DRAINAGE AND WETLAND IMPACT ANALYSIS

I-12 to Bush Environmental Impact Statement
USACE Permit No. MVN-2006-0037

Prepared for

United States Army Corps of Engineers, New Orleans District

and

Louisiana Department of Transportation and Development

June 2011

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Acronyms

ADH	Allowable Differential Head
AHW	Allowable Headwater
ALT B/O	Alternative B/O
ALT J	Alternative J
ALT P	Alternative P
ALT Q	Alternative Q
AMC	Antecedent Moisture Condition
ArcGIS	ESRI ArcMap 9.3
ArcHydro	ArcHydro Tools Version 1.2
BFE	Base Flood Elevation
CEMVN	U.S. Army Corps of Engineers New Orleans District
CN	Curve Number
CSC	Coastal Services Center
CWA	Clean Water Act
DA	Department of Army
DFIRM	Digital Flood Insurance Rate Map
DOQQ	Digital Orthophoto Quarter Quads
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
HEC-HMS	USACE Hydrologic Engineering Center's Hydrologic Modeling System
HEC-RAS	USACE - Hydrologic Engineering Center's River Analysis System
HSG	Hydrologic Soil Group
HUC	Hydrologic Unit Codes
HYDR1120	LADOTD Hydraulics Analysis of Culverts Software
HYDR1140	LADOTD Open Channel Flow Software
LADOTD	Louisiana Department of Transportation and Development
LDWF	Louisiana Department of Wildlife and Fisheries
LiDAR	Light Detection and Ranging Data
LOSCO	Louisiana Oil Spill Coordinator's Office
LULC	Land Use and Land Cover Data
ND 2025	St. Tammany Parish's New Direction 2025 Comprehensive Plan
NRCS	Natural Resources Conservation Services
ROW	Right-of-Way
NOAA	National Oceanic and Atmospheric Administration
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
SCS	Soil Conservation Service
SSURGO	Soil Survey Geographic Database
TIMED	Transportation Infrastructure Model for Economic Development
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USFWS	U.S. Department of Interior – Fish and Wildlife Service
WLF	Water Level Fluctuation

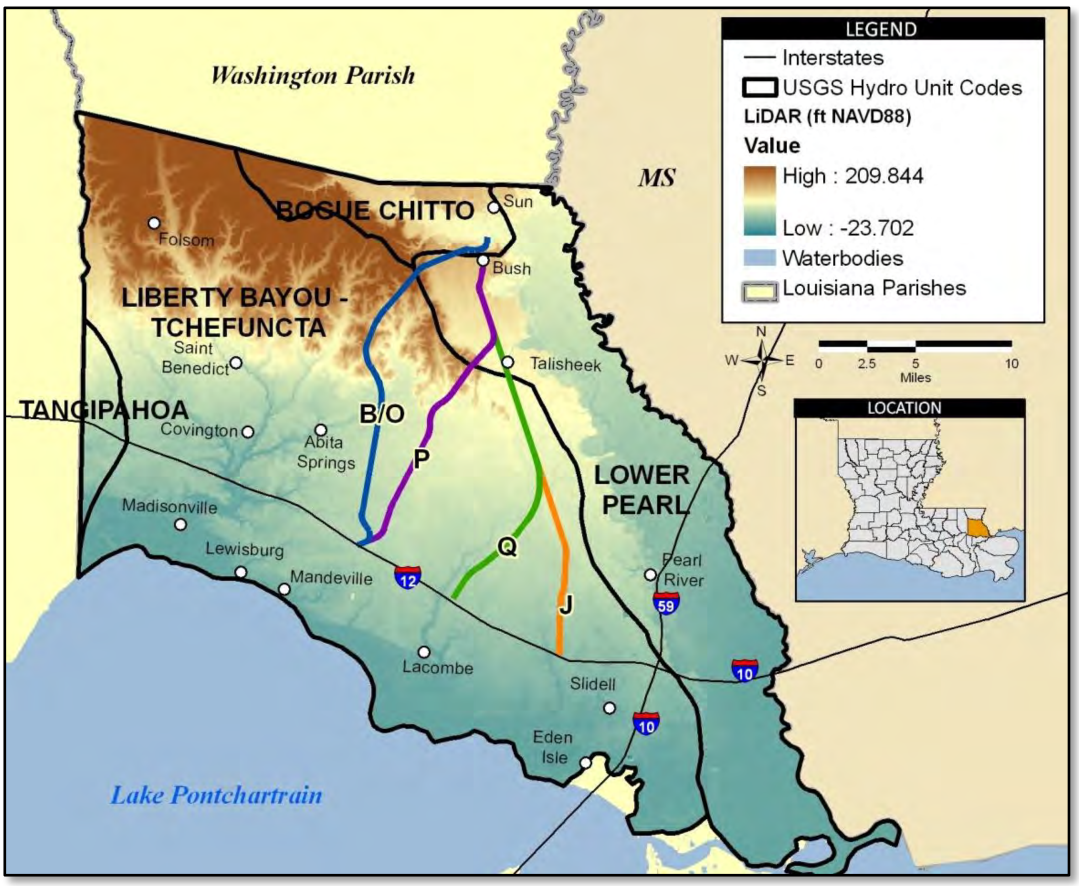
Executive Summary

1.0 Introduction

The U.S. Army Corps of Engineers (USACE), New Orleans District (CEMVN), has prepared an environmental impact statement (EIS) to evaluate the potential environmental and socioeconomic consequences of granting permits to the Louisiana Department of Transportation and Development (LADOTD) for the construction of the proposed Louisiana Highway (LA) 3241 from the LA 40/41 intersection in Bush, Louisiana, to Interstate 12 (I-12).

This technical report presents the development and results of the hydrologic modeling, hydraulic analysis, and indirect wetland impact analysis for the existing conditions, as well as four chosen roadway alignments for the I-12 to Bush corridor. These alignments include Alternative B/O, Alternative P, Alternative Q, and Alternative J (*Figure ES-1*).

Figure ES-1: USGS Hydrologic Codes and LiDAR for St. Tammany Parish



Source: USGS, 2005, LSU CADGIS Reasearch Laboratory, 2010

2.0 Hydrologic and Hydraulic Analysis

At the EIS level of this project, there was no field survey data collected. The work presented here is based on the best available data at the time of writing this report. A field investigation was completed along the areas with available access. In areas with dense trees and wetlands further verification in the design phase is needed.

This study analyzed the existing conditions – no build alternative, the future (2025) land use conditions – no build alternative, and each of the four alternative routes (Alternative B/O, Alternative P, Alternative Q, and Alternative J) based on the future (2025) land use conditions. Proposed structures locations and sizes were determined.

2.1 Hydrologic Model

The hydrologic models were completed using the USACE Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) Version 3.4. As part of this study, it was determined that there would be 19 hydrologic basins impacted, totaling 145.3 square miles (mi^2) (93,002 acres) (*Figure ES-2*). Each basin includes smaller subbasins. For the existing conditions, 424 subbasins were delineated.

For each subbasin, the peak discharge was determined and routed through the drainage system in HEC-HMS. Subbasin parameters including Curve Number (existing and future), time of concentration, and channel lag time were calculated. The HEC-HMS models were used to calculate the runoff for the 50-year and 100-year flood frequency storms.

2.2 Hydraulic Model

The peak flows determined through the HEC-HMS hydrologic modeling were used to size the proposed drainage structures. Structures were analyzed using the LADOTD HYDRWINT software series. The LADOTD Hydraulics Analysis of Culverts (HYDR1120) was used for culvert sizing, and the LADOTD Open Channel Flow (HYDR1140) was used to check the water surface elevation for bridges.

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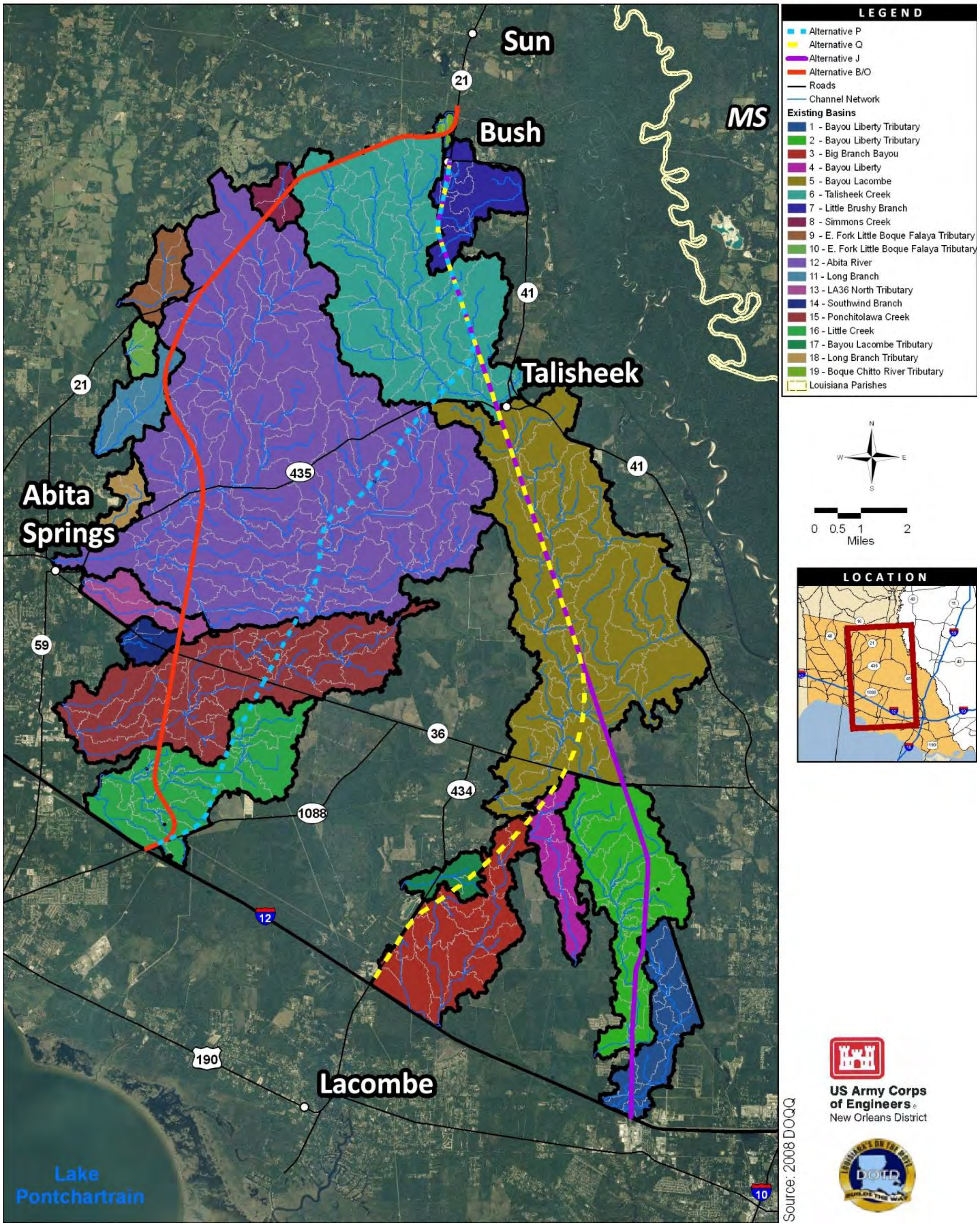
Figure ES-2 Hydrologic Drainage Basins



The sizes and types of structures provided in this report should be considered preliminary (and not for construction). However, these designs are sufficient for the line and grade study and to provide a construction cost estimate that can be incorporated into the total project costs. Major hydraulic crossings were sized for the 50-year storm event under future land use conditions following LADOTD guidelines. The following assumptions were made for culvert calculations:

- There were only two types of culverts used for design: reinforced concrete pipe (RCP) or reinforced concrete box (RCB).
- All RCP structures are projecting from the fill, while RCB structures have a flat headwall.
- Structure length is 176 feet.
- The maximum number of pipes in a row is four (LADOTD *Hydraulic Design Standards* 7).
- Allowable Differential Head is less than one foot for the 50-year design storm.
- A standard uniform slope of 0.1% (0.001 ft/ft) for all major culverts was used. This assumption was based on the recommendation of LADOTD due to the generally flat channel slopes. Culverts are designed on the same slope as the natural streambed slope. Therefore, a complete survey should be completed during the design phase of this project, and the major culverts should be reevaluated based on the channel slope data.
- Structures with high outlet velocities (greater than nine feet per second) shall require discharge erosion protection at the time of final design (LADOTD 1987).
- For low fills, a one foot minimum must be upheld between the edge of the travel lane and the allowable headwater elevations (LADOTD 1987).
- For high fills, a three foot maximum must be upheld between the top of the pipe and the average headwall elevations (LADOTD 1987).
- The crown elevation of the roadway must not be overtopped during the 100-year design storm.
- The tailwater elevation of the culverts was set to equal the culvert diameter.

