Consulting Parties, including any communities, organizations, private land owners, or other individuals that may have an interest in a specific Undertaking and its effects on historic properties.

b) Will participate in meetings as needed and any other roles appropriate to the completion of the goals of this PA.

c) Agrees comply with all stipulations and conditions pursuant to this PA regarding real property under its ownership, authority, control, or political jurisdiction that is being investigated or used for the BBA Mitigation Program.

d) Agrees that, to the greatest extent practicable, it will consider any guidance regarding the treatment of historic properties provided by CEMVN or other Consulting Parties in future planning regarding the subject real property.

e) Will review the annual report provided by CEMVN and will recommend any actions or revisions to be considered; including updates to the appendices in accordance with Stipulation IV.E.2.

f) Will participate in meetings convened by CEMVN or any other Signatory, Invited Signatory, or Concurring Party to review the effectiveness of this PA.

g) Will assist in determining the final disposition of any recovered archaeological collections from a CEMVN-funded archaeological survey, evaluation, Standard Treatment Measure (STM) or project-specific Memorandum of Agreement (MOA) Treatment Measure (TM), or post-review discovery, in accordance with Stipulation III.D(1) of this PA and will coordinate with any private land owners regarding State of Louisiana *Archaeological Collection Donation Forms*, if necessary.

4. ACHP:

    a) Will review any Adverse Effect (AE) determination as required in CFR § 800.6(a)(1).

    b) Will participate in dispute resolution as required by Stipulation IV.B of this PA.

F. Public Participation

1. To date, CEMVN has undertaken the public outreach and participation activities which have been memorialized in "Whereas" clauses found in this PA.

2. It is the intent of NEPA that federal agencies encourage and facilitate public involvement to the extent practicable in decisions that may affect the quality of the environment. CEMVN will also provide public notices and the opportunity for public comment or participation on any Undertaking through the NEPA public participation process, and if applicable, Executive Order 12898 (Environmental Justice) provided such notices specifically reference Section 106 as a basis for public involvement.

3. CEMVN recognizes that the views of the public are essential to informed decision making throughout the Section 106 consultation process. CEMVN will notify the public of proposed Undertakings, the implementation of STM or project-specific MOA TM as required by this PA in a manner that reflects the nature, complexity, and significance of historic properties potentially affected by the Undertaking and the likely public interest given CEMVN's specific involvement.

4. CEMVN may confer with other Consulting Parties to determine if there are individuals, groups, or organizations with a demonstrated interest in historic properties that should be included as a Consulting Party for any specific Undertaking in accordance with 36 CFR § 800.2(c)(5). If such parties are identified, or identify themselves to CEMVN, CEMVN will provide them with information regarding the Undertaking and its effects on historic properties, consistent with the confidentiality provisions of Stipulation I.D of this PA.

5. CEMVN will ensure that reasonable time frames for public comment are afforded and will consider all views provided by the public regarding any specific Undertaking. CEMVN will provide contact information and accept responses to its requests for public comments through the U.S. mail or e-mail submittals.

6. Should a member of the public object to implementation of the PA's terms, CEMVN will notify the other Consulting Parties by e-mail and take the objection into consideration. CEMVN will consult with the objecting party and, if that party so requests, the other Signatories, for not more than fifteen (15)-days. In reaching its decision regarding the objection, CEMVN will take into consideration all comments from these parties. Within

fifteen (15)-days after closure of this consultation period, CEMVN will provide the other Consulting Parties with its final decision in writing.

7. Additional opportunities for NEPA participation and NEPA-related public comment will be relayed through appropriate means (e.g., postings, publications, social media), as is applicable.

II. PROJECT REVIEW

A. Standards

1. This PA uses the definitions presented in the subsequent paragraphs to establish standards for performing all cultural resource project reviews and investigations required under the terms of this PA including, but not limited to, site identification, NRHP eligibility evaluations, and as appropriate, STM or MOA TM for the resolution of adverse effects to historic properties:

    a) "*Qualified Staff* " - shall mean staff who meet, at a minimum, the SOI *Professional Qualifications Standards* set forth at 48 FR 44738 (September 29, 1983), for History, Archaeology, Architectural History, Architecture, or Historic Architecture (https://www.nps.gov/history/local-law/arch_stnds_9.htm) and the appropriate qualifications presented in *Professional Qualifications* (36 CFR Part 61, Appendix A).

    b) "*Standards*" — shall mean the Secretary of the Interior's (SOI) *Standards and Guidelines for Archaeology and Historic Preservation* [Federal Register 48(190) 1983:44716-44737] (https://www.nps.gov/history/local-law/arch_stnds_0.htm).

    c) *"Professional Standards"* — shall mean that all cultural resource investigations shall be performed by, or under the direct (in-field) supervision of appropriate professional(s) or by contractors, who are "*Qualified Staff*."

    d) "*Field and Reporting Standards*" — CEMVN shall ensure that all fieldwork and documentation resulting from Undertakings reviewed pursuant to this PA are consistent with all applicable Louisiana Division of Archaeology (LDOA) *Field Standards* (https://www.crt.state.la.us/cultural-development/archaeology/CRM/section-106/field-standards/index) and *Reporting Standards* (https://www.crt.state.la.us/cultural-development/archaeology/CRM/section-106/report-standards/index), and the Louisiana Division of Historic Preservation (LDHP) *Louisiana Historic Resource Inventory Guidelines* (https://www.crt.state.la.us/Assets/OCD/hp/standing-structures-survey/SurveyGuidelines.pdf), or the most current versions located on the Louisiana Office of Cultural Development website.

e) "*Policies and Guidelines*" — shall mean guidance from any of the following:

- The National Park Service publication The Archaeological Survey: Methods and Uses (National Park Service 1978);
- ACHP's *Treatment of Archeological Properties: A Handbook* (1980; https://www.achp.gov/sites/default/files/documents/2018-11/Treatment%20of%20Archeological%20Properties-A%20Handbook-OCR.pdf);
- *Identification of Historic Properties: A Decision-making Guide for Managers* (1988, joint ACHP-NPS publication);
- *Consulting About Archeology Under Section 106* (1990);
- ACHP's *Recommended Approach for Consultation on Recovery of Significant Information from Archeological Sites* (1999);
- ACHP's *Policy Statement Regarding the Treatment of Burial Sites, Human Remains and Funerary Objects* (2007; https://www.achp.gov/sites/default/files/2018-06/FactSheetPolicyRegardingTreatmentofBurialSitesHumanRemainsandFuneraryObjects.pdf);
- ACHP's *Section 106 Archaeology Guidance: A reference guide to assist federal agencies in making effective decisions about archaeological sites* (2009; https://www.achp.gov/sites/default/files/guidance/2017-02/ACHP%20ARCHAEOLOGY%20GUIDANCE.pdf);
- ACHP's *Section 106 Archaeology Guidance* (2009; https://www.achp.gov/sites/default/files/guidance/2017-02/ACHP%20ARCHAEOLOGY%20GUIDANCE.pdf);
- SOI's *Standards and Guidelines for Archaeology and Historic Preservation* (48 FR 44716-42, September 29, 1983); and
- *National Register Bulletin 38, Guidelines for Evaluating and Documenting Traditional Cultural Properties* (1998).

2. In developing Scopes of Work (SOW) for identification and evaluation studies, STM or MOA TM(s), or any other stewardship activities required under the terms of this PA, CEMVN, will comply with the requirements of the *Standards*, *Professional Standards*, *Field and Reporting Standards*, and the *Policies and Guidelines*, as in existence at the time they are performed.

B. Standardized Project Review

1. For Undertakings not exempt from further Section 106 review under Stipulation I.A., CEMVN will ensure that the standardized project review steps are implemented (Stipulations II.C-H).

C. Defining the Undertaking

1. Plans and specifications for individual Undertakings implemented under this PA will be submitted to the SHPO, Tribes, and interested Consulting Parties, at the 35% or greater level of completion along with a narrative description of the Undertaking. Updated plans and specifications and narrative descriptions will be provided only if the construction footprint or scope of project changes after development of the 35% level design. If there are no subsequent revisions to the construction footprint or scope of project, additional plans and specifications will be provided only upon written request.

D. Area of Potential Effects

1. For each Undertaking implemented under this PA, and in consultation with SHPO and participating Tribes, Qualified CEMVN staff will determine the APE in accordance with 36 CFR § 800.16(d). CEMVN may consider additional information provided by other parties, such as the NFS, local governments, and the public, when establishing the APE.

2. The APE will incorporate both direct effects (e.g., access, staging, and construction areas) and indirect effects (e.g., visual), including all areas to be impacted by construction activities.

3. At the feasibility level of design, the APE for each individual mitigation area is conceptual; CEMVN acknowledges that the APE(s) could change as further design is completed. In accordance with Stipulation II.B.1 of this PA, the PA includes a standardized review process for plans and specifications as they are developed, and therefore; changes to the APE may be warranted as the pre-construction design is further refined. If necessitated, CEMVN will re-initiate consultation to revise the APE in accordance with the PA and ensure that SHPO and Tribes are provided the opportunity to comment as defined under Stipulation II.D.1.

4. CEMVN will provide to SHPO and participating Tribes, a map displaying the APE for each Undertaking and provide any pertinent background information relevant to CEMVN's determination of the APE. SHPO and Tribes will provide comment and/or concurrence on the proposed APE within the timeframes outlined in Stipulation I.B.

E. Identification and Evaluation of Historic Properties

1. In consultation with SHPO and Tribes, as appropriate, CEMVN will complete the identification and evaluation of historic properties within the APE prior to the approval of an individual Undertaking in accordance with 36 C.F.R. § 800.4(a-c).

2. Cultural Resource Investigation and Evaluation:

    a) CEMVN will make a reasonable and good faith effort to identify historic properties [as defined at 36 CFR § 800.16(l)(1)] in accordance with 36 CFR § 800.4(b)(1).