According to the LADOTD Hydraulics Manual (page 73), on long continuous grades, which are unbroken by lateral outfalls, equalizers shall be used at intervals of approximately 1,000 to 1,500 feet. Equalizers should be 24-inch diameter pipes or round equivalent pipe arches. In the design phase of the project, a more detailed field investigation is needed to properly pinpoint the best location for these equalizers. At this phase of the study, only the number of equalizer pipes for each alternative was determined, and located based on distance between major structures.

Bridges are recommended at locations where the peak runoff exceeds 1,000 cubic feet per second. A preliminary estimate of the bridge spans were obtained using LADOTD HYDR1140 Open Channel Flow program. At the time of final design, a comprehensive hydraulic analysis of each bridge should be conducted using HEC- RAS or WSPRO to determine the 50-year and 100-year existing and constructed conditions as well as the 500-year scour analysis. Further, a detailed FEMA no-rise analysis may need to be completed at the bridge locations as part of the final design.

To verify the analysis performed in this report, elevations and flows were compared to the Preliminary (April 2008) FEMA USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) models where available. The comparison showed good agreement. A complete list of the proposed structures can be seen in *Table ES-1*.

Table ES-1: Structure Sizes

Structure No.	Structure Type			
	ALT B/O	ALT P	ALT Q	ALT J
1	2– 48" RCP	2 – 48" RCP	2 -48" RCP	1 – 60" RCP
2	3 – 60" RCP	2 – 60" RCP	1 – 42" RCP	425' Bridge
3	3 – 54" RCP	1 – 54" RCP	1 – 54" RCP	1 – 54" RCP
4	450' Bridge	1 – 54" RCP	2 – 60" RCP	1 – 54" RCP
5	1 – 42" RCP	140' Bridge	1 – 36" RCP	2 – 60" RCP
6	1 – 42" RCP	1 – 42" RCP	1 – 60" RCP	250' Bridge
7	1 – 54" RCP	2 – 54" RCP	1 – 60" RCP	1 – 54" RCP
8	450' Bridge	100' Bridge	1 – 48" RCP	450' Bridge
9	2 – 54" RCP	1 – 54" RCP	4 – 54" RCP	1 -30" RCP
10	2 – 48" RCP	2 – 48" RCP	500' Bridge	2 – 48" RCP
11	2 – 54" RCP	1 – 54" RCP	1 – 30" RCP	3 – 54" RCP
12	2 – 54" RCP	3 – 60" RCP	1 – 60" RCP	2 – 60" RCP
13	150' Bridge	1 – 48" RCP	2 – 48" RCP	3 – 54" RCP
14	300' Bridge	140' Bridge	3 – 8' x 5' RCB	2 – 60" RCP
15	540' Bridge	400' Bridge	450' Bridge	450' Bridge
16	1 – 60" RCP	340' Bridge	1 – 48" RCP	1 – 60" RCP
17	3 – 54" RCP	250' Bridge	1 – 54" RCP	1 – 60" RCP
18	450' Bridge	3 – 8' x 5' RCB	3 – 7' x 5' RCB	2 – 48" RCP
19	3 – 60" RCP	2 – 54" RCP	500' Bridge	3 – 8' x 5' RCB
20	4 – 60" RCP	3 – 7' x 5' RCB	2 – 60" RCP	450' Bridge
21	2 – 60" RCP	1 – 54" RCP	4 – 7' x 5' RCB	1 – 48" RCP
22	3 – 60" RCP	3 – 60" RCP	2 – 60" RCP	1 – 54" RCP
23	3 – 60" RCP	1 – 54" RCP	2 – 54" RCP	3 – 7' x 5' RCB
24	3 – 7' x 5' RCB	1 – 48" RCP	3 – 54" RCP	500' Bridge
25	4 – 8' x 5' RCB	1 – 30" RCP	1 – 60" RCP	2 – 60" RCP
26	500' Bridge	420' Bridge		4 – 7' x 5' RCB
27	4 – 8' x 5' RCB	3 – 54" RCP		2 – 60" RCP
28	3 - 8' x 5' RCB	4 – 8' x 5' RCB		2 – 54" RCP
29	4 – 60" RCP	4 – 7' x 5' RCB		3 – 54" RCP
30	1 – 60" RCP	2 – 60" RCP		1 – 60" RCP
31		2 – 54" RCP		
32		3 – 54" RCP		
33		1 – 60" RCP		
No. of Major Culverts	**23**	**26**	**22**	**24**
No. Bridges	**7**	**7**	**3**	**6**
Total No. of Major Structures	**30**	**33**	**25**	**30**
Total No. of Equalizer Culverts	**67**	**54**	**71**	**78**

2.3 Geomorphology

Alternative P, Alternative Q, and Alternative J would require only minor stream adjustments. However, through proper engineering design, the impacts would be minimal. Protection has also been recommended near proposed structures where velocities exceed nine feet per second and possible erosion would occur. Further investigation on geomorphologic impacts would need to be completed at the design phase of this study.

2.4 Hydrologic and Hydraulic Alternative Results

The impact of road crossings on the hydrology and hydraulics of the existing system is dependent on a number of factors. The impacts created by each bridge and culvert crossing can vary significantly based on the conditions at each location.

The following equation was used to determine the points assigned to each structure crossing:

Bridge Score = Structure Type X New or Existing Structure X Length of Bridge/100 *Equation ES-1*

Culvert Score = Structure Type X New or Existing Structure X Width of Culverts/10 *Equation ES-2*

Structure Type: Bridge = 2.0
Culvert = 1.0

New or Existing Structure: New Structure = 1.0
Replace Existing Structure = 0.5

Example 1: Replace existing crossing on railroad alignment with 450 ft Bridge
2.0 (Bridge) X 0.5 (Existing Structure) X 450 LF/100 = 4.5 Points

Example 2: Construct two 4 ft Culverts on new alignment
1.0 (Culvert) X 1.0 (New structure) X 2 X 4 ft /10 = 0.8 Points

Table ES-2 shows the total number of bridges and culverts required for each alternative and the number of structures located on new alignment sections. The impacts to the channel system are directly related to the number of channel crossings, particularly those located on a new alignment. The table also quantifies the total length of the bridges and width of culverts for each structure identified.

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Table ES-2: Bridge and Culvert Summary Table

	ALTERNATIVE B/O				ALTERNATIVE P				ALTERNATIVE Q				ALTERNATIVE J			
	Str. No.	No. of Pipes	Str. Width (ft)	Points	Str. No.	No. of Pipes	Str. Width (ft)	Points	Str. No.	No. of Pipes	Str. Width (ft)	Points	Str. No.	No. of Pipes	Str. Width (ft)	Points
BRIDGES	4		450	9	5		140	2.8	10		500	10	2		425	4.25
	8		450	9	8		100	2	15		450	4.5	6		250	2.5
	13		150	3	14		140	2.8	19		500	5	8		450	9
	14		300	6	15		400	8					15		450	4.5
	15		540	10.8	16		340	6.8					20		450	4.5
	18		450	9	17		250	5					24		500	5
	26		500	5	26		420	8.4								
CULVERTS	1	2	4	0.4	1	2	4	0.4	1	2	4	0.4	1	1	5	0.25
	2	3	5	0.75	2	2	5	0.5	2	1	3.5	0.35	3	1	4.5	0.23
	3	3	4.5	1.35	3	1	4.5	0.45	3	1	4.5	0.45	4	1	4.5	0.23
	5	1	3.5	0.35	4	1	4.5	0.45	4	2	5	1	5	2	5	0.5
	6	1	3.5	0.35	6	1	3.5	0.35	5	1	3	0.3	7	1	4.5	0.45
	7	1	4.5	0.45	7	2	4.5	0.9	6	1	5	0.5	9	1	2.5	0.25
	9	2	4.5	0.9	9	1	4.5	0.45	7	1	5	0.5	10	2	4	0.8
	10	2	4	0.8	10	2	4	0.8	8	1	4	0.4	11	3	4.5	1.35
	11	2	4.5	0.9	11	1	4.5	0.45	9	4	4.5	1.8	12	2	5	1
	12	2	4.5	0.9	12	3	5	1.5	11	1	2.5	0.25	13	3	4.5	0.68
	16	1	5	0.5	13	1	4	0.4	12	1	5	0.25	14	2	5	0.5
	17	3	4.5	1.35	18	3	8	2.4	13	2	4	0.4	16	1	5	0.25
	19	3	5	1.5	19	2	4.5	0.9	14	3	8	1.2	17	1	5	0.25
	20	4	5	2	20	3	7	2.1	16	1	4	0.2	18	2	4	0.4
	21	2	5	1	21	1	4.5	0.45	17	1	4.5	0.23	19	3	8	1.2
	22	3	5	1.5	22	3	5	1.5	18	3	7	1.05	21	1	4	0.2
	23	3	5	1.5	23	1	4.5	0.45	20	2	5	0.5	22	1	4.5	0.23
	24	3	7	2.1	24	1	4	0.4	21	4	7	1.4	23	3	7	1.05
	25	4	8	1.6	25	1	2.5	0.25	22	2	5	0.5	25	2	5	0.5
	27	4	8	1.6	27	3	4.5	1.35	23	2	4.5	0.45	26	4	7	1.4
	28	3	8	1.2	28	4	8	3.2	24	3	4.5	0.68	27	2	5	0.5
	29	4	5	1	29	4	7	1.4	25	1	5	0.25	28	2	4.5	0.45
	30	1	5	0.25	30	2	5	0.5					29	3	4.5	0.68
					31	2	4.5	0.45					30	1	5	0.25
					32	3	4.5	0.68								
					33	1	5	0.25								
	TOTAL POINTS =			76.05	TOTAL POINTS =			58.73	TOTAL POINTS =			32.55	TOTAL POINTS =			43.325

[shaded box] = Structures located on an existing road alignment or railroad corridor where there is an existing crossing.

Table ES-3 summarizes the results of the hydrologic and hydraulic impact analysis and provides the ranking for each alternative:

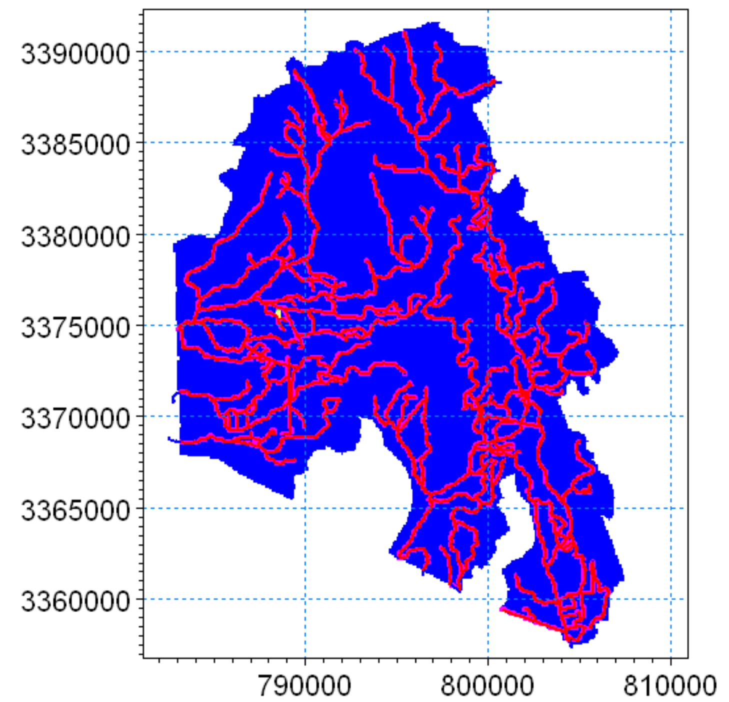
Table ES-3: Hydrologic and Hydraulic Analysis Results

Alternative	Total Points	Ranking
ALT Q	32.55	1
ALT J	43.33	2
ALT P	58.73	3
ALT B/O	76.05	4

3.0 Wetland Impact Analysis

The impact of the proposed alignments on the natural overland sheet flow patterns and adjacent wetland areas were analyzed. A one and two-dimensional coupled modeling approach (MIKE FLOOD) was used for modeling the flow exchange between the wetlands, lakes, and channels (*Figure ES-3).*

Figure ES-3: MIKE FLOOD Layout (Coupled MIKE 11 and MIKE 21)



The construction of roads across streams and wetlands areas, especially in shallow systems such as eastern St. Tammany Parish, may alter the natural drainage pattern and specifically the flow exchange between streams and surrounding wetland areas. A list of common hydrologic stressors on urban wetlands is provided below (Wright 2006):

- Changes to topography and canopy
- Changes to the inundation (Ponding)
- Increased Hydrologic Drought of Riparian Wetlands
- Changes to Water Level Fluctuations
- Increased Flow Constrictions
- Changes to Sedimentation and Nutrient Loading

These hydrologic stressors were evaluated individually for each alternative to determine the indirect impact to the wetland areas located outside of each alignment's 250 feet of right-of-way. All analyses were performed on the entire drainage system to determine the total impacts. These results were then filtered to focus on the impacts to wetland areas Through coordination with Tetra Tech, Inc. and the governmental agencies involved in this project, the wetland areas were determined using hydric soil classifications and LiDAR data. These wetland areas were used for analysis purposes herein. It should be noted that the wetland areas identified in this report may not match with areas classified as wetlands in other publications. In order to properly classify an area as a wetland a complete field investigation and wetland delineation outside of the alternative right-of-ways is needed. Such extensive field investigation was beyond the scope of this EIS, but is recommended for future phases of this project.

In order to present a comparative analysis and ranking system for each alternative, a normalized scale was used for each hydrologic stressor. The normalized procedure is based on *Equation ES-3*:

$$Normalize\ Score = \left(\frac{alternative\ value}{\max alternative\ value}\right) * 10 \qquad \text{Equation ES-3}$$

The “alternative value” here represents the specific hydrologic stressor being considered, e.g. wetland acreage impacted, or linear miles of clearing canopy for a given alignment. This scoring system is designed such that an alternative with no impact would receive a score of zero and the alternative with the largest impact would receive a score of ten (*Table ES-4).*

Table ES-4: Definition of Normalized Values

Normalized Value	Definition
0	No Impact
10	Largest Impact

3.1 Impacts to Topography and Canopy

Constructing a new roadway may require clearing of canopy and vegetation along its path. Alignments constructed on undeveloped terrain change the existing canopy and topography. Whereas, alignments constructed on existing roadways or abandoned rail beds pose no additional impact to the surrounding environment. Each of the alternative alignments considered here was assessed to determine the length of roadway constructed on undeveloped land. *Table ES-5* summarizes these results.

Table ES-5: Score of Impact on Topography and Canopy for the various Roadway Alignments based on the Length of New Roadway

Rank	Alternative	Length of New Roadway (Miles)	Normalized Score
1	ALT J	5.4	3.6
2	ALT Q	8.7	5.9
3	ALT B/O	12.5	8.4
4	ALT P	14.8	10

In addition to the impact on canopy and topography by each alignment, it is important to take into account the direct impacts of each alignment on the wetlands within its right-of-way. The wetland area along the length of each alignment was delineated by Tetra Tech, Inc. and can be found in the *Waters of the United States Delineation Reports – I-12 to Bush Environmental Impact Statement* dated December 2010. These results are summarized in *Table ES-6*.

Table ES-6: Direct Wetland Impacts within the 250 ft Right-of-Way of each Alternative (*Waters of the United States Delineation Report – I-12 to Bush Environmental Impact Statement, 2010)*

Rank	Alternative	Direct Wetland Impacts Acres	Normalized Score
1	ALT Q	305	7.9
2	ALT P	358	9.3
2	ALT J	373	9.7
4	ALT B/O	385	10

3.2 Impacts on Inundation (Ponding)

Changes to the extent or inundation (ponding) duration of wetland areas may occur when obstructions such as roadways alter the natural sheet flow of water. Altering the ponding duration (increase or reduction) leads to changes, often undesirable, in wetland type, function, and quality, as well as to the native plants and animals (Wright, 2006). The duration an area remains submerged is a critical parameter that impacts the functionality of wetlands. An exact duration was not agreed on among scientists. The range varied from three to seven days.

The inundation of wetland areas were analyzed for the existing conditions and compared to each alternative alignment. *Figure ES-4* illustrates how each alignment may impact the wetland inundation. Ponding was defined as areas inundated for three consecutive days with a depth greater than 0.025 meters. The change (expressed in acreage) to the inundated areas is used to express the impact of a given alignment. As shown in *Figure ES-4*, the comparison between the existing conditions and a given alignment reveals areas that have not been impacted, new inundated areas, and areas that have been drained as a result of constructing a given alignment. This analysis was repeated with adjusting the definition of ponding to five then again to seven days. The five day ponding results can be found in *Table ES-7.*

Figure ES-4: Schematic of How the Impact on Ponding and Drought Was Computed for a Given Alignment

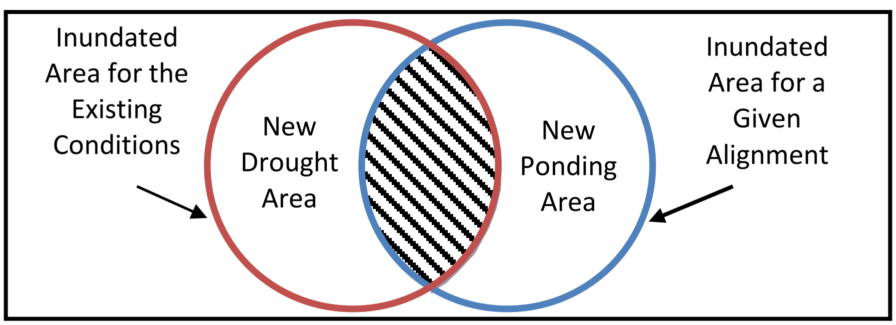


Table ES-7: Inundation impact and Scoring Analysis: Seven Days Inundation Duration

Rank	Alternative	Increase in Wetland Inundation (Acres)	Normalized Score
1	ALT P	297	6.8
2	ALT Q	307	7.0
3	ALT B/O	385	8.8
4	ALT J	438	10

3.3 Hydrologic Drought Impact Analysis

Hydrologic drought events are defined as wetland areas that remain dry for three consecutive days. To investigate the sensitivity of the results to the duration of the drought used herein, the same analysis was repeated with adjusting the drought duration to five and seven days. The hydrologic drought analysis counted the acres of wetlands experiencing hydrologic drought as a result of a given alignment compared to the existing conditions. A summary of the results for the five day analysis can be seen in *Table ES-8.*

Table ES-8: Hydrologic Drought Impact and Scoring Analysis: Seven Days Hydrologic Drought Duration

Rank	Alternative	Increase in Wetland Drought (Acres)	Normalized Score
1	ALT Q	129	5.3
2	ALT P	135	5.6
3	ALT B/O	184	7.6
4	ALT J	243	10

3.4 Water Level Fluctuations Impact Analysis

Water level fluctuation (WLF) is defined as the difference in maximum and minimum water levels in a wetland for a given period of time. This is often used to quantify a wetland's hydro period (Wright, 2006). Water level typically increases in response to moderate or large storm events, but quickly returns to base levels. These changes in water level are commonly referred to as the "bounce" in water levels during and after a storm event. Research has shown that changes in WLF on wetlands have caused a consistent decline in diversity and often an increase in invasive species (Wright 2006).

The WLF impact analysis was performed for the 2, 25, and 100-year storm events. Changes to the WLF patterns between the existing conditions and each alternative were determined. A change in the WLF was registered only if it exceeded a 0.025 meters (whether an increase or decrease). The total area registering such a change was tallied up for each alternative. This tolerance was set based on the resolution and sensitivity of the numerical model. The wetland areas that experienced a change in the WLF for the 2-year storm event can be found in *Table ES-9*.

Table ES-9: Water Level Fluctuations Impact and Scoring Analysis for the 2-Year Storm

Rank	Alternative	WLF Impacted Wetland Areas (Acres)	Normalized Score
1	ALT P	860	4.7
2	ALT B/O	1,128	6.1
3	ALT Q	1,237	6.7
4	ALT J	1,838	10

3.5 Flow Constrictions Impact Analysis

The most common type of flow constriction is caused by the placement of hydrologic structures to convey water underneath a roadway. The hydrologic changes associated with flow constrictions contribute to increase in ponding, drought, and water level fluctuations both upstream and downstream of the hydraulic structures (Wright 2006). A normalized scoring was computed for each alternative and is shown in *Table ES-10.*

Table ES-10: Flow Constriction Impact and Scoring and Analysis

Rank	Alternative	Culvert Analysis Score	Normalized Score
1	ALT Q	33	4.3
2	ALT J	43	5.7
3	ALT P	59	7.7
4	ALT B/O	76	10

3.6 Changes to Sedimentation and Nutrient Loading

Changes to sedimentation and nutrient loading within channels may occur as a result of urbanization and other alterations to a natural wetland system. Since no channel surveys are available at this phase, it is not possible to quantify the indirect impacts on wetlands due to sediment deposition, pollutant accumulation, or nutrient discharges. However, these stressors must be investigated at the design phase when detailed information is available.

3.7 Summary of Wetland Impacts

Three primary indicators of hydrologic stress were analyzed for each alternative. They included (2-YR WLF), increased ponding (7 day inundation), and decreased ponding (7 day drought), as defined previously. It should be noted that a wetland area could be affected by more than stressor. Hence, the impacted areas from ponding, drought, and WLF should not be simply added. The total indirect wetland impacted area was determined by merging the impacted wetland areas for the seven day inundation duration and drought periods and the areas that showed change in WLF for the 2-year storm event. The total indirect wetland impacted area was calculated using GIS. The total area was the union of the three separate stress indicators. All subsequent acreages and ranking criteria were calculated based on the union, or total stress caused by a given alignment. A summary table of the total indirect wetland impacted acreage can be found in *Table ES-11.*

Table ES-11: Summary Table of Indirect Wetland Impacts Acreages

Rank	Alt	Total Indirect Wetland Impacts Based on the 2 YR WLF, 7 Day Inundation, and 7 Day Drought Results (acres)	Normalized Score
1	P	1,082	5.0
2	B/O	1,390	6.5
3	Q	1,429	6.6
4	J	2,151	10.0

Alternative P ranks the highest with the least wetland area impacted. Alternative P passes through virgin territory and may appear to impact large areas of wetlands. However, the topography of land where this alignment passes is fairly steep and thus it drains efficiently with or without the alignment in place. This is evident in the small amount of wetland acreage impacted by this alignment.

Alternative B/O and Alternative Q showed similar indirect wetland impacts, while Alternative J showed the most. Alternative B/O passes through a ridge on the northern edge of the project area (along HWY 21). The topography of the local area around that alternative is steep. Moreover, most of the overland areas downstream of that alternative are not classified as wetlands. Thus it did not impact large amount of wetland acreage. Alternative J scored lower than Alternative Q even though their northern portion shares the same alignment. The southern portion of Alternative J intercepts two low gradient basins, namely Bayou Lacombe and Bayou Liberty. That added significantly to the total wetland areas impacted by Alternative J, hence the lower ranking.

These acreages are estimates based on the model results presented within this report. At the EIS phase of this study these acreages should be used for comparative purposes only. A more thorough hydrologic analysis including topographic surveys, grid refinement, and field visits will be required during the design phase to refine the preliminary acreages presented herein.

The cumulative impact of each alignment was determined by adding the normalized scores for the hydrologic stressors. The normalized scores that are shown in *Table ES-11* were used to represent the indirect wetland impacts for the seven day inundation (ponding) and drought and the 2-year WLF results. A summary of the scoring system is shown in *Table ES-12*. It was assumed here that all hydrologic stressors have equal weight.

Table ES-12: Summary Table of Indirect Wetland Impacts based on Normalized Scores

Rank	Alt	Length of New Roadway Score	Direct Wetland Impacts within the ROW Score	Indirect Wetland Impacts Outside of the ROW Score	Culvert Analysis Score	Total Points
1	Q	5.9	7.9	6.6	4.3	24.7
3	J	3.6	9.7	10	5.7	29
2	P	10	9.3	5	7.7	32
4	B/O	8.4	10	6.5	10	34.9

4.0 Conclusions

A drainage and wetland impact analysis was performed for four alternative alignments, namely Alternative P, J, Q, and B/O. The analysis included three main components, drainage, direct wetland impact, and indirect wetland impact analyses. A simple ranking system was adopted herein to rank the four alternatives. An equal weight was given to each factor included in the analysis. Based on the ranking system, Alternative Q is the most favorable alternative (*Table ES-13*). Alternative J and Alternative P ranked second and third; while Alternative B/O showed the most impacts from a hydraulic and wetland stand point. It should be noted that this ranking is limited to drainage and wetland impact analyses. These alternative routes may score differently in other technical areas (e.g. traffic analysis, or line and grade) and hence these rankings alone do not constitute a final endorsement of any given alignment.

Table ES-13: H & H and Indirect Wetland Impact Results

Alternative	Overall Ranking
ALT Q	1
ALT J	2
ALT P	3
ALT B/O	4

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1.0 Introduction

1.1 Overview

The U.S. Army Corps of Engineers (USACE), New Orleans District (CEMVN), has prepared an environmental impact statement (EIS) to evaluate the potential environmental and socioeconomic consequences of granting permits to the Louisiana Department of Transportation and Development (LADOTD) for the construction of the proposed Louisiana Highway (LA) 3241 from the LA 40/41 intersection in Bush, Louisiana, to Interstate 12 (I-12). Since the project proposes work in wetlands and structural crossings along various waterways in the project area, a Department of Army (DA) permit pursuant to section 10 of the Rivers and Harbors Act of 1899 and section 404 of the Clean Water Act (CWA) is required prior to any construction activities. Therefore, this technical report will present the development and results of the hydrologic modeling, hydraulic analysis, and indirect wetland impact analysis for the existing conditions, as well as four chosen roadway alignments for the I-12 to Bush corridor.