CEMVN may consult with SHPO and Tribes to determine the level of effort, methodology necessary to identify and evaluate a variety of historic property types. For properties of religious and cultural significance to affected Tribes, CEMVN will consult with the affected Tribes to determine geographical areas containing them that may be affected by an Undertaking and determine the necessary level of effort to identify and evaluate or avoid any such historic properties.

b) CEMVN will take the appropriate measures necessary to identify historic properties within the APE including, but not limited to: buildings; structures; archeological sites (including shipwrecks and/or and properties of traditional religious and cultural importance to Tribes); prehistoric or historic districts; objects; cemeteries or other sites that may contain human remains, funerary objects, sacred objects, or objects of cultural patrimony; and Traditional Cultural Properties (TCP); including artifacts, records, and remains that are related to and located within such properties and that meet the National Register (NR) criteria.

c) When CEMVN identifies an Undertaking with the potential to affect a National Historic Landmark (NHL), CEMVN will contact the National Park Service (NPS) NHL Program Manager of the Southeast NPS Regional Office in addition to SHPO, participating Tribes, and other Consulting Parties. The purpose of this notification is to ensure early coordination for the Undertaking which CEMVN later may determine adversely affects the NHL.

d) All cultural resource surveys will be implemented on a schedule established to accommodate all field investigations and appropriate SHPO and Tribal review prior to the approval of an Undertaking. CEMVN will provide all documentation for these efforts to the SHPO, Tribes, or other Consulting Parties, as appropriate, consistent with the confidentiality provisions of Stipulation I.D of this PA.

3. Background Research:

a) CEMVN will ensure that background research is conducted as per the *Standards* and will entail a review of primary and secondary sources relevant to the environmental, geological, and cultural processes that have influenced the study area to gain an understanding of resource sensitivity, determine the kinds of resources that might be identified within the study area, develop research questions, guide fieldwork, and to facilitate the evaluation of resources using the NR Criteria. Research materials consulted may include, but are not limited to, information provided by Consulting Parties and the public, the NRHP database, the LDOA *Louisiana Cultural Resources Map* (LDOA Website), historic maps, pertinent regional and local cultural resources investigations, historic aerial photography, and other appropriate sources.

4. Identification and Evaluation of Archaeological Resources:

    a) CEMVN will ensure that previous fieldwork and background information is reviewed in conjunction with the APE to guide the level of field efforts necessary for each Undertaking and will attempt to re-identify all previously recorded archaeological sites and determine what, if any, additional fieldwork is necessary.

    b) In consultation with SHPO and Tribes, survey methods may appropriately exclude land shown to be recently disturbed to an extent that it is unlikely that cultural resources would possess integrity sufficient to be considered eligible for listing on the NRHP. Documentation for excluding such land will be provided in the cultural resource survey report.

    c) If the Phase I level of effort does not provide adequate information to provide eligibility recommendations for any archaeological sites identified within the APE, CEMVN will conduct Phase II Investigation sufficient to provide conclusive eligibility recommendations and meet the *Standards*. The intent of Phase II Investigation is to determine the eligibility of a site for listing on the NRHP utilizing the least amount of ground disturbance to obtain the necessary information.

    d) CEMVN will ensure that a LDOA Archaeological Site Form is completed for any newly identified archaeological site. Forms for previously recorded sites will be updated as is necessary.

    e) CEMVN will ensure that any new and updated LDOA Sites Form for a given project are accepted as final prior to any draft report submittal.

5. Identification and Evaluation of Built Environment Resources:

    a) CEMVN will ensure that an inventory of all above-ground structures or properties within the APE over forty-five (45)-years of age, along with any structures that may possess exceptional significance, is completed that includes a brief architectural description, at least two (2) photos (including primary elevation), and provides the details necessary to determine a site's limits/boundaries, function, and/or integrity. A forty-five (45)-year threshold anticipates that the Undertaking commences no more than five (5)-years after an inventory's completion. Site-specific research will be limited to what is necessary for CEMVN to conduct a professional NR eligibility evaluation.

    b) CEMVN will ensure that all elements of the built environment that are surveyed will be evaluated according to guidelines set forth in 36 CFR § 800.4(c)(1), as well as additional guidance provided in National Register Bulletin 15: *How to Apply the National Register Criteria for Evaluation*.

c) All submissions will utilize the LDHP's *Louisiana Historic Resource Inventory* (LHRI) system.

d) CEMVN will ensure that all LHRI forms for a given project are accepted as final prior to any draft report submittal.

6. All fieldwork and reporting will meet the *Field and Reporting Standards* as defined in Stipulation II.A.1(d).

F. Determinations of Eligibility and Effect

1. CEMVN will review any NRHP eligibility recommendation based on identification and evaluation efforts and make its own finding of effect resulting from the performance of these activities prior to submitting such determinations to the SHPO, Tribes, and other Consulting Parties.

2. CEMVN will determine NRHP eligibility, and consult with SHPO, participating Tribes, and other Consulting Parties regarding these determinations. Should SHPO, participating Tribes, or another Consulting Party disagree with the determination of eligibility, CEMVN will either:

(1) Elect to consult further with the objecting party until the objection is resolved;

(2) Treat the property as eligible for the NRHP; or

(3) Obtain a determination of eligibility from the Keeper of the NR in accordance with 36 CFR § 63.2(d-e) and 36 CFR § 800.4(c)(2).

3. Findings of No Historic Properties Affected:

a) CEMVN will make a finding of "No Historic Properties Affected" under the following circumstances:

(1) If no historic properties are present in the APE; or

(2) The Undertaking is designed to avoid effects to historic properties, including NRHP-listed or eligible properties of religious or cultural significance to participating Tribes; or

(3) The Undertaking does not affect the character defining features of a historic property.

b) CEMVN will notify SHPO and participating Tribes(s) and provide supporting documentation in accordance with 36 CFR § 800.11(d) and applicable *Standards*. Unless SHPO or a participating Tribes objects to the finding within the applicable timeframes outlined in Stipulation I.B, the Section 106 review of the Undertaking will have concluded.

c) If SHPO or participating Tribes, objects to a finding of "No Historic Properties Affected," CEMVN will consult with the objecting party to resolve the disagreement:

(1) If the objection is resolved, CEMVN either may proceed with the Undertaking in accordance with the resolution or reconsider effects on the historic property by applying the criteria of adverse effect pursuant to Stipulation II.F.4.

(2) If CEMVN is unable to resolve the disagreement, it will forward the finding and supporting documentation to the ACHP and request that the ACHP review CEMVN's finding in accordance with 36 CFR § 800.4(d)(1)(iv)(A) through 36 CFR § 800.4(d)(1)(iv)(C). CEMVN will consider ACHP's recommendation in making its final determination. If CEMVN's final determination is to reaffirm its "no historic properties affected" finding, the Section 106 review of the Undertaking will have concluded. Otherwise, CEMVN will proceed to Stipulation II.G.

4. Application of the Criteria of Adverse Effect:

a) If CEMVN finds an Undertaking may affect historic properties in the APE, including those of religious or cultural significance to affected Tribes, CEMVN will apply the criteria of adverse effect to historic properties within the APE including cumulative effects taking into account the views of the Consulting Parties and the public concerning effects in accordance with 36 CFR § 800.5(a).

b) If CEMVN determines that an Undertaking does not meet the adverse effect criteria, CEMVN will propose a finding of "No Adverse Effect" in accordance with 36 CFR § 800.5(b):

(1) CEMVN will notify SHPO and participating Tribes, and all other Consulting Parties of its finding; describe any project specific conditions and future submissions; and provide supporting documentation pursuant to 36 CFR §800.11(e).

(2) Unless a Consulting Party objects within the applicable timeframe outlined in Stipulation I.B CEMVN will proceed with its "No Adverse Effect" determination and conclude the Section 106 review.

(3) If a Consulting Party objects to a finding of "No Adverse Effect," CEMVN will consult with the objecting party to resolve the disagreement.

(4) If the objection is resolved, CEMVN will proceed with the Undertaking in accordance with the resolution; or

(5) If the objection cannot be resolved, CEMVN will request that ACHP review the findings in accordance with 36 CFR § 800.5(c)(3)(i)-(ii) and submit the required supporting documentation. CEMVN will consider ACHP's comments in making its final determination.

c) If CEMVN finds the Undertaking may adversely affect historic properties, CEMVN will seek ways to revise the scope of the project to substantially conform to the *Standards*, and/or avoid or minimize adverse effects for NRHP-listed or eligible historic properties and/or properties of religious or cultural significance to Tribes, or TCP(s) as is outlined in Appendix C; STM I.A: *Design Review*.

d) If CEMVN determines in consultation with SHPO and Tribes(s), as appropriate, that an Undertaking has a low potential to effect archaeological resources, CEMVN may determine "No Adverse Effect," and may require archaeological monitoring of construction activities. In these instances, an archaeological monitoring plan will be developed in consultation with SHPO and participating Tribes prior to construction.

e) If an Undertaking is not modified to avoid the adverse effect(s), CEMVN will initiate consultation to resolve the adverse effect(s) in accordance with Stipulation II.G.

G. Resolution of Adverse Effects

1. If CEMVN determines that an Undertaking may adversely affect a historic property, it will resolve the effects of the Undertaking in consultation with SHPO, NFS, participating Tribes, ACHP (if participating), and other Consulting Parties, by one (1) of the following methods depending upon the severity of the adverse effect(s), as well as determination of the historic property's significance on a local, state, or national level. When CEMVN determines an Undertaking will adversely affect an NHL, CEMVN will notify and invite the Secretary and ACHP to participate in consultation in accordance with 36 CFR § 800.10. When ACHP participates in consultation related to an NHL, ACHP will report the outcome of the consultation to the Secretary and the CEMVN Administrator.

2. Abbreviated Consultation Process

a) After taking into consideration the significance of the historic properties affected, the severity of the adverse effect(s), and avoidance or minimization of the adverse effect(s), CEMVN may propose in writing to the Consulting Parties to resolve the adverse effects of the Undertaking through the application of one or more STM(s) outlined in Appendix C as negotiated with SHPO, participating Tribes, and other Consulting Parties. The use of these STM(s) may not require the execution of a project-specific MOA.

b) In consultation with SHPO, participating Tribes, and other Consulting Parties, CEMVN will propose in writing the implementation of a specific STM, or combination of STMs, with the intent of expediting the resolution of adverse effects, and provide documentation as required by 36 CFR § 800.11(e) subject to the confidentiality provisions of 36 CFR § 800.11(c)). Unless a Consulting Party or ACHP objects to CEMVN's proposal within the timeframe outlined in Stipulation I.B, CEMVN will proceed with the implementation of the STM(s) and will conclude the Section 106 review.

c) If any of the Consulting Parties or ACHP objects within the timeframe outlined in Stipulation I.B to the resolution of adverse effects through the application of the Abbreviated Consultation Process, CEMVN will resolve the adverse effect(s) using procedures outlined below in Stipulation II.G.3.

d) Because funding and implementation details of STMs for specific Undertakings may vary by program, CEMVN will provide written notice to the Consulting Parties within sixty (60)-days of the completion of the STM(s). This written notice will serve as confirmation that the STM(s) for a specific Undertaking have been implemented. CEMVN also will include information pertaining to the progress and completion of STMs in the annual report pursuant to Stipulation IV.E.