1.2 Geographical Description

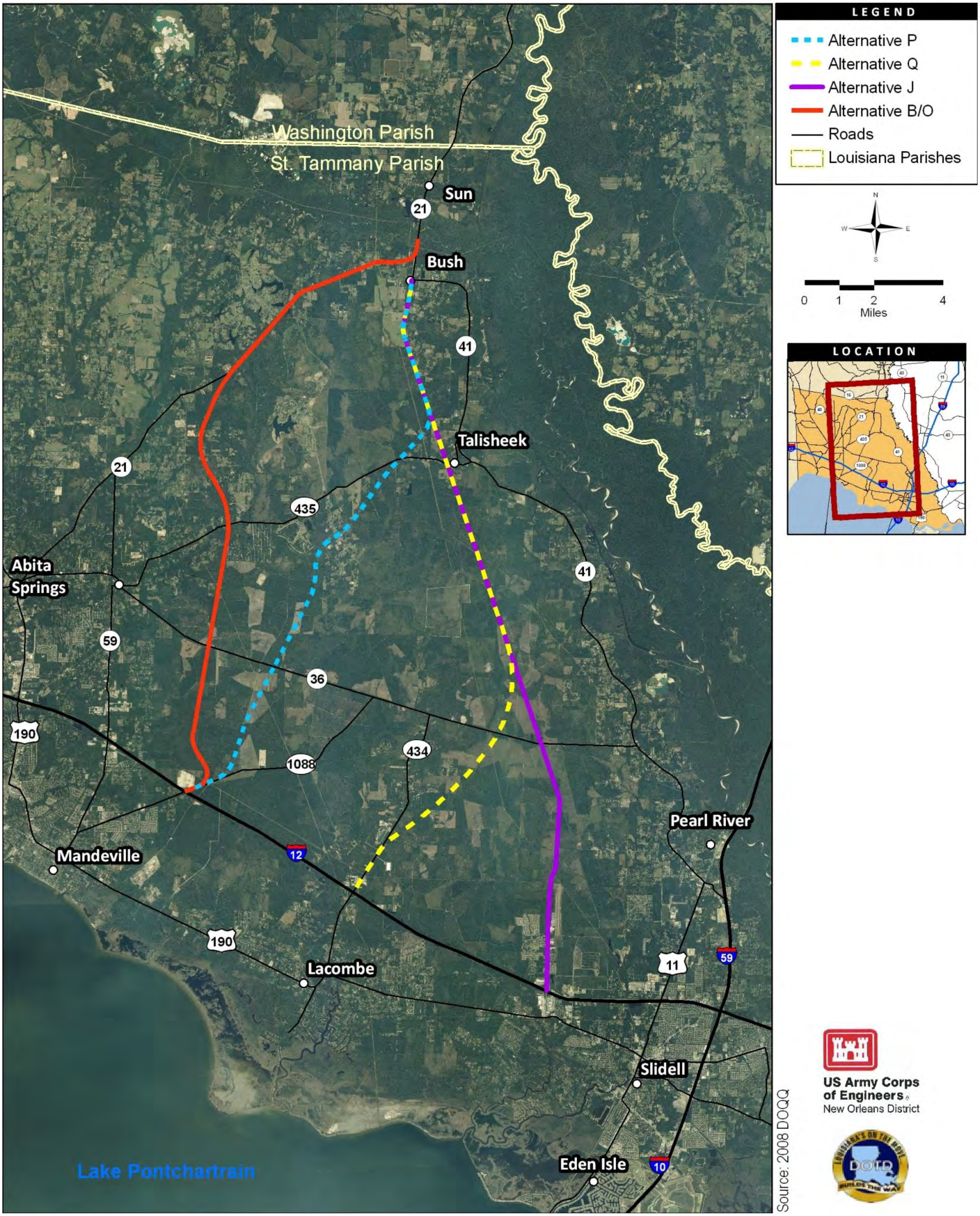
The project area is wholly located within St. Tammany Parish, Louisiana, and roughly bounded by LA 21, U.S. Highway (US) 190, I-12, US 11, and LA 41 (*Figure 1*). It encompasses approximately 245 square miles in area and includes the incorporated areas of Abita Springs, Pearl River, and portions of the cities of Slidell and Covington. Unincorporated areas, such as Bush, Hickory, Talisheek, and Waldheim, are included in the project area.

1.3 Project Background

The proposed I-12 to Bush highway is a planning effort by the LADOTD and funded by the Transportation Infrastructure Model for Economic Development (TIMED) program (Louisiana Revised Statute 48:820.2). The TIMED program, approved by the 1989 General Session of the Louisiana State Legislature, identified a 15-year construction program funded by a 4-cent fuel tax, which includes the construction of the proposed LA 3241 highway between Bush, LA, and I-12 in St. Tammany Parish. Revised Statute 47:820.2.B(1)(e) provides that a project from I-12 to Bush be constructed as a four-lane or more highway. The proposed highway would implement a four-lane highway connection for Washington and northern St. Tammany Parishes to I-12, with the purported goal of providing for regional transportation needs and stimulating undefined economic growth and activity in the region.

Louisiana Highway (LA) 21 is a four-lane divided highway between the cities of Bogalusa in Washington Parish and Bush in St. Tammany Parish, ending at its intersection with LA 41. The proposed I-12 to Bush highway would extend the four-lane section from that point to an existing interchange on I-12 by upgrading the existing highway to a four-lane highway or by constructing a new alignment. The proposed highway would be designed as a rural arterial-3 (RA-3) with a posted speed limit of 65 miles per hour. The typical cross section of the highway would have two, 12-foot travel lanes, an 8-10 foot outside shoulder, and a four-foot inside shoulder in each direction. The median width would vary depending on highway design but typically consists of 60 feet. The right-of-way (ROW) width would typically be 250 feet but may require additional ROW in areas of large cut or fill sections, such as bridge embankments.

Figure 1 Vicinity Map



1.4 Coordination

Several federal and state agencies have joined the CEMVN in preparing the EIS. The CEMVN acts as the project lead while the other agencies participate as commenting agencies. These other agencies contribute information and experience in resource-specific areas, as well as an interest in identifying and analyzing the relevant issues. The following have accepted commenting agency status for preparing the draft EIS: U.S. Environmental Protection Agency (EPA), U.S. Department of the Interior—Fish and Wildlife Service (USFWS), Louisiana Department of Wildlife and Fisheries (LDWF), LADOTD, and Louisiana State Historic Preservation Officer. The St. Tammany Parish government is also providing data and resources in the completion of this hydrologic and hydraulic analysis.

1.5 Proposed Alignments

During LADOTD's alternatives development process, 64 alternatives were considered and then further reduced to 13 alternatives (Burk-Kleinpeter, 2006). As detailed in Section 2 of the EIS, these 13 alternatives were screened through two stages— fatally flawed and alternatives development screening. Ultimately, it was determined that four (4) build alternatives and the no-build alternative should be carried forward for detailed impact analyses. The four build alternatives include Alternative B/O, Alternative P, Alternative Q, and Alternative J *(Figure 1)*.

1.5.1 No Build Alternative

Under the No Build Alternative, the CEMVN would not issue any permits for construction of a new modern, high-speed, four-lane highway between Bush and I-12. As a result, the existing roadway network in the region would remain in its current condition and continue to serve as the transportation network to travel between Bush and I-12. LADOTD could implement future roadway projects in the project area that might improve the transportation network, but these projects may not necessarily fully meet the purpose and need of this project. If the proposed highway is not constructed, project-related impacts would be avoided. The No Build Alternative ensures that there would be no direct or indirect impacts to threatened and endangered species, wetlands, environmentally sensitive areas, aquatic resources, or historic sites as a result of the project. The CEQ-required No Build Alternative in the EIS serves as a benchmark against which build alternatives can be evaluated.

1.5.2 Alternative B/O

Alternative B/O would widen LA 21 to a four-lane highway from Bush to just north of Waldheim, then continue south along the new alignment as a new four-lane roadway. This alignment would continue south along the west side of St. Tammany Airport just south of LA 36, terminating at LA 1088 and I-12. This alternative optimizes as much of the existing highway alignments and non-wetland areas as possible to minimize impacts to the human and natural environment. The alternative would be approximately 19.5 miles long, with 7.0 miles being the existing alignment and 12.5 miles of new alignment. The majority of the alignment would consist of an RA-3 typical cross section, which would have a typical ROW width requirement of 250 feet. Access to this route would exist in Bush and highway crossings at LA 40, LA 435 and LA 36, and then connect to LA 1088. For Alternative B/O, TetraTech, Inc. completed the determination and delineation for the waters of the U.S. The results identified approximately 385 acres of wetlands within the proposed Alternative B/O alignment right of way (TetraTech, 2010).

1.5.3 Alternative P

LADOTD's preferred alignment, Alternative P, would begin at the intersection of LA 41 and LA 40 in Bush and proceed southward for approximately 17.4 miles to LA 1088. The majority of the project (15.2 miles) would consist of an RA-3 typical cross section, which has a typical ROW width requirement of 250 feet. The northern 0.7 miles of the project would consist of an RA-2 cross section, and the southern 1.5 miles would be designed as a suburban arterial -2 (SA-2) typical section. The proposed route moves due south from the intersection of LA 41 and LA 40 in Bush for 1.5 miles. Then it would utilize an abandoned railroad corridor (approximately 2.5 miles) before turning southwesterly for approximately 13.3 miles on a new alignment and connecting with LA 1088 approximately 0.1 miles north of the current I-12 Interchange improvements. Access to this route would exist in Bush, at LA 435, at LA 36, and at the intersection with LA 1088. Existing highway crossings would be at-grade. For Alternative P, TetraTech, Inc. completed the determination and delineation for the waters of the U.S. Results showed approximately 358 acres of wetlands within the proposed Alternative P alignment right of way (TetraTech, 2010).

1.5.4 Alternative Q

Alternative Q is defined as the alternative that would include new construction of a 4-lane highway beginning at the existing I-12 interchange (Exit 74). It would tie into LA 434, and then follow an abandoned railroad corridor from a point approximately 1.7 miles north of LA 36 to Bush. This alternative would be approximately 20.0 miles long, with 9.8 miles using the abandoned railroad embankment, 8.7 miles on new alignment, and 1.3 miles on existing roadway. The majority of the alternative (17.2 miles) consists of a RA-3 typical cross section, which would have a ROW width of 250 feet. The northern 0.7 miles of the route would have a RA-2 cross section, while the southern 1.9 miles will have suburban arterial SA-1 cross section. For Alternative Q, TetraTech, Inc. completed the determination and delineation for the waters of the U.S., with results identifying approximately 305 acres of wetlands within the proposed Alternative Q alignment right of way (TetraTech, 2010).

1.5.5 Alternative J

Alternative J is defined as the alternative that would construct a new 4-lane highway from an existing interchange at I-12 (Exit 80), connecting to Airport Road. The proposed route would continue to a point directly north of the Slidell Municipal Airport, where it would then follow the abandoned railroad corridor to Bush. This proposed route would be approximately 21.1 miles long, with 14.2 miles using the abandoned railroad embankment, 5.4 miles on new alignment, and 1.5 miles of existing roadway. The majority of the route (17.5 miles) consists of a RA-3 typical cross section, which would have a ROW width of 250 feet. The northern 0.7 miles of the route consists of a RA-2 cross section, which would have a ROW width of 250 feet. There would be limited access to the route except at Bush and where the highway crosses LA 435, LA 36, and connects to Airport Road. For Alternative J, TetraTech, Inc. completed the determination and delineation for the waters of the U.S., which resulted in the identification of approximately 373 acres of wetlands within the proposed Alternative J alignment right of way (TetraTech, 2010).

2.0 Gathering and Compiling Data

Background data was compiled from a variety of sources and used in the completion of this hydrologic study. Geospatial data was obtained from federal, state, and parish agencies. The Preliminary Environmental Assessment (EA) completed by the CEMVN in 2008 also provided data. *Table 1* summarizes the datasets used in this study along with the dates they were originated and the sources from which they were collected.

Table 1: Compiled Data used in the Completion of the I-12 to Bush Corridor H&H Study

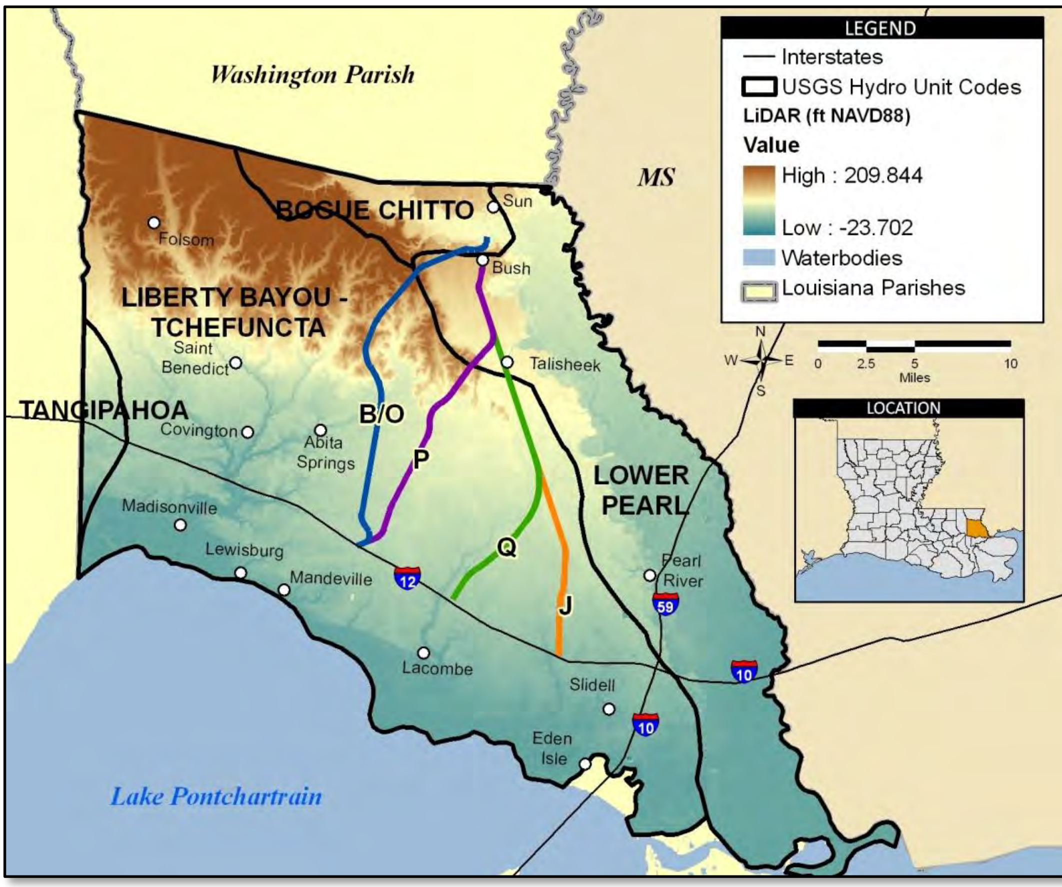
Title	Date	Source	Link
LiDAR	2004	LSU Atlas	http://atlas.lsu.edu/lidar/default.asp
DOQQ Imagery	2008	USGS	http://lacoast.gov/new/Pubs/Map_data/2008doqq/Default.aspx
Soil Data	Accessed March 2010	USDA, NRCS - SSURGO	http://soildatamart.nrcs.usda.gov
Existing Land Use and Land Cover Data	2005	LOSCO/NOAA	http://lagic.lsu.edu/loscoweb/
2025 Future Land Use and Land Cover Data	December 2003	St. Tammany Parish	http://www.stpgov.org/
Active St. Tammany Parish FEMA Flood Maps	1999	FEMA	http://www.fema.gov/
Preliminary St. Tammany Parish FEMA Flood Zones	April 30, 2008	St. Tammany Parish	http://www.stpgov.org/
Preliminary St. Tammany Parish FEMA HEC-RAS Models	April 30, 2008	St. Tammany Parish	http://www.stpgov.org/
Field Reconnaissance Photographs	May and June 2010	Fenstermaker	http://www.fenstermaker.com/
US Topographic Map	2009	USGS/National Geographic Society/ESRI	http://www.arcgis.com/home/item.html?id=9608ff2e65224ef29c7337f47108b8a5

Additionally, the detailed Hydrologic Investigation report completed in 2006, as a supporting technical document for the EA, was obtained and reviewed in detail (Burk-Kleinpeter, Inc., 2006). This report examined the hydrologic impact of LADOTD's preferred alignment, Alternative P. Since this investigation, the horizontal and vertical alignments of this alternative have been adjusted and were therefore re-evaluated as part of this study.

3.0 Hydrology

Watershed characteristics, such as watershed size, overland slope, soil types, and man-made obstructions, all affect drainage patterns and flooding within the project area. According to the U.S. Geological Survey (USGS) Hydrologic Unit Codes (HUCs), St. Tammany Parish has four major watersheds: the Bogue Chitto, Lower Pearl, Tangipahoa, and Liberty Bayou-Tchefuncta (*Figure 2*). Those watersheds are quite expansive and extend up into Washington Parish and the state of Mississippi. Within those major watersheds are smaller subbasins that drain into Lake Pontchartrain, Lake Maurepas, and the Pearl River.

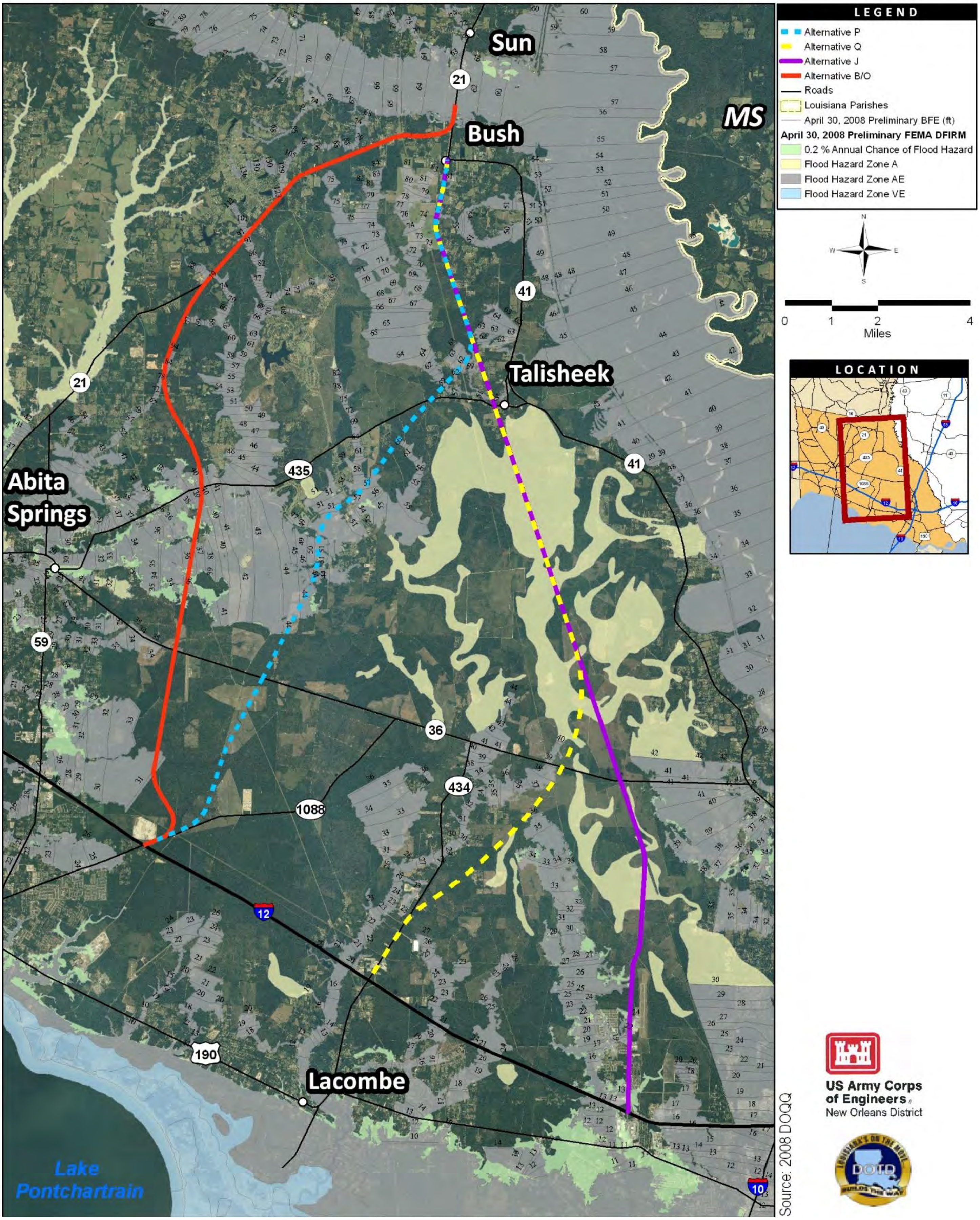
Figure 2: USGS Hydrologic Codes and LiDAR for St. Tammany Parish



Source: USGS, 2005, LSU CADGIS Reasearch Laboratory, 2010

St. Tammany Parish has a generally flat overland slope. Therefore, water tends to pond and drain slowly. This results in localized flooding conditions, as shown in the Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Maps (DFIRM) (*Figure 3*). The map shown in *Figure 3* is the preliminary DFIRM for the parish, dated April 30, 2008, and is currently under review. The maps are estimated to be approved by the end of 2011. As the best available data, these maps and base flood elevations (BFEs) were used in the completion of both the Line and Grade and Hydrologic and Hydraulic portions of this project.

Figure 3 2008 Preliminary FEMA DFIRMS



The flat topography makes it difficult to identify the natural drainage paths, which are often interrupted by man-made obstructions, such as developments and roadways. Much of the runoff in the project area occurs as sheet flow through the broad flats of land and enters tributaries that discharge into the larger channels.

3.1 Modeling Approach and Assumptions

This study analyzed the existing conditions – no build alternative, the future (2025) land use conditions – no build alternative, and each of the four alternative routes (Alternative B/O, Alternative P, Alternative Q, and Alternative J) based on the future (2025) land use conditions. The hydrologic models were completed using the USACE Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) Version 3.4. At the EIS level of this project, there was no field survey data collected. As a result, assumptions were made in the setup of the hydrologic models. These assumptions are described in the appropriate and relevant locations in the report. The work presented here is based on the best available data at the time of writing this report. Due to the flat topography of this area, as well as the broad scale of the study, further details are needed to verify basin boundaries and channel networks. A field investigation was completed along the areas with available access, but due to the dense trees and wetlands in the entire area, some places were not accessible at this phase of the study and would need further verification in the design phase.

3.2 Basin Delineation

Basins were delineated based on the Light Detection and Ranging (LiDAR) data for St. Tammany Parish, Washington Parish, and Tangipahoa Parish using ESRI ArcMap 9.3 (ArcGIS) Spatial Analyst Extension and ArcHydro Tools Version 1.2 (ArcHydro). ArcHydro runs within ArcGIS and uses the LiDAR data to model the movement of water across a surface, determining flow directions, flow accumulation, stream definitions, and basin boundaries. The basin boundaries were then verified through aerial photography, field investigations, and topographic maps.

The basin delineations were overlaid with the four alternative routes to determine the areas that would be impacted by each route. This study determined that there would be 19 hydrologic basins impacted, all totaling 145.3 square miles (mi^2) (93,002 acres).

Each basin includes smaller subbasins. For the existing conditions, 424 subbasins were delineated. For each Alternative, the subbasins were divided based on the alternative alignment. A table showing the breakdown of each alternative and the number of subbasins analyzed can be found in *Table 2*. Due to the shifting of the horizontal alignments of some of the alternatives, three of the original basins (Basins 9, 10, and 18) used in the existing analysis are no longer impacted by any of the alternatives.

A map of the existing/future drainage basins can be seen in *Figure 4*. Drainage basins for Alternative B/O, Alternative P, Alternative Q, and Alternative J can be seen in *Figure 5*, *Figure 6*, *Figure 7*, and *Figure 8*, respectively.

Table 2: Basin Summary Table

Outlet No.	Basin Name	Area (mi^2)	Existing No. of Subbasins	No. of Subbasins for each Alternative			
				ALT P	ALT Q	ALT J	ALT B/O
1	Bayou Liberty Tributary	3.60	18			23	
2	Bayou Liberty Tributary	8.12	25			33	
3	Big Branch Bayou	6.74	18		23		
4	Bayou Liberty	2.64	7		8		
5	Bayou Lacombe	24.82	63		76	69	
6	Talisheek Creek	18.06	48	54	52	52	49
7	Little Brushy Branch	3.08	10	13	13	13	
8	Simmons Creek	0.91	5				6
9	E. Fork Little Bogue Falaya Tributary	1.63	5	Not Used			
10	E. Fork Little Bogue Falaya Tributary	0.72	4	Not Used			
11	Abita River	2.09	4				5
12	Long Branch	46.96	137	151			152
13	LA 36 North Tributary	1.79	4				5
14	Southwind Branch	0.89	4				4
15	Ponchitolawa Creek	13.15	35	38			38
16	Little Creek	7.77	27	34			34
17	Bayou Lacombe Tributary	1.07	3		4		
18	Long Branch Tributary	1.03	3	Not Used			
19	Bogue Chitto River Tributary	0.23	4				5
TOTAL SUBBASINS			424	290	172	190	298
TOTAL AREA		145.33		89.02	56.6	57.71	91.85

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Figure 4 Hydrologic Drainage Basins