3. Project-Specific Memorandum of Agreement

a) CEMVN will provide ACHP with an adverse effect notice in accordance with 36 CFR § 800.6(a)(1) if it has not already provided such under the Abbreviated Consultation Process of this Agreement. If a Consulting Party or ACHP objects in accordance with Stipulation IV.B, or if CEMVN in consultation with SHPO, participating Tribes, and other Consulting Parties has determined that a project-specific MOA would be more appropriate to resolve the adverse effects. In consultation with SHPO, participating Tribes, and other Consulting Parties, including ACHP (if participating), CEMVN will develop a project-specific MOA, in accordance with 36 CFR § 800.6(c) to agree upon a TM to avoid, minimize, and/or mitigate adverse effects on historic properties.

4. Objections

a) Should any Consulting Party object within the timeframes established by this PA to any plans, specifications, or actions taken pursuant to resolving an adverse effect, CEMVN will consult further with the objecting party to seek resolution in accordance with Stipulation IV.B.

H. Reports

1. CEMVN will ensure that all reports and other documents resulting from the actions pursuant to this PA will be provided in a format acceptable to SHPO and Tribes, as appropriate. CEMVN will ensure that all such reports (e.g., identification surveys, evaluation reports, treatment plans, and data recovery reports) meet or exceed the Department of the Interior's *Format Standards for Final Reports of Data Recovery* (42 FR 5377-79) and the *Field and Report Standards* identified in Stipulation II.A.1(d).

2. CEMVN will provide all documentation for these efforts to SHPO, Tribes, or other Consulting Parties, as appropriate, consistent with the confidentiality provisions of Stipulation I.D. of this PA.

3. Once supporting documentation is received, SHPO and Tribes will have thirty (30)-days to review supporting documentation (e.g., site forms and reports). If SHPO or Tribes intend to review and comment on documentation, and are unable to do so within the thirty (30)-day review period, a request for additional review time must be made in writing to CEMVN and specify the anticipated completion date. CEMVN will consider the request and work with the requesting party to come to a mutually agreeable timeframe. CEMVN will notify other Consulting Parties of the extinction by e-mail.

III. OTHER CONSIDERATIONS

A. Changes to an Approved Scope of Work

1. If CEMVN determines the change has no potential to affect the property or the previous effect determination is still applicable, CEMVN will approve the change.

2. If CEMVN determines that the change can be modified to conform to any applicable *Standards*, or a previously determined finding of effect is still applicable, CEMVN will conclude its Section 106 review responsibilities.

3. If CEMVN determines that the change may cause additional effects to the property; does not conform to any applicable *Standards*; or changes a previously determined finding of effect, CEMVN will initiate consultation pursuant to Stipulation II.B.1.

B. Provisions for Post-Review Discoveries

1. If previously unreported properties that may be eligible for nomination to the NR or of significance to Tribes, and/or, unanticipated effects on historic properties are found during

the construction phase, CEMVN will implement the provisions outlined below that are intended to ensure that the Undertaking is in compliance with all applicable federal and state laws and regulations, including Section 106 of the NHPA:

2. If there is no reasonable expectation that the property contains human remains, funerary objects, sacred objects, or objects of cultural patrimony, all work within a fifty (50) meter (164 ft) radius buffer zone must stop immediately. CEMVN will notify SHPO and Tribes, as appropriate, as well as any other affected party, of the discovery, and implement interim measures to protect the discovery from theft and vandalism. Construction may continue outside the fifty (50) meter (164 ft) radius buffer zone. Within seventy-two (72) hours of receipt of notification of the discovery, CEMVN, as appropriate, will:

    a) Inspect the work site to determine the extent of the discovery and ensure that work activities have halted within the fifty (50) meter (164 ft) radius buffer zone;

    b) Clearly mark the area of the discovery;

    c) Implement additional measures, as appropriate, to protect the discovery from theft and vandalism; and

    d) Provide an initial assessment of the site's condition and eligibility to SHPO and Tribes; and

    e) Notify other Consulting Parties, if applicable, of the discovery.

3. If CEMVN, in consultation with SHPO, Tribes, and other Consulting Parties, as appropriate, determines the site is either isolated, does not retain integrity sufficient for listing on the NRHP, or will not be further disturbed by construction activities, construction may resume within the fifty (50) meter (164 ft) radius buffer zone.

4. If CEMVN determines that the cultural resource site or artifact either is, or may be, eligible for inclusion on the NRHP, CEMVN will consult with the SHPO, Tribes, and other Consulting Parties, as appropriate, regarding appropriate measures for site treatment pursuant to 36 C.F.R. § 800.6(a). SHPO and Tribes will have seven (7)-days to provide their objections or concurrence on the proposed actions. These measures may include:

    a) Formal archaeological evaluation of the site;

    b) Visits to the site by SHPO and/or Tribes;

    c) Exploration of potential alternatives to avoid the site;

    d) Preparation and implementation of a mitigation plan by CEMVN in consultation and concurrence with the SHPO, Tribes, and other Consulting Parties, as appropriate.

5. The notified Consulting Parties will have seven (7)-days following notification to provide comment regarding CEMVN's determination of the NRHP eligibility of the discovery.

6. A report of findings describing the background history leading to and immediately following the reporting and resolution of an inadvertent discovery will be prepared within thirty (30)-days of the resolution of each inadvertent discovery.

7. CEMVN will communicate the procedures to be observed with its contractors and personnel.

C. Treatment of Human Remains, Funerary Objects, Sacred Objects, and Objects of Cultural Patrimony

1. In the event that previously unreported and unanticipated human remains, burials, funerary objects, sacred objects, or objects of cultural patrimony are encountered during field investigations, laboratory work, or during construction or maintenance activities, CEMVN will comply with the provisions outlined below:

2. Any USACE employee, contractor, or subcontractor who knows or has reason to know that they have inadvertently discovered human remains, burials, funerary objects, sacred objects, or objects of cultural patrimony on Federal lands or human remains or funerary objects on state or private lands must provide immediate telephone notification of the inadvertent discovery, with written confirmation, to CEMVN Cultural Resources Section (CRS).

3. All work must stop immediately within a one hundred (100) meter (328 ft) radius buffer zone around the point of discovery; unless there is reason to believe that the area of the discovery may extend beyond the one hundred (100) meter (328 ft) radius buffer zone in which case the buffer zone will be expanded appropriately. CEMVN will implement measures to protect the discovery from theft and vandalism. Any human remains or other items in the immediate vicinity of the discovery must not be removed or otherwise disturbed. CEMVN will take immediate steps, if necessary, to further secure and protect inadvertently discovered human remains, burials, funerary objects, sacred objects, or objects of cultural patrimony, as appropriate, including stabilization, or covering the find location.

4. If abandoned cemeteries, unmarked graves, or human remains are discovered during the implementation of a CEMVN-funded undertaking on privately-owned lands or lands owned by a state or local governmental entity CEMVN will comply with the Louisiana Unmarked Human Burial Sites Preservation Act (La. R.S. 8:671 et seq.) and, if applicable, the Louisiana Cemetery Law (La. R.S. 8). CEMVN will notify local law enforcement and the Louisiana Division of Archaeology (LDOA), within the Louisiana Department of Culture,

Recreation and Tourism, Office of Cultural Development, by telephone to assess the nature and age of the human skeletal remains within twenty-four (24) hours of the discovery of unmarked human remains and accompany local law enforcement personnel during all field investigations. If the appropriate local law enforcement official determines that the remains are not involved in a legal investigation, LDOA has jurisdiction over the remains. In cases where the human remains are determined to be Native American, the LDOA will notify and coordinate with Tribes as required by state law. CEMVN will assist LDOA, as requested, to consult with Tribes and affected parties, as appropriate.

5. If human remains, burials, funerary objects, sacred objects, or objects of cultural patrimony are discovered during the implementation of a CEMVN-funded undertaking on Federal or Tribal land, CEMVN will notify by telephone and e-mail, SHPO, Tribes, and other affected parties (e.g., living descendants) that may that might attach religious and cultural significance to the discovery at the earliest possible time, but no later than forty-eight (48) hours and inform them of the steps already taken to address the discovery. CEMVN will consult with SHPO, Tribes, and other affected parties to develop a mutually agreeable action plan with timeframes to take into account the effects of the Undertaking on the discovery; resolve adverse effects if necessary; and ensure compliance with applicable federal and state laws and their implementing regulations.

6. In the case of the discovery of Native American human remains, funerary objects, sacred objects, or objects of cultural patrimony on Federal or Tribal land, and local law enforcement determines that the remains are not involved in a legal investigation, CEMVN will follow the procedures outlined by the Native American Graves Protection and Repatriation Act of 1990 (NAGPRA), as amended (25 U.S.C. § 3001 et seq.), and its implementing regulations (43 C.F.R. Part 10); Archeological Resources Protection Act of 1979 (ARPA) (16 U.S.C. § 470aa-mm); and Section 106 of the NHPA. In addition, CEMVN will follow the guidelines outlined in the ACHP's *Policy Statement Regarding the Treatment of Burial Sites, Human Remains, and Funerary Objects* (2007). This step is not intended to substitute the requirements of 43 C.F.R. 10.4(d)(iii).

7. CEMVN, when on Federal or Tribal lands, in consultation with SHPO and Tribes, whether they are Signatories to this PA or not, and other affected parties, may consult with a qualified physical anthropologist, forensic scientist, or other experts as may be needed to examine and assess the discovery. Unless the remains were inadvertently removed, the evaluation will be conducted at the site of discovery. Other than for crime scene investigation, no excavation, examination, photographs, or analysis of Native American human remains or remains suspected of being Native American will be conducted or allowed by CEMVN archaeologists or any other professional without first consulting with the appropriate Tribes, whether they are Signatories to this PA or not. The consulting expert will be allowed to draw and measure the exposed remains and associated funerary objects. Drawings cannot be published in any form or shown as part of scholarly presentations without the written permission of the appropriate Tribes or next living descendant.