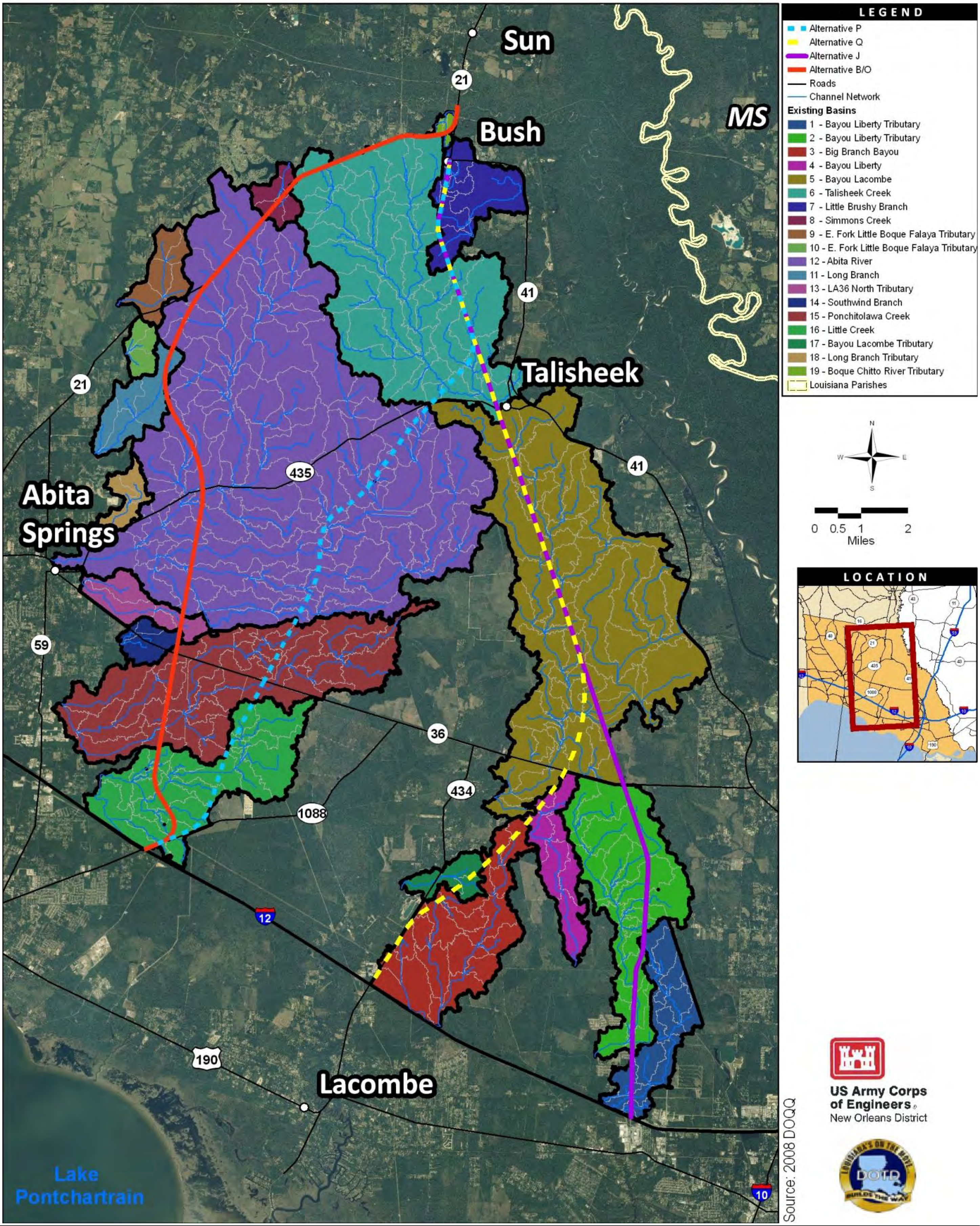


Figure 5 Alternative B/O - Hydraulic Structures and Hydrologic Basins

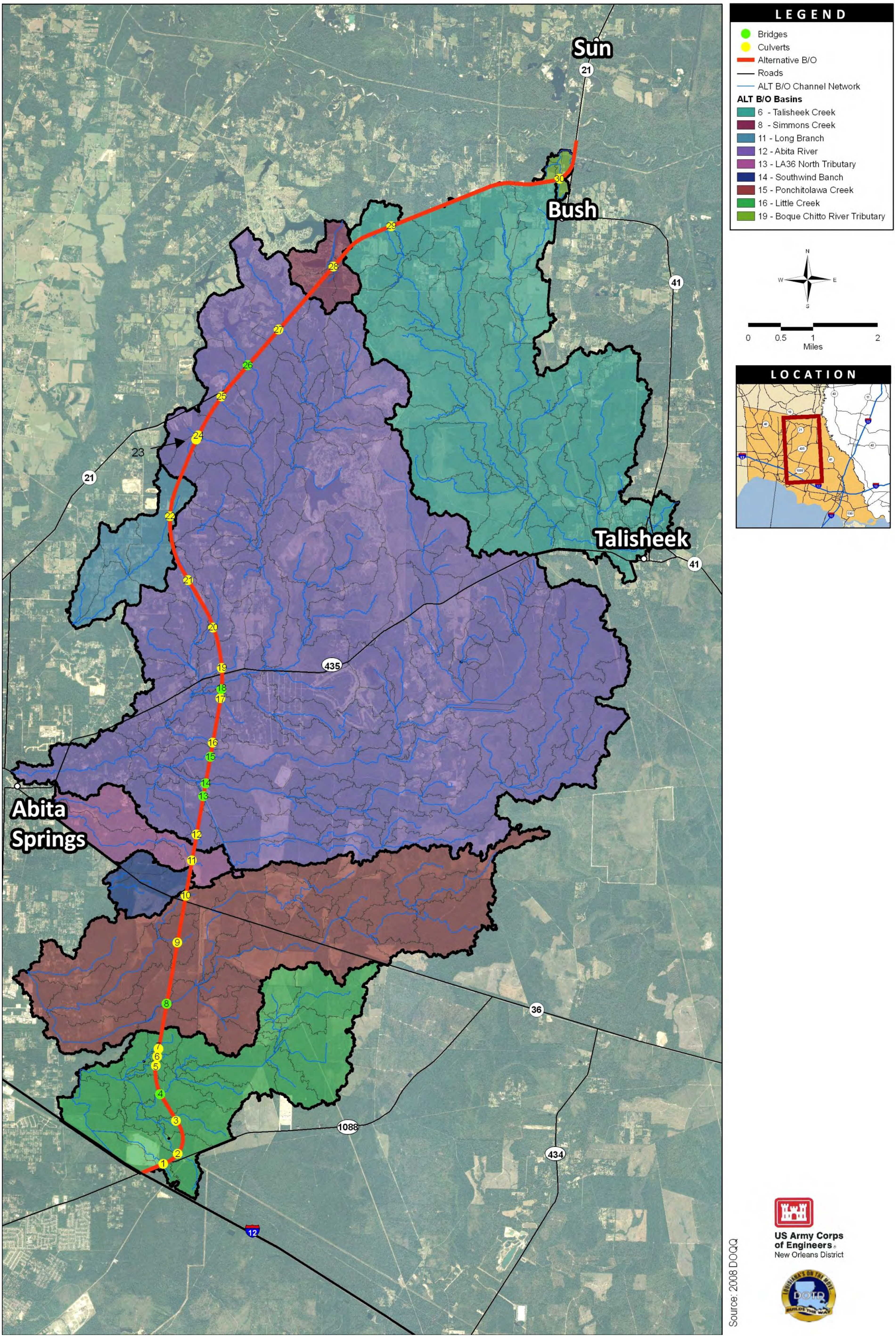


Figure 6 Alternative P - Hydraulic Structures and Hydrologic Basins

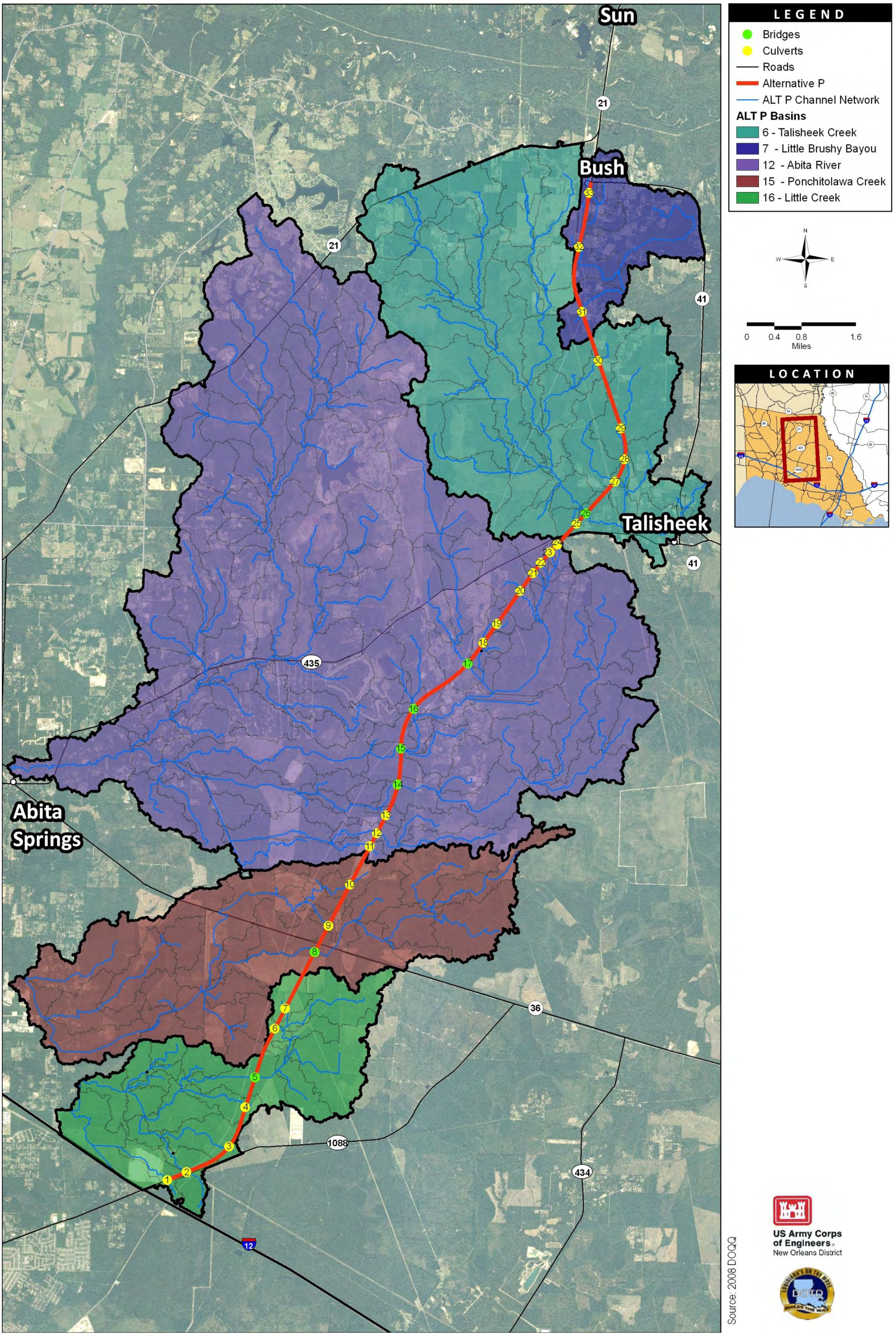


Figure 7 Alternative Q - Hydraulics Structures and Hydrologic Basins

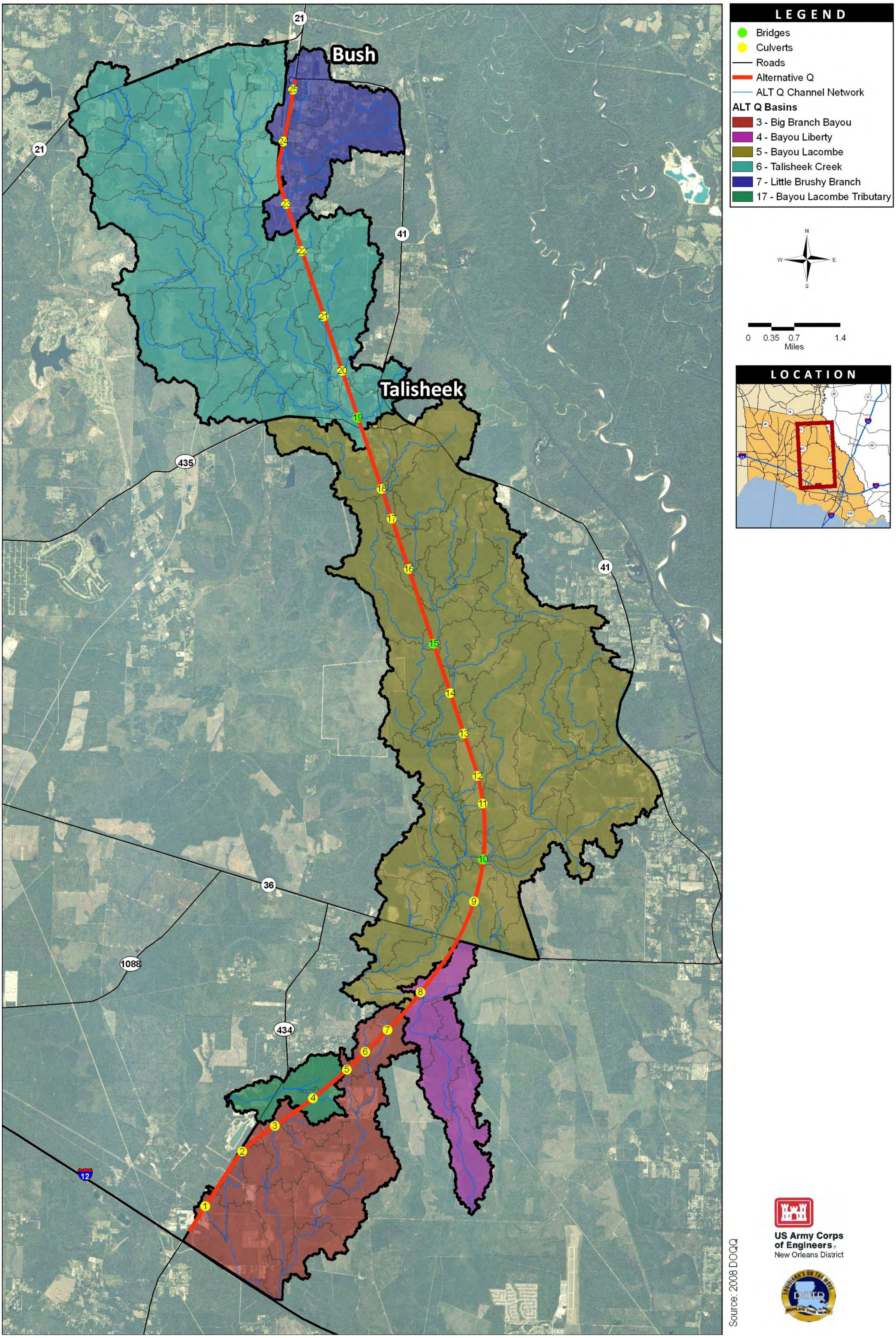
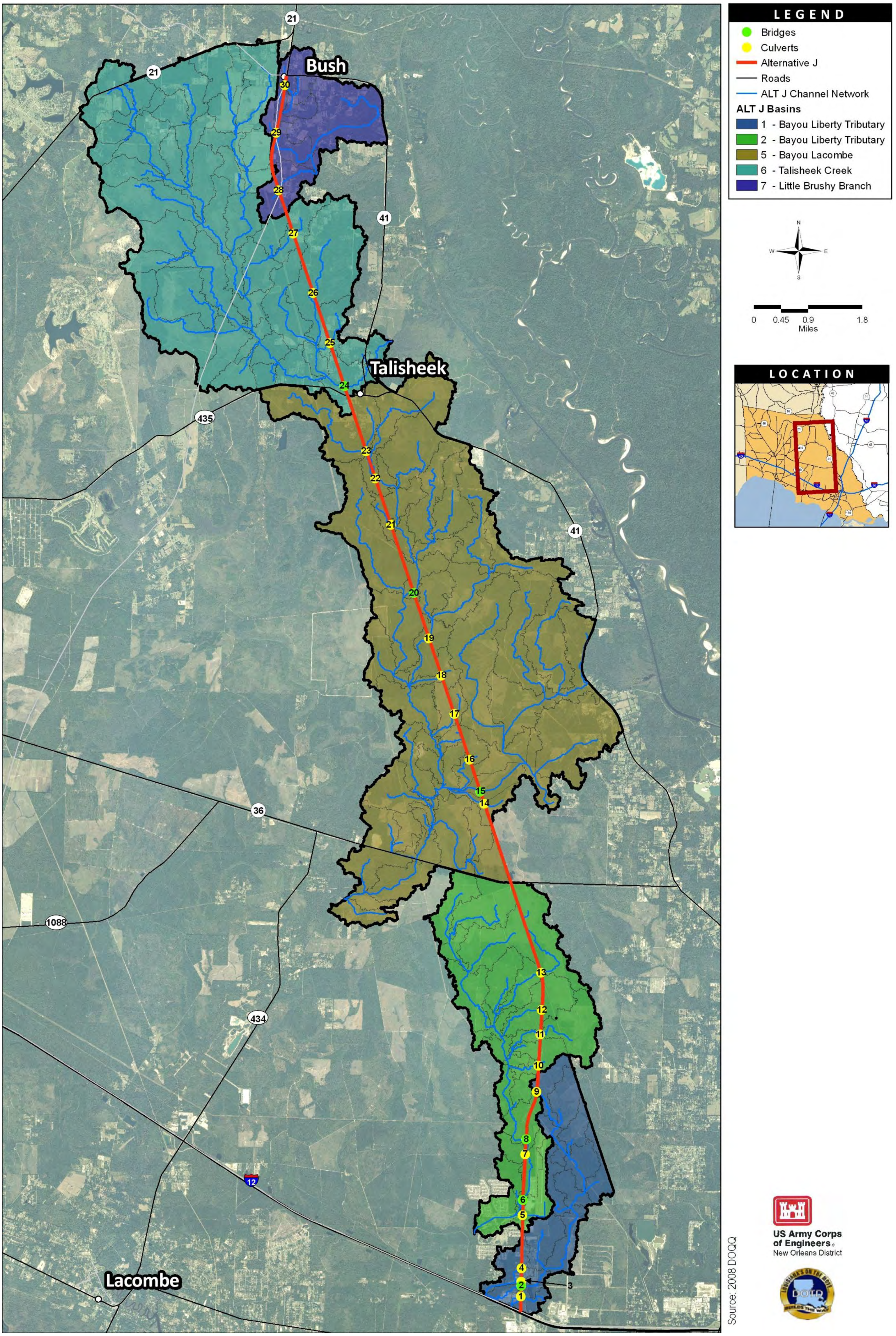


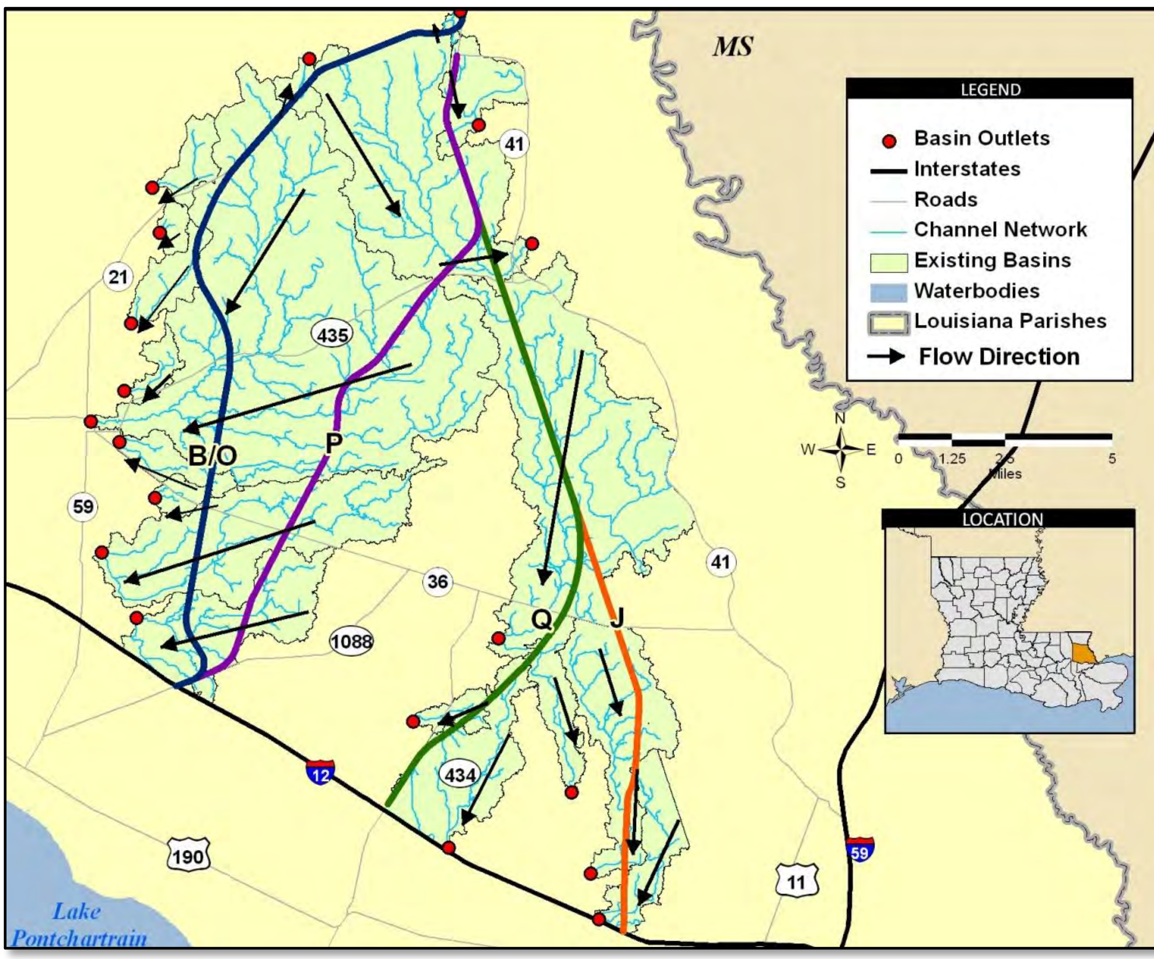
Figure 8 Alternative J - Hydraulic Structures and Hydrologic Basins



3.3 Channel Network and Direction of Flow

The project area's flat topography often makes it difficult to identify the natural drainage paths. Much of the runoff in the area occurs as sheet flow through the broad flats of land and enters tributaries that discharge into the larger channels of Abita River, Big Branch Bayou, Long Branch, Ponchitolawa Creek, Bayou Lacombe, Bayou Liberty, Talisheek Creek, Simmons Creek, E. Fork Little Bogue Falaya, Long Branch, Southwind Branch, Little Creek, Bogue Chitto River, and Little Brushy Branch. The named channels are identifiable on topographic maps. As part of the basin delineation process, the channel network for the project area was determined using LiDAR, ArcGIS, and ArcHydro. The total length of these major channels, along with their tributaries, is approximately 372 miles. The channel network was verified using aerial photography and topographic maps. However, channel networks need more extensive verification through field investigations and topographic surveys at the design phase of this project. *Figure 9* shows the flow direction, channel network, and subbasin outlets.