8. CEMVN, when on Federal lands, in consultation with SHPO, Tribes, and other affected parties, as appropriate, whether they are Signatories to this PA or not, will have seven (7)-days to determine if the skeletal remains are human, the degree to which they were disturbed, and if possible, using reasonable measures to assess their potential age, cultural affiliation, and identity, without any further disturbance. Upon making a determination or at the end of the seven (7)-days, whichever comes first, CEMVN will notify the appropriate affected parties of its findings. This notification will include pertinent information as to kinds of human remains, funerary objects, sacred objects, or items of cultural patrimony discovered, their condition, and the circumstances of their inadvertent discovery. SHPO, Tribes, and other affected parties, whether they are Signatories to this PA or not, will have seventy-two (72) hours to respond to CEMVN's notification verbally followed by written response via U.S. mail and/or e-mail specifying the intent of the affected party to conduct or decline further consultation.

9. For discoveries of human remains, burials, funerary objects, sacred objects, or objects of cultural patrimony on Federal or Tribal lands, CEMVN will continue to consult with SHPO, Tribes, and other affected parties, as appropriate, whether they are Signatories to this PA or not, regarding additional measures to avoid and protect or mitigate the adverse effect of the Undertaking. These measures may include:

    a) Visits to the site by the SHPO, Tribes, and other affected parties, as appropriate;

    b) Formally evaluate the archaeological site for NRHP-eligibility;

    c) Explore potential avoidance alternatives;

    d) Develop and implement a mitigation plan in consultation and concurrence with the SHPO, Tribes, and other affected parties, as appropriate, including procedures for disinterment and re-interment.

10. CEMVN will coordinate with any contractor(s) and/or sub-contractor(s) regarding any required scope of project modification necessary to implement recommendations from the consultation and facilitate proceeding with the Undertaking.

D. Curation

1. Recovered archaeological collections from a CEMVN-funded archaeological survey, evaluation, and mitigation remain the property of the land owner of the subject property at the time of excavation. Any records generated are the property of the Federal government. CEMVN, in coordination with Consulting Parties and the appropriate NFS, will encourage land owners to donate any recovered collections to an appropriate long-term curation facility or Tribal entity. CEMVN, in coordination with the NFS, SHPO, and

affected Tribes, as appropriate, will work with all land owners to support steps that ensure the long-term curation of these artifacts through the transfer of the materials to a suitable repository as agreed to by CEMVN, SHPO, and affected Tribes(s), pursuant to 36 CFR § 79. The disposition of human remains and associated burial items will comply with the Louisiana Unmarked Burial Sites Preservation Act (R.S. 8:681) if on private or state lands.

IV. IMPLEMENTATION OF AGREEMENT

A. Amendments

1. If any Signatory or Invited Signatory who signs this PA determines that an amendment to the terms of this PA must be made, the Signatory or Invited Signatory will consult to seek amendment in the following manner:

    a) The Signatory or Invited Signatory will submit a written request for amendment to CEMVN containing the proposed amendment.

    b) Upon receipt of a request to amend this PA, CEMVN will immediately notify the Signatories and Invited Signatories who have signed this PA and initiate a (30)-day period to consult on the proposed amendment, whereupon the Signatories and Invited Signatories will consult to consider such amendments.

    c) If agreement to the amendment cannot be reached within the (30)-day period, resolution of the issue may proceed by following the dispute resolution process in Stipulation IV.B.

    d) An amendment to this PA, exclusive of the appendices, will be effective only when it has been signed by all the Signatories and Invited Signatories. An amendment will be effective for Undertakings occurring on or affecting historic properties on Tribal lands only when the affected Tribe has signed the amended PA as an Invited Signatory. The terms of this Agreement will not apply to Undertakings on or affecting Tribal lands without prior execution of the Amended PA by the affected Tribes.

    e) Amendments to this PA will take effect on the date that they are fully executed by all Signatories and Invited Signatories.

    f) Modifications, additions, or deletions to the appendices made as a result of continuing consultation among the Consulting Parties do not require the PA to be amended.

2. Modifications, additions, or deletions to the appendices may be amended at the request

of CEMVN or another Signatory or Invited Signatory who has signed this PA in the following manner:

a) CEMVN, on its own behalf, or on the behalf of another Signatory or Invited Signatory, will notify all Signatories and Invited Signatories to this PA of the intent to add to or modify the current Appendix or Appendices and will provide a draft of the updated Appendix or Appendices to all Signatories and Invited Signatories.

b) If no Signatory or Invited Signatory objects in writing within (30)-days of receipt of CEMVN's proposed addition or modification, CEMVN will date and sign the amended Appendix and provide a copy of the amended Appendix to all Signatories and Invited Signatories. Such an amendment will go into effect on the date CEMVN transmits the amendment to the other Signatories and Invited Signatories or an alternative date provided by the terms of the amendment.

B. Dispute Resolution

1. Should any party to this PA object in writing to the terms of this PA or to any actions proposed or the manner in which the terms of this PA are implemented, CEMVN will consult with such party to resolve the objection for not more than thirty (30)-days.

2. If the objection is resolved within thirty (30)-days, CEMVN will proceed in accordance with the resolution.

3. If CEMVN determines that such objection cannot be resolved, CEMVN will forward to ACHP all documentation relevant to the objection, including CEMVN's proposed resolution.

4. Within thirty (30)-days of receipt, ACHP will:

    a) Concur with CEMVN's proposed resolution; or

    b) Provide CEMVN with recommendations, which CEMVN will take into account in reaching a final decision regarding the objection; or

    c) Notify CEMVN that the objection will be referred for comment in accordance with 36 CFR § 800.7(a)(4), and proceed to do so.

5. Prior to reaching a final decision on the dispute, CEMVN will prepare a written response that takes into account any timely advice or comments regarding the dispute from the ACHP, Signatories, Invited Signatories, and Concurring Parties, and provide them with a copy of this written response. CEMVN will then proceed according to its final decision. The Signatories will continue to implement all other terms of this PA that are not subject

to objection.

6. If the ACHP does not provide its advice regarding the dispute within the thirty (30)-day time period, CEMVN may make a final decision on the dispute and proceed with its proposed resolution to the objection after providing ACHP, Signatories, Invited Signatories, and Concurring Parties, with a written summary of its final decision.

C. Severability and Termination

1. In the event any provision of this PA is deemed by a Federal court to be contrary to, or in violation of, any applicable existing law or regulation of the United States of America, only the conflicting provision(s) will be deemed null and void, and the remaining provisions of the PA will remain in effect.

2. Any Signatory or Invited Signatory who signs this PA may terminate this PA by providing thirty (30)-days' written notice to the other Consulting Parties, provided that the Consulting Parties consult during this period to seek amendments or other actions that would prevent termination. If this PA is terminated, CEMVN will comply with Section 106 through other applicable means pursuant to 36 CFR Part 800. Upon such determination, CEMVN will provide ACHP, Signatories, Invited Signatories, and Concurring Parties written notice of the termination of this PA.

3. Any Invited Signatory or Concurring Party may notify the other Consulting Parties that it is fully withdrawing from participation in the PA. Following such a withdrawal, CEMVN will review the activities within the Undertaking that may affect historic properties of religious and cultural significance to any Tribe in accordance with 36 CFR § 800. Withdrawal from this PA by a Concurring Party does not terminate the PA. A Concurring Party that has withdrawn from the PA may at any time notify ACHP, Signatories, Invited Signatories, and Concurring Parties in writing, that it has rescinded its notice to withdraw from participation in the PA.

4. This PA may be terminated by the implementation of a subsequent Agreement that explicitly terminates or supersedes this PA, or by CEMVN's implementation of Alternate Procedures, pursuant to 36 CFR § 800.14(a).

D. Duration and Extension

1. The PA will remain in effect from the date of final signature for a period not to exceed ten (10)-years unless otherwise extended pursuant to Stipulation V.D.2 (below), or terminated pursuant to Stipulation V.C(2) or V.C(4).

2. The Signatories may collectively agree in writing to execute this PA to cover additional calendar years, or portions thereof, provided that the original PA has not expired or if the

PA has expired while a new Agreement is in preparation.

E. Monitoring and Reporting

1. Each year following the execution of this PA, until it expires or is terminated, CEMVN will provide the other Signatories, Invited Signatories, Concurring Parties, and the ACHP with an annual report detailing work carried out pursuant to its terms. This annual report will summarize the actions taken to implement the terms of this PA (e.g., statistics on resolution of adverse effects, use of other agency's determinations, the progress and completion of all STM/MOA TM), include any scheduling changes proposed, any disputes and objections received, and will recommend any actions or revisions to be considered; including updates to the Appendices.

2. Any Signatory, Invited, Signatory, or Concurring Party, including CEMVN, may request a meeting to review the annual report or discuss issues and concerns in greater detail regarding implementation of the PA within the thirty (30)-days' following receipt of the annual report. This review will occur in person or by telephone as determined by CEMVN.

V. EXECUTION OF AGREEMENT

1. This PA may be executed in counterparts, with a separate page for each Signatory, Invited Signatory, and Concurring Party and will become effective on the date of the final signature of the Signatories.

2. The PA will go into effect regarding Undertakings occurring, or affecting historic properties, on Tribal lands when the subject Tribe has signed the PA as an Invited Signatory.

3. CEMVN will ensure that each Signatory, Invited Signatory, and Concurring Party is provided with an electronic (.pdf) copy of the PA including signatures. CEMVN will provide electronic copies of additional executed signature pages to the Signatories, Invited Signatories, and Concurring Parties as they are received. CEMVN will provide a complete copy of the PA with original signatures to any Consulting Party on request.

4. EXECUTION of this PA and implementation of its terms is evidence that CEMVN has taken into account the effects of these Undertakings on historic properties and afforded the ACHP an opportunity to comment on CEMVN's administration of the referenced Programs, and that CEMVN has satisfied its Section 106 responsibilities for all individual Undertakings of its referenced Programs.