Figure 9: Flow Direction, Channel Network, and Subbasin Outlets



3.4 Loss Method (SCS Curve Number)

The maximum subbasin area was calculated to be 1071 acres; therefore the Soil Conservation Services (SCS) Curve Number (CN) Loss Method was used to determine the runoff volume of each subbasin within the study areas. The composite CN for each subbasin was estimated as a function of hydrologic soil group (HSG), land use conditions, and antecedent moisture conditions (AMC). Existing and future CN grids were generated through ArcGIS, ArcHydro, and HEC-GeoHMS using the Natural Resources Conservation Services (NRCS) soil data and the 2005 Land Use and Land Cover Data (LULC) of existing conditions. The St. Tammany Parish prediction of 2025 Future LULC data was used to estimate the CN values for the future conditions.

3.4.1 Existing LULC Data

The 2005 LULC dataset (existing LULC data) was obtained through the Louisiana Oil Spill Coordinator's Office (LOSCO) Data Catalog and was originally generated by the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center (CSC). This dataset was delineated pre-Hurricane Katrina (2005 era) and consisted of 23 LULC classifications. Twenty-one of these classifications are located within St. Tammany Parish, and eighteen are located within the project area. In order to simplify the task of creating the CN grid, these eighteen LULC categories were aggregated into five classifications. As can be seen from *Table 3* and *Figure 10*, the existing LULC in the project area consists predominately of variations of forest, shrub/scrub, and wetlands.