Signatory Page

PROGRAMMATIC AGREEMENT AMONG THE U.S. ARMY CORPS OF ENGINEERS, NEW ORLEANS DISTRICT; AMITE RIVER BASIN COMMISSION; EAST BATON ROUGE PARISH; LOUISIANA COASTAL PROTECTION AND RESTORATION AUTHORITY; LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT; PONTCHARTRAIN LEVEE DISTRICT; LOUISIANA STATE HISTORIC PRESERVATION OFFICER OF THE DEPARTMENT OF CULTURE, RECREATION & TOURISM; AND CHOCTAW NATION OF OKLAHOMA; REGARDING THE BIPARTISAN BUDGET ACT OF 2018 COMPENSATORY HABITAT MITIGATION PROGRAM FOR THE COMITE RIVER DIVERSION, EAST BATON ROUGE PARISH WATERSHED FLOOD RISK MANAGEMENT, AND WEST SHORE LAKE PONTCHARTRAIN HURRICANE AND STORM DAMAGE RISK REDUCTION PROJECTS IN LOUISIANA

United States Army CEMVN of Engineers

By: ______________________ Date: 2/19/20

Stephen Murphy
Colonel, U.S. Army
District Engineer

Signatory Page

**PROGRAMMATIC AGREEMENT AMONG
THE U.S. ARMY CORPS OF ENGINEERS, NEW ORLEANS DISTRICT; AMITE RIVER BASIN COMMISSION; EAST BATON ROUGE PARISH; LOUISIANA COASTAL PROTECTION AND RESTORATION AUTHORITY; LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT; PONTCHARTRAIN LEVEE DISTRICT; LOUISIANA STATE HISTORIC PRESERVATION OFFICER OF THE DEPARTMENT OF CULTURE, RECREATION & TOURISM; AND CHOCTAW NATION OF OKLAHOMA; REGARDING THE BIPARTISAN BUDGET ACT OF 2018 COMPENSATORY HABITAT MITIGATION PROGRAM FOR THE COMITE RIVER DIVERSION, EAST BATON ROUGE PARISH WATERSHED FLOOD RISK MANAGEMENT, AND WEST SHORE LAKE PONTCHARTRAIN HURRICANE AND STORM DAMAGE RISK REDUCTION PROJECTS IN LOUISIANA**

Louisiana State Historic Preservation Officer

By: Kristin P. Sanders   Date: 3/4/2020

Kristin P. Sanders
Louisiana State Historic Preservation Officer

Invited Signatory Page

**PROGRAMMATIC AGREEMENT AMONG
THE U.S. ARMY CORPS OF ENGINEERS, NEW ORLEANS DISTRICT; AMITE RIVER BASIN COMMISSION; EAST BATON ROUGE PARISH; LOUISIANA COASTAL PROTECTION AND RESTORATION AUTHORITY; LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT; PONTCHARTRAIN LEVEE DISTRICT; LOUISIANA STATE HISTORIC PRESERVATION OFFICER OF THE DEPARTMENT OF CULTURE, RECREATION & TOURISM; AND CHOCTAW NATION OF OKLAHOMA; REGARDING THE BIPARTISAN BUDGET ACT OF 2018 COMPENSATORY HABITAT MITIGATION PROGRAM FOR THE COMITE RIVER DIVERSION, EAST BATON ROUGE PARISH WATERSHED FLOOD RISK MANAGEMENT, AND WEST SHORE LAKE PONTCHARTRAIN HURRICANE AND STORM DAMAGE RISK REDUCTION PROJECTS IN LOUISIANA**

Amite River Basin Commission

By: [signature] Date: 3/10/2020

Dietmar Rietschier
Executive Director
Amite River Basin Commission

Invited Signatory Page

PROGRAMMATIC AGREEMENT AMONG THE U.S. ARMY CORPS OF ENGINEERS, NEW ORLEANS DISTRICT; AMITE RIVER BASIN COMMISSION; EAST BATON ROUGE PARISH; LOUISIANA COASTAL PROTECTION AND RESTORATION AUTHORITY; LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT; PONTCHARTRAIN LEVEE DISTRICT; LOUISIANA STATE HISTORIC PRESERVATION OFFICER OF THE DEPARTMENT OF CULTURE, RECREATION & TOURISM; AND CHOCTAW NATION OF OKLAHOMA; REGARDING THE BIPARTISAN BUDGET ACT OF 2018 COMPENSATORY HABITAT MITIGATION PROGRAM FOR THE COMITE RIVER DIVERSION, EAST BATON ROUGE PARISH WATERSHED FLOOD RISK MANAGEMENT, AND WEST SHORE LAKE PONTCHARTRAIN HURRICANE AND STORM DAMAGE RISK REDUCTION PROJECTS IN LOUISIANA

East Baton Rouge Parish

By: ______________________ Date: 3/23/2020

Sharon Weston Broome
Mayor
City of Baton Rouge

APPROVED AS TO FORM

PARISH ATTORNEY'S OFFICE

Invited Signatory Page

PROGRAMMATIC AGREEMENT AMONG THE U.S. ARMY CORPS OF ENGINEERS, NEW ORLEANS DISTRICT; AMITE RIVER BASIN COMMISSION; EAST BATON ROUGE PARISH; LOUISIANA COASTAL PROTECTION AND RESTORATION AUTHORITY; LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT; PONTCHARTRAIN LEVEE DISTRICT; LOUISIANA STATE HISTORIC PRESERVATION OFFICER OF THE DEPARTMENT OF CULTURE, RECREATION & TOURISM; AND CHOCTAW NATION OF OKLAHOMA; REGARDING THE BIPARTISAN BUDGET ACT OF 2018 COMPENSATORY HABITAT MITIGATION PROGRAM FOR THE COMITE RIVER DIVERSION, EAST BATON ROUGE PARISH WATERSHED FLOOD RISK MANAGEMENT, AND WEST SHORE LAKE PONTCHARTRAIN HURRICANE AND STORM DAMAGE RISK REDUCTION PROJECTS IN LOUISIANA

Louisiana Office of Coastal Protection and Restoration Authority

By: ______________________ Date: 3/25/2020

Bren Haase
Executive Director
Louisiana Office of Coastal Protection and Restoration Authority

Invited Signatory Page

PROGRAMMATIC AGREEMENT AMONG THE U.S. ARMY CORPS OF ENGINEERS, NEW ORLEANS DISTRICT; AMITE RIVER BASIN COMMISSION; EAST BATON ROUGE PARISH; LOUISIANA COASTAL PROTECTION AND RESTORATION AUTHORITY; LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT; PONTCHARTRAIN LEVEE DISTRICT; LOUISIANA STATE HISTORIC PRESERVATION OFFICER OF THE DEPARTMENT OF CULTURE, RECREATION & TOURISM; AND CHOCTAW NATION OF OKLAHOMA; REGARDING THE BIPARTISAN BUDGET ACT OF 2018 COMPENSATORY HABITAT MITIGATION PROGRAM FOR THE COMITE RIVER DIVERSION, EAST BATON ROUGE PARISH WATERSHED FLOOD RISK MANAGEMENT, AND WEST SHORE LAKE PONTCHARTRAIN HURRICANE AND STORM DAMAGE RISK REDUCTION PROJECTS IN LOUISIANA

Louisiana Department of Transportation and Development

By:________________________________ Date: _____________

Dr. Shawn D. Wilson
Secretary
Louisiana Department of Transportation and Development

Invited Signatory Page

**PROGRAMMATIC AGREEMENT AMONG
THE U.S. ARMY CORPS OF ENGINEERS, NEW ORLEANS DISTRICT; AMITE RIVER BASIN COMMISSION; EAST BATON ROUGE PARISH; LOUISIANA COASTAL PROTECTION AND RESTORATION AUTHORITY; LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT; PONTCHARTRAIN LEVEE DISTRICT; LOUISIANA STATE HISTORIC PRESERVATION OFFICER OF THE DEPARTMENT OF CULTURE, RECREATION & TOURISM; AND CHOCTAW NATION OF OKLAHOMA; REGARDING THE BIPARTISAN BUDGET ACT OF 2018 COMPENSATORY HABITAT MITIGATION PROGRAM FOR THE COMITE RIVER DIVERSION, EAST BATON ROUGE PARISH WATERSHED FLOOD RISK MANAGEMENT, AND WEST SHORE LAKE PONTCHARTRAIN HURRICANE AND STORM DAMAGE RISK REDUCTION PROJECTS IN LOUISIANA**

Pontchartrain Levee District

By:________________________________ Date: _____________
Ricky Bosco
Board President
Pontchartrain Levee District

Concurring Party Signatory Page

PROGRAMMATIC AGREEMENT AMONG THE U.S. ARMY CORPS OF ENGINEERS, NEW ORLEANS DISTRICT; AMITE RIVER BASIN COMMISSION; EAST BATON ROUGE PARISH; LOUISIANA COASTAL PROTECTION AND RESTORATION AUTHORITY; LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT; PONTCHARTRAIN LEVEE DISTRICT; LOUISIANA STATE HISTORIC PRESERVATION OFFICER OF THE DEPARTMENT OF CULTURE, RECREATION & TOURISM; AND CHOCTAW NATION OF OKLAHOMA; REGARDING THE BIPARTISAN BUDGET ACT OF 2018 COMPENSATORY HABITAT MITIGATION PROGRAM FOR THE COMITE RIVER DIVERSION, EAST BATON ROUGE PARISH WATERSHED FLOOD RISK MANAGEMENT, AND WEST SHORE LAKE PONTCHARTRAIN HURRICANE AND STORM DAMAGE RISK REDUCTION PROJECTS IN LOUISIANA

Choctaw Nation of Oklahoma

By:________________________________ Date: _____________
Chief Gary Batton
Choctaw Nation

APPENDIX A
Contact List

Primary Contact	Secondary Contact
Advisory Council on Historic Preservation Christopher Daniel Program Analyst Advisory Council on Historic Preservation 401 F Street NW, Suite 308 Washington DC 20001-2637 202.517.0223 cdaniel@achp.gov	**Advisory Council on Historic Preservation** Reid Nelson, Chairman Office of Federal Agency Programs Advisory Council on Historic Preservation 401 F. Street NW, Suite 308 Washington, DC 20001-2637 Telephone: (202) 517-0228 E-mail: rnelson@achp.gov
Alabama-Coushatta Tribe of Texas Ms. Joann Battise, Chairwoman Alabama-Coushatta Tribe of Texas 571 State Park Rd. 56 Livingston, TX 77351 Telephone: (936) 563-1181 E-mail: histpres@actribe.org	**Alabama-Coushatta Tribe of Texas** Mr. Bryant Celestine Historic Preservation Officer Alabama-Coushatta Tribe of Texas 571 State Park Rd. 56 Livingston, TX 77351 Telephone: (936) 563-1181 E-mail: celestine.bryant@actribe.org
Amite River Basin Commission Dietmar Rietschier Executive Director Amite River Basin Commission 3535 South Sherwood Forest Blvd. Suite 135 Baton Rouge, Louisiana 70816 Telephone: (225) 296-4900 E-mail: drietschier@amitebasin.org	**Amite River Basin Commission** Larry Bankston Attorney at Law Bankston & Associates, L.L.C. 8708 Jefferson Highway, Suite A Baton Rouge, Louisiana 70809 Telephone: (225) 766.3800 E-mail: larry@bblawyers.net
City of Baton Rouge Parish Fred Raiford, Director City of Baton Rouge Department of Transportation and Drainage 222 Saint Louis Street 8th Floor Baton Rouge, LA 70802 Telephone: (225) 389-3159 E-mail: fraiford@brla.gov	**City of Baton Rouge Parish** Thomas A. Stephens, P.E. City of Baton Rouge Chief Design and Construction Engineer Public Works and Planning Center 1100 Laurel Street Baton Rouge, LA 70802 Telephone: (225) 389-3186 x 566 E-mail: TStephens@brla.gov
Caddo Nation Mr. Phillip Cross, THPO Caddo Nation 117 Memorial Lane Binger, OK 73009 Telephone: (405) 656-2344 x 248 E-mail: dhill@caddo.xyz	**Caddo Nation** Chairman Tamara Francis Fourkiller Caddo Nation P.O. Box 487 Binger, OK 73009 E-mail: tffourkiller.cn@gmail.com

Primary Contact	Secondary Contact
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Coushatta Tribe of Louisiana Dr. Linda Langley Cultural Preservation Officer Coushatta Tribe of Louisiana 1940 C.C. Bell Road Elton, LA 70532 Telephone: (337) 584-1567 E-mail: llangley@mcneese.edu	**Coushatta Tribe of Louisiana** Chairman Kevin Sickey Coushatta Tribe of Louisiana 1940 C.C. Bell Road Elton, LA 70532 Telephone: (337) 584-2998
Chitimacha Tribe of Louisiana Kimberly S. Walden, THPO Chitimacha Tribe of Louisiana 155 Chitimacha Loop Charenton, LA 70523 Telephone: (337) 923-9923 E-mail: kim@chitimacha.gov	**Chitimacha Tribe of Louisiana** Chairman Melissa Darden Chitimacha Tribe of Louisiana 155 Chitimacha Loop Charenton, LA 70523 Telephone: (337) 924-4973
Jena Band of Choctaw Indians Alina J. Shively Jena Band of Choctaw Indians THPO P.O. Box 14 Jena, LA 71342 Telephone: (318) 992-1205 E-mail: ashively@jenachoctaw.org	**Jena Band of Choctaw Indians** Chief B. Cheryl Smith Jena Band of Choctaw Indians 1052 Chanaha Hina Street Trout, LA 71371 Telephone: (318) 992-2717
Louisiana Coastal Protection and Restoration Authority Travis Byland Project Manager Coastal Protection and Restoration Authority 150 Terrace Avenue Baton Rouge, Louisiana 70802 Telephone: (225) 342-6750 E-mail: travis.byland@la.gov	**Louisiana Coastal Protection and Restoration Authority** Bren Haase Executive Director Louisiana Office of Coastal Protection and Restoration Authority P.O. Box 44027 Baton Rouge, LA 70804-4027 Telephone: (225) 342-1475

Primary Contact	Secondary Contact
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Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism Chip McGimsey State Archaeologist Division of Archaeology P.O. Box 44247 Baton Rouge, LA 70804-4241 Telephone: (225) 219-4598 E-mail: cmcgimsey@crt.la.gov	**Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism** Rachel Watson Division of Archaeology P.O. Box 44247 Baton Rouge, LA 70804-4241 Telephone: (225) 342-8165 E-mail: rwatson@crt.la.gov
Mississippi Band of Choctaw Indians Mr. Ken Carleton Tribal Archeologist Mississippi Band of Choctaw Indians 101 Industrial Road Choctaw, MS 39350 Telephone: (601) 656-5251 E-mail: ken.carleton@choctaw.org	**Mississippi Band of Choctaw Indians** Chief Ben Cyrus Mississippi Band of Choctaw Indians 101 Industrial Road Choctaw, MS 39350 Telephone: (601) 656-5251 E-mail: info@choctaw.org
Muscogee (Creek) Nation Mr. David Hill THPO Muscogee (Creek) Nation Historic & Cultural Preservation Office P.O. Box 580 Okmulgee, OK 74447 Telephone: (918) 732-7733 E-mail: Section106@mcn-nsn.gov	**Muscogee (Creek) Nation** Principal Chief, Mr. James Floyd Muscogee (Creek) Nation Historic & Cultural Preservation Office P.O. Box 580 Okmulgee, OK 74447
Pontchartrain Levee District Ms. Monica Salins-Gorman Executive Director	**Pontchartrain Levee District** Dwight D. Poirrier, APLC PLD Board Attorney

Primary Contact	Secondary Contact
Pontchartrain Levee District Post Office Box 426 Lutcher, Louisiana 70071 Telephone: (225) 869-9721 E-mail: mgorman@leveedistrict.org	1420 South Burnside Avenue P.O. Box 868 Gonzales, Louisiana 70737 Telephone: (225) 621-3200 Fax: (225) 621-3210 E-mail: dwight@poirrierlaw.com E-mail: stacey@poirrierlaw.com
Seminole Nation of Oklahoma Mr. David Franks THPO Seminole Nation of Oklahoma P.O. Box 1498 Wewoka, OK 74884 Telephone: (405) 257-7292 E-mail: franks.d@sno-nsn.gov	**Seminole Nation of Oklahoma** Principal Chief Greg Chilcoat Seminole Nation of Oklahoma P.O. Box 1498 Wewoka. OK 74884 Telephone: (405) 257-7200 E-mail: principalChief@seminolenation.com
Seminole Tribe of Florida Primary: Paul Backhouse, Ph.D., THPO Seminole Tribe of Florida Ah-Ta-Thi-Ki Museum 30290 Josie Billie Hwy, PMB 1004 Clewiston, FL 33440 Telephone: (863) 983-6549 x 12244 E-mail: THPOCompliance@semtribe.com	**Seminole Tribe of Florida** Secondary: Honorable Marcellus W. Osceola Chairman Seminole Tribe of Florida 6300 Stirling Road Hollywood, FL 33024 Telephone: (954) 966-6300 E-mail: trishanastrom@semtribe.com
Tunica-Biloxi Tribe of Louisiana Primary: Mr. Earl J. Barbry, Jr., THPO Tunica-Biloxi Tribal Historic Preservation Office P.O. Box 1589 Marksville, LA 71351 Telephone: (318) 253-8174 x 6451 E-mail: earlii@tunica.org	**Tunica-Biloxi Tribe of Louisiana** Secondary: Vice-Chairman Marshall Pierite Tunica-Biloxi Tribe of Louisiana 151 Melancon Drive Marksville, LA 71351 Telephone: (318) 253-1946 E-mail: joeypbarbry@tunica.org

APPENDIX B
Project Summaries

To meet part of its mission, CEMVN is conducting the present Bottomland Hardwoods (BLH)-Wet and Swamp Compensatory Habitat Mitigation under the standing authority of the Bipartisan Budget Act of 2018 (BBA; Pub. L. 115-123), Division B, Subdivision 1, H. R. 1892-13, Title IV, Corps of Engineers--Civil, Department of the Army, Investigations, for flood and storm damage risk reduction, signed into law February 9, 2018. This PA is applicable to BLH-Wet and Swamp Compensatory Habitat Mitigation for the following the following previously authorized USACE projects in Louisiana that have since been included in the BBA for construction:

1. Comite River Diversion (Comite);

2. East Baton Rouge Parish Watershed Flood Control (EBR); and

3. West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction (WSLP).

Supplemental information regarding the aforementioned individual USACE-funded programs is provided below:

COMITE RIVER DIVERSION
On 27 August 1991, the Chief of Engineers signed a report for the Amite River and Tributaries, Comite River Diversion, Louisiana, recommending construction of a 12 mile long diversion channel from the Comite River to the Mississippi River. The primary project features include a control structure at the Comite River, a control structure at Lilly Bayou, three (3) control drop structures at the intersections of the diversion channel with White, Cypress and Baton Rouge Bayous, a drop control structure in the vicinity of McHugh Road, two (2) railroad bridges and five highway or parish road bridges

Project Purpose
The Project is located in East Baton Rouge Parish, LA in the southern portion of the Comite River Basin. The features will provide urban flood damage reduction to reduce risks from rainfall events/headwater flooding for residents in the area.

Project Features
The primary project features include a control structure at the Comite River, a control structure at Lilly Bayou, three (3) control drop structures at the intersections of the diversion channel with White, Cypress and Baton Rouge Bayous, a drop control structure in the vicinity of McHugh Road, two railroad bridges, four highway bridges and one parish road bridge.

EAST BATON ROUGE FLOOD RISK REDUCTION PROJECT
Authorized project to reduce flooding along five (5) sub-basins throughout the parish, including Jones Creek, Ward Creek, Bayou Fountain, Blackwater Bayou, and Beaver Bayou. This project

consists of improvements to 66 miles of channels, including clearing and snagging, widening, concrete lining and improvements to existing culverts and bridges to reduce headwater flooding/backwater overflow in the Amite River Basin. The Feasibility Study was authorized in WRDA 1992 and the Chief's report approved Dec 1996. Project was first authorized for construction in WRDA 1999 at a total cost of $113M, increased in 2003 by the Consolidated Appropriations Resolution (CAR) to $150M, increased again in WRDA 2007 to $187M ($255M in current dollars).

Project Purpose
The authorized project is intended to reduce flooding throughout East Baton Rouge Parish by improving 66 miles of channels in five (5) sub-basins including:

- Jones Creek and tributaries (Designed to convey a 50-year event): Clearing and snagging three (3) miles and structurally lining 16 miles with reinforced concrete;
- Ward Creek and its tributaries (Designed to convey a 10-year event with a portion to convey a 50 year event): Clearing/snagging miles of channel and concrete lining;
- Bayou Fountain (Designed to convey a 10-year event): Clearing and widening 11 miles of channel;
- Beaver Bayou (Designed to convey a 25-year event): Widening eight (8) miles of existing earthen channel and improvements to existing culverts and bridges;
- Blackwater Bayou and its main tributary (Designed to convey a 10-year event): Widening 13 miles of existing earthen channel and improvements to existing culverts and bridges.

WEST SHORE LAKE PONTCHARTRAIN
The West Shore Lake Pontchartrain project is located in southeast Louisiana on the east-bank of the Mississippi River in St. Charles, St. John the Baptist, and St. James Parishes in Southeast LA. The West Shore Lake Pontchartrain Chief's report was published in June 2016 and the project has been included in the Bipartisan Budget Act of 2018.

Project Purpose
Over 60,000 people in the three (3) parish study area have little to no hurricane risk reduction in place. Additionally, the dominant evacuation route for the New Orleans metropolitan area (I-10) bisects the study area. During Hurricane Isaac, storm surge inundated approximately 7,000 homes and the interstate was submerged for several days slowing emergency response across the region. The Project will construct a 100 year level risk reduction system extending from the Bonnet Carré spillway to Garyville.

Project Features
The $760 million project is approximately 18.5 miles in length and includes 17.5 miles of levee, 1 mile of T-wall, four (4) pumping stations, two (2) drainage structures, and approximately 35 utility relocations. The project will also provide localized risk reduction measures focused in St. James Parish. The project will include mitigation to offset unavoidable environmental impacts.

APPENDIX C
Standard Treatment Measures

As provided in Stipulation II.F.4(a), if an Undertaking may adversely affect NRHP-listed or eligible historic properties and/or properties of religious or cultural significance to Tribes, or TCP(s), CEMVN may propose to resolve the adverse effect through the application of one or more of the STMs set out below. The selected measures will be developed by CEMVN after discussions with the SHPO, Tribes, and other Consulting Parties, as appropriate, and will be documented in writing in a Treatment Plan (TP). CEMVN will provide SHPO, and/or Tribes, and other Consulting Parties, as appropriate, with the opportunity to object to the proposed STM as set out in II.H.2(c). If CEMVN, in consultation with stakeholders, determines that a TM not included in the list below is in the public interest and is the most appropriate means to resolve an adverse effect, CEMVN will initiate consultation to develop a project-specific MOA as set out in Stipulation II.G.4(a).

The TP will identify, as appropriate: the responsible party/entity that will implement and complete each STM; the STM SOW and the standards that will apply to the preparation and distribution of a deliverable; the deliverable(s) (e.g., the quantity, size, materials, content, final ownership/ copyrights); measures to ensure that any STM documenting the condition of, or requiring the data recovery on the historic property, is implemented before the property is adversely affected; any *Professional Standards* in addition to those specified in Stipulation II.A.1(c) that will be required to prepare deliverable(s) described in the STM(s); the repositories and/or parties that will receive copies of a deliverable and the disposition of any deliverable that is not curated; milestones when CEMVN, SHPO, Tribes, and other Consulting Parties, as appropriate, will be given the opportunity to review and comment on the deliverable; and timeframes for each review and deliverable.

CEMVN will provide written notice to SHPO, Tribes, and other Consulting Parties, as appropriate, within sixty (60)-days of the completion of the STM as required by Stipulation II.G.2(d). CEMVN will include information pertaining to the progress of and completion of all STM(s) in the annual report pursuant to Stipulation IV.E.

Any dispute regarding the implementation of a TP will be resolved following the process set out in Stipulation IV.G.4(a).

This Appendix may be amended in accordance with Stipulation IV.A.2 of this Agreement.

List of Standard Treatment Measures:

I. **DESIGN REVIEW:** The purpose of this STM is to determine if there are feasible alternatives that may avoid or minimize potential adverse effects to historic properties. Avoidance and minimization of adverse effects will be dependent on the type of historic property (e.g., archaeological site vs. historic structure) and the type of adverse effect. CEMVN anticipates that it will identify work items that may cause an adverse effect during the review of a project, or at an early stage of project planning, when the design has not been fully developed. The implementation of this STM will allow CEMVN, in consultation with SHPO, Tribes, and other Consulting Parties, as appropriate, to continue with plan development, and allows CEMVN and Consulting Parties the potential to influence the design. CEMVN may include this STM with other measures that are intended to mitigate any adverse effects that cannot be avoided or minimized.

A. Design Review

Based on CEMVN's review of the construction design, if CEMVN determines that the proposed Undertaking may adversely affect a historic property:

1. CEMVN will consider ways to resolve adverse effects to a historic property by assessing feasible alternatives and/or determining if avoidance of the historic property is feasible through redesign of the project and/or specific project elements that are causing the adverse effect.

2. If avoidance is not feasible or practical, CEMVN then will look for ways to minimize the adverse effect to a historic property. Minimizing the adverse effect could include shifting specific project elements away from the historic property to lessen the adverse effect (e.g., buffering) and/or, considering ways to revise the scope of the project to substantially conform to the *Standards* as described in Stipulation II.A.1(a).

3. CEMVN will provide a written assessment of any alternatives, avoidance, and/or minimization measures considered along with sufficiently developed plans to SHPO, Tribes, and or Consulting Parties, as appropriate, for a fifteen (15)-day review and comment period. Protective measures may be further developed in consultation with stakeholders on a case-by-case basis to avoid or minimize adverse effects.

4. Following the fifteen (15)-day review period CEMVN will consider all comments, and if the scope of the project can be substantially revised to avoid the adverse effects, or the Undertaking no longer affects the character defining features of a

historic property, CEMVN will make a determination of “No Adverse Effect”; describe any project specific conditions; and provide supporting documentation pursuant to 36 CFR §800.11(e). Unless a Consulting Party makes a timely objection in accordance with the applicable timeframe outlined in Stipulation I.B, then design review is complete and CEMVN will proceed with its "No Adverse Effect" determination, including any conditions, and conclude the Section 106 review and CEMVN is not required to carry out any additional STMs that may have been identified to offset the potential adverse effect. Any subsequent construction footprint or scope of project changes will be reviewed in accordance with Stipulation II.D.1.

5. Should avoidance or minimization of the adverse effect not be feasible, in whole or in part, or if the adverse effect is determined to be in the best interest of the public and unavoidable, CEMVN will continue consultation with SHPO, Tribes, and or Consulting Parties, as appropriate, in accordance with Stipulation II.H.2 and the following treatment measures outlined below are suggested for the resolution of adverse effects.

II. PHOTOGRAPHIC RECORDATION: CEMVN, in consultation with SHPO, Tribes, and other Consulting Parties, as appropriate, will select the photographic medium or mediums from the options described below and identify a list of photographs that will serve to document the historic property to archival standards. Photographic images may include existing drawings and plans. If the Consulting Parties determine that it is in the public interest to document a property through the preparation of measured drawings, CEMVN will initiate consultation to develop a project-specific MOA.

A. Recordation for Standing Structures (Flexible Standards)

CEMVN will ensure that a trained professional who meets the *Professional Qualifications Standards* as defined in Stipulation II.A.1(a) photograph the exterior and/or interior, if it is accessible, in the selected photographic format(s) with an emphasis on documenting those portions of the exterior and/or interior that will be altered. The trained professional will take photographs of the views identified by CEMVN, SHPO, Tribes, other Consulting Parties, as appropriate, and/or agent or contractor, and will print specifically identified images:

a. Digital Photography: The digital photography and color photographs must comply with the “Best” category of requirements from the latest *National Register Photo Policy Fact Sheet:* https://www.nps.gov/subjects/nationalregister/upload/Photo_Policy_update_2013__15_508.pdf, with the following additional requirements:

1. Image files must be saved as both TIFF and JPEG files;

2. Color images must be produced in RGB (Red/Green/Blue) color mode as 24-bit or 48-bit color files;

3. In addition to the requirements specified by the *National Register Photo Policy Fact Sheet*, photographs will be digitally labeled to state the address (name of facility, street number, street name, city, and state); date of photograph; description of view, including direction of camera; and name of photographer, agent, or contractor responsible for the recordation.

b. <u>35mm Black/White and Color Photography:</u> Photographs must be taken with a 35mm SLR Camera or a 35mm point-and-shoot camera using 35mm black/white or color film. Photographs taken with disposable cameras are not acceptable.

1. The 35mm film black/white or color film photography package will include one (1) full set of 35mm film black/white or color photographs printed on acid free paper specifically designed for color prints, the corresponding 35mm film negatives in acid free sleeves.

2. Photographs will be labeled in pencil on the back to state the address, name of facility, street number, street name, city, and state; date of photograph; description of view, including direction of camera; and name of photographer, agent, or contractor responsible for the recordation.

c. <u>Large Format Photography</u>: Photographs must be taken with a large-format view camera with ample movement for perspective correction. The minimal complement of lenses includes a sharp rectilinear wide angle, a normal, and a mildly telephoto lens.

1. Acceptable film formats are 4x5, 5x7, and 8x10-inch. Acceptable polyester-based films include those of medium and slow speed (100 and 400 ASA) produced by a wide array of manufacturers.

2. The large format film photography package will include one (1) full set of 4 x 5 or 5 x 7-inch photographs printed on acid free paper and the corresponding 4 x 5 or 5 x 7-inch negatives in acid free sleeves.

3. Photographs will be labeled in pencil on the back to state the address name of facility, street number, street name, city, and state; date of photograph; description of view, including direction of camera; and name of photographer, agent, or contractor responsible for the recordation.

d. Video: A video documentary regarding the historic property may include on-camera interviews, archival footage and/or images, current footage of the historic property, and current footage of other similar historic properties. The content and length of the video will be described in the TP.

e. Narrative History: A narrative history may be prepared to provide a context for the photographs following the Historic American Building Survey (HABS) *Guidelines for Historical Reports*: "Short" or "Outline" format: https://www.nps.gov/hdp/standards/HABS/HABSHistoryGuidelines.pdf.

f. Recordation Package: The recordation package will include a photo log, printed copies of selected photographs, digital copies of photographs, and may include a narrative history. The recordation package may include reproductions of historic photographs, existing building plans, contemporary sketch plans, and/or maps. All materials will be packaged in archival sleeves and boxes. Archival disks will be used for all digital materials.

g. Review: The photographer, agent, or contractor responsible for the recordation may informally consult with SHPO, Tribes, and other Consulting Parties, as appropriate, to select photographs and other images that will be included in the recordation materials. The process to review and finalize the photographs and other images will be described in the TP.

h. Distribution: The photographer, agent, or contractor responsible for the recordation will prepare a minimum of three (3) archival quality copies of the recordation materials and will forward two (2) copies to SHPO and one (1) copy to CEMVN for archiving. In consultation with SHPO, Tribes, other Consulting Parties, as appropriate, CEMVN may identify additional archives and/or parties that will receive copies of the recordation materials. The responsible entity will provide CEMVN with documentation confirming that the recordation materials have been archived as described in the TP.

B. Recordation for Standing Structures (Established Standards)

The TP will document the proposed Level and Standard that will be most appropriate to capturing the significance of the historic property prior to alteration and define the responsible entity. Choices will be made between the National Park

Service (NPS), Heritage Documentation Programs (https://www.nps.gov/hdp/): *Historic American Building Standards* (HABS); *Historic American Engineering Standards* (HAER); or the *Historic American Landscape Standards* (HALS) at *Level III* or *Level II*. During the development of the TP, CEMVN will coordinate with the NPS, SHPO, Tribes, and other Consulting Parties, as necessary to make the selection. Any permission requiring a *Level I* effort under any of these standards will require an individual MOA to resolve the effects. The responsible entity will ensure that a trained professional who meets the *Professional Qualifications Standards* as defined in Stipulation II.A.1(a) photographs the exterior and/or interior, if it is accessible, in the selected standard with an emphasis on documenting those portions of the historic property that will be altered or demolished. The trained professional will take photographs of the views identified by CEMVN, in consultation with stakeholders, and will print specifically identified images and produce the required historical narrative.

III. **PUBLIC INTERPRETATION:** CEMVN will consult with SHPO, Tribes, and other Consulting Parties, as appropriate, to design an educational or public interpretive plan. The educational or public interpretive plan may include historical markers, signs, displays, educational pamphlets, websites, workshops, videos, and other similar mechanisms to educate the public on historic properties within the local community, state, or region. In certain instances SHPO may request that the proposed historical marker conform to the requirements of the Louisiana Historical Marker Program, in the Department of Culture, Recreation, and Tourism, and request that the responsible entity apply to this program (https://www.crt.state.la.us/tourism/industry-partners/).

IV. **HISTORICAL CONTEXT STATEMENTS:** CEMVN will consult with SHPO, Tribes, and other Consulting Parties, as appropriate, to identify the topic, audience, and framework of a historic context statement and format for the final deliverable. The context statement may focus on an individual property, a set of related properties, historic district, or other relevant themes identified in the *Louisiana Comprehensive Preservation Plan* (https://www.crt.state.la.us/cultural-development/historic-preservation/louisiana-state-plan-shpo/index) or the NPS *National Historic Landmark Thematic Framework* (https://www.nps.gov/subjects/nationalhistoriclandmarks/nhl-thematic-framework.html).

V. **ORAL HISTORY DOCUMENTATION:** CEMVN will consult with SHPO, Tribes, and other Consulting Parties, as appropriate, to identify the list of potential interview candidates; the parameters of the oral history project; qualifications of the individual or individuals conducting the oral interviews; the process for any ongoing coordination with stakeholders; and format for the final deliverable.

VI. **HISTORIC PROPERTY INVENTORY:** CEMVN will consult with SHPO, Tribes, and other Consulting Parties, as appropriate, to establish the appropriate level of effort to accomplish a historic property inventory. Efforts may be directed toward the resurvey of previously designated historic properties which have undergone change or lack sufficient documentation, or the survey of new historic properties that lack formal designation. The proposed STM will describe the boundaries of the survey area and the data collection method in accordance with Stipulation II.A.

VII. **NATIONAL REGISTER AND NATIONAL HISTORIC LANDMARK NOMINATIONS:** CEMVN will consult with SHPO, Tribes, and other Consulting Parties, as appropriate, to identify individual properties that would benefit from a completed NRHP or NHL nomination form. Once the Consulting Parties have agreed to a property, the responsible entity will continue to coordinate with CEMVN through the drafting of the NRHP nomination form and will contact the NHL Program to begin the nomination process. CEMVN in turn, will forward the materials to Consulting Parties for review and comment. The SHPO and/or Tribes will provide adequate guidance to the responsible entity during the preparation of the nomination form. CEMVN will work with the SHPO to ensure the completed NRHP form is presented to the Louisiana National Register Review Committee in a timely manner for consideration by the SHPO and the Keeper of the Register.

VIII. **GEO-REFERENCING OF HISTORICAL MAPS AND AERIAL PHOTOGRAPHS:** CEMVN will consult with SHPO, Tribes, and other Consulting Parties, as appropriate, to identify the historical maps and/or aerial photographs for scanning and geo-referencing. Once a list of maps and/or aerial photographs have been agreed upon, the responsible entity will continue to coordinate with CEMVN through the scanning and geo-referencing process and will submit drafts of paper maps and electronic files to CEMVN, who in turn forward the materials to Consulting Parties for review and comment. The final deliverable produced by the responsible entity will include: 1) a paper copy of each scanned image; 2) a geo-referenced copy of each scanned image; 3) original high-resolution digital image of map/aerial photograph in TIFF file format; 4) copies of the user agreements for every geo-referenced image with transferability of use to all parties; 5) a process report outlining the research, and; 6) the metadata relating to both the original creation of the paper maps and the digitization process.

IX. ARCHAEOLOGICAL RESEARCH DESIGN AND DATA RECOVERY PLAN: CEMVN will consult with SHPO, Tribes, and other Consulting Parties, as appropriate, to develop and implement a data recovery plan with a research design to recover data from archaeological properties listed in, or eligible for listing in the NRHP, which will be adversely affected by ground-disturbing activities that are part of the Undertaking. The research design and data recovery plan will be consistent with the *Standards* in accordance with Stipulation II.A as well as the Louisiana Unmarked Human Burial Sites Preservation Act (RS 8:671 et seq.). This STM does not apply to the excavation of burials or burial objects.

X. MARKETING PLAN FOR DEMOLITION OR ABANDONMENT: CEMVN will consult with SHPO, Tribes, and other Consulting Parties, as appropriate, to develop and implement a feasible marketing plan to advertise the availability of historic structures identified for demolition or abandonment for sale and/or relocation. A good faith and reasonable marketing plan will include publicizing and advertising the property in newspapers, magazines, and/or websites of record for a specific period of time. The plan may require the purchaser to relocate the property outside of the Special Flood Hazard Area (100-year floodplain), and the plan will give preference to a purchaser who proposes to use a professional house mover that follows the recommendations contained in the U.S. Department of the Interior, Heritage Conservation and Recreation Service, publication: *Moving Historic Buildings* by John Obed Curtis (1979) or other similar updated reference material. If a good faith and reasonable marketing effort does not result in the identification of a party or parties willing to purchase and, if necessary, relocate the property, the property may be demolished or abandoned. This marketing plan will be used in conjunction with STM II.A or II.B, and CEMVN will ensure that the property is recorded prior to relocation or demolition.

XI. SALVAGE: CEMVN will consult with SHPO, Tribes, and other Consulting Parties, as appropriate, to identify selective architectural elements that may be salvaged from a building/structure slated for demolition. The salvaged elements may be re-used in another structure or in displays for educational purposes. As an alternative, CEMVN will consult with SHPO, Tribes, and other Consulting Parties, as appropriate, to attempt to identify a private or public not-for-profit local or regional historic preservation organization interested in receiving a donation of the architectural features. The organization may sell the architectural features to the general public for the specific purpose of raising funds to support future historic preservation activities in the region. Salvage activities will not occur at or below grade in order to avoid affecting unevaluated archaeological resources.

Water Quality Certification

JOHN BEL EDWARDS
GOVERNOR

CHUCK CARR BROWN, PH.D.
SECRETARY

State of Louisiana

DEPARTMENT OF ENVIRONMENTAL QUALITY
ENVIRONMENTAL SERVICES

APR 30 2021

Mr. Daniel Meden
US Army Corps of Engineers, New Orleans District
CEMVN-PDN-CEP
7400 Leake Avenue
New Orleans, Louisiana 70118

AI No.: 101235
Activity No.: CER20210002

RE: West Shore Lake Pontchartrain Environmental Mitigation
Water Quality Certification WQC 210426-02
St. John the Baptist Parish

Dear Mr. Meden:

The Louisiana Department of Environmental Quality, Water Permits Division (LDEQ), has reviewed the application to construct a freshwater diversion to reconnect the Mississippi River to the Maurepas Swamp in St. John the Baptist Parish.

The information provided in the application has been reviewed in terms of compliance with State Water Quality Standards, the approved Water Quality Management Plan and applicable state water laws, rules and regulations. LDEQ determined that the requirements for a Water Quality Certification have been met. LDEQ concludes that the discharge of fill will not violate water quality standards as provided for in LAC 33:IX.Chapter 11. Therefore, LDEQ hereby issues US Army Corps of Engineers, New Orleans District Water Quality Certification, WQC 210426-02 for the proposed West Shore Lake Pontchartrain Environmental Mitigation.

Should you have any questions concerning any part of this certification, please contact Elizabeth Hill at (225) 219-3225 or by email at elizabeth.hill@la.gov. Please reference Agency Interest (AI) number 101235 and Water Quality Certification 210426-02 on all future correspondence to this Department to ensure all correspondence regarding this project is properly filed into the Department's Electronic Document Management System.

Sincerely,

Scott Guilliams
Administrator
Water Permits Division

c: IO-W

ec: Dan Meden
daniel.c.meden@usace.army.mil