Table 3: Existing (2005) LULC Data for the Project Watershed and St. Tammany Parish

Land Use and Land Cover Description	Percent of Project Area Watershed	Percent of St. Tammany Parish
Developed	3%	7%
Agricultural/Pasture/Rangeland	8%	7%
Forest	44%	21%
Shrub/Scrub	31%	13%
Water/Wetland	14% (1% Water and 13% Wetland)	52% (25% Water and 27% Wetlands)

Source: NOAA 2006

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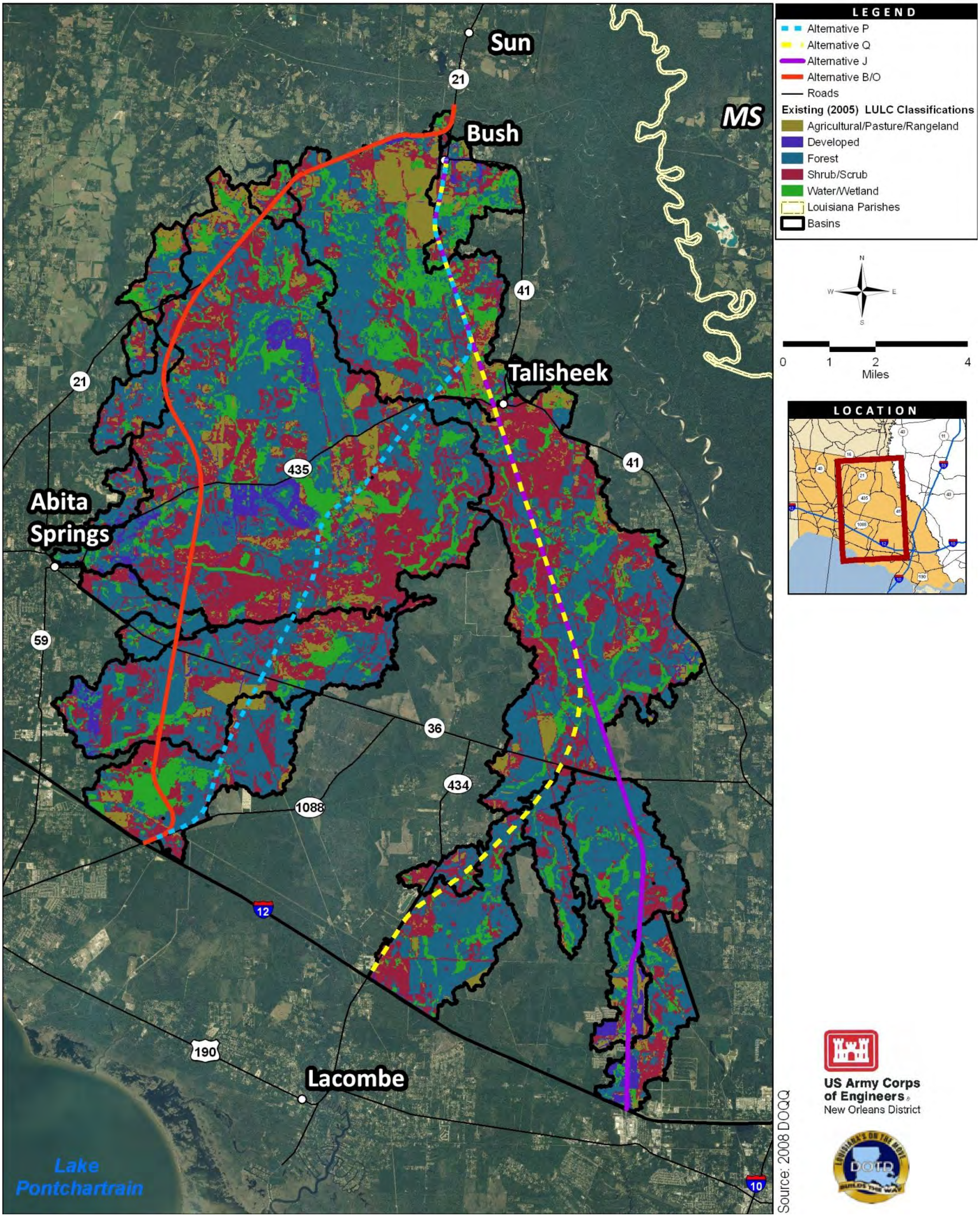
Figure 10 Existing (2005) Land Use and Land Cover (LULC) Data



3.4.2 Future LULC Data

The New Directions 2025 (ND 2025) comprehensive plan for St. Tammany Parish was initiated in December 1998. It included a vision statement (adopted in 2000), transportation plan (adopted August 2001), and a 2025 land use plan (adopted December 2003) for the parish. The designation of the 2025 land use areas were determined based on predicted commercial, industrial, and residential growth, recreational areas, rural zones, flood protection, transportation (I-12 to Bush Alternative P was considered as part of the transportation plan), conservation, and tax and economic growth. The New Directions 2025 Plan was completed prior to hurricane Katrina and does not reflect any impacts the hurricane may have had on the development or growth on the study area. Despite that, this was the best available data at the time of research and was therefore used to approximate the future CN values in the project area.

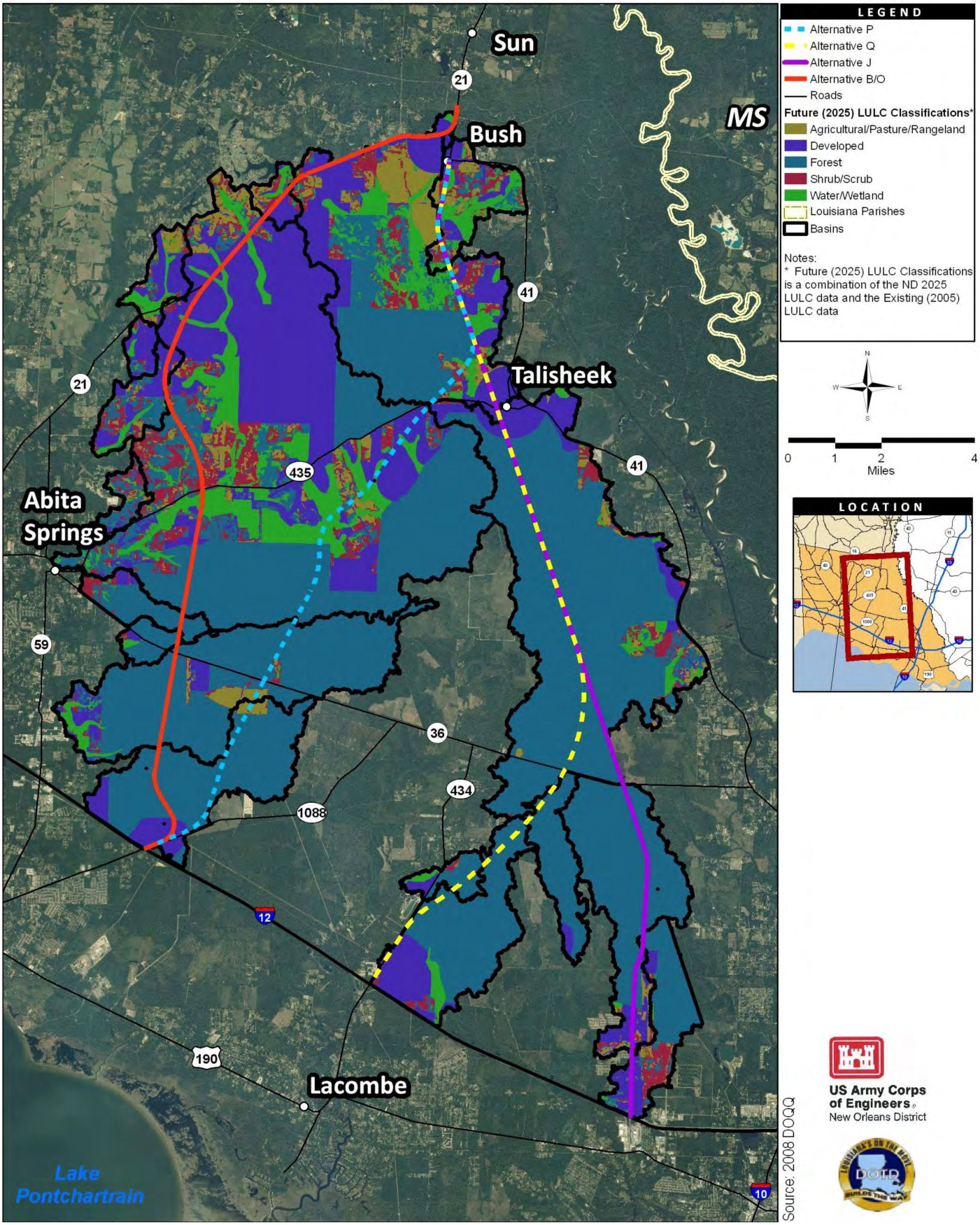
The ND 2025 LULC data was completed on a coarser scale than the existing (2005) LULC data and was therefore merged with the existing (2005) LULC data in order to calculate the future CN values (*Table 4*). The reduction in wetland area in the future LULC conditions can be attributed to the change in territory classification from forested wetlands in the 2005 LULC data to forest area. The aggregated future (2025) LULC map can be seen in *Figure 11*.

Table 4: Existing (2005) LULC Data for the Project Watershed and St. Tammany Parish

<table>
<tr><th>Land Use and Land Cover Description</th><th>Aggregated LULC Classification</th><th>Percent of Project Area Watershed</th></tr>
<tr><td>Airport</td><td rowspan="6">Developed</td><td rowspan="6">22%</td></tr>
<tr><td>Commercial</td></tr>
<tr><td>Industrial</td></tr>
<tr><td>Mixed Use</td></tr>
<tr><td>Residential</td></tr>
<tr><td>Developed (Existing 2005 LULC)</td></tr>
<tr><td>Agricultural/Pasture/Rangeland (Existing 2005 LULC)</td><td>Agricultural/Pasture/Rangeland</td><td>4%</td></tr>
<tr><td>Timber</td><td rowspan="2">Forest</td><td rowspan="2">59%</td></tr>
<tr><td>Forest (Existing 2005 LULC)</td></tr>
<tr><td>Shrub/Scrub (Existing 2005 LULC)</td><td>Shrub/Scrub</td><td>6%</td></tr>
<tr><td>Conservation</td><td rowspan="2">Water/Wetland</td><td rowspan="2">9%</td></tr>
<tr><td>Water/Wetlands (Existing 2005 LULC)</td></tr>
</table>

Source: St. Tammany Parish

Figure 11 Future (2025) Land Use and Land Cover (LULC) Data



3.4.3 Soil Data and Hydrologic Soil Groups

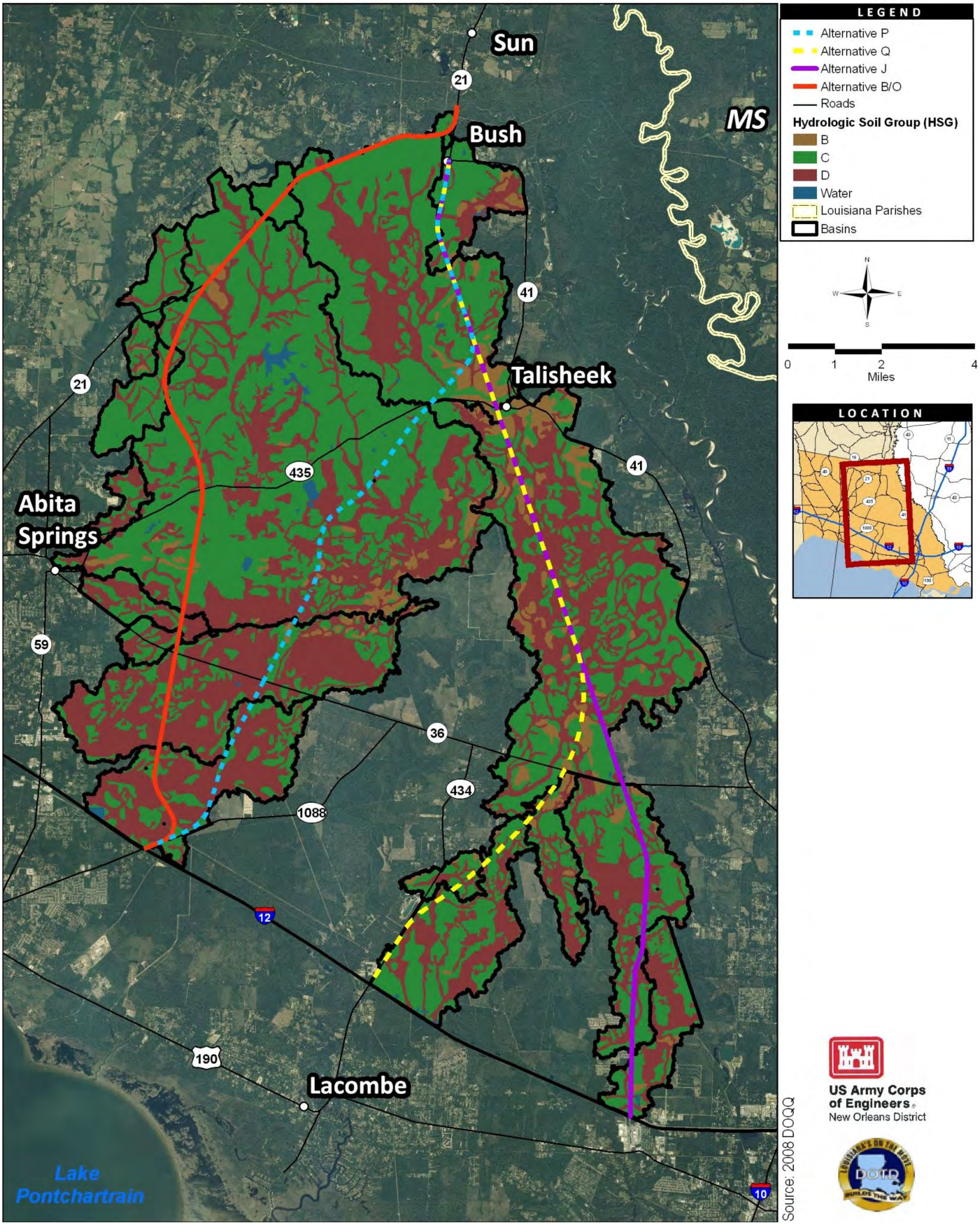
Soils are classified into Hydrologic Soil Groups (HSGs) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. According to the Natural Resources Conservation Services (NRCS), the majority of the soil in the area of the proposed alternative routes is classified as HSGs C and D (*Table 5* and *Figure 12*). Soils classified as Group C are sandy clay loam and have low infiltration rates when thoroughly wetted. Soils classified as Group D are clay loam, silty clay loam, sandy clay loam, silty clay, or clay and have high runoff potential with very low infiltration rates. To simplify CN calculations, areas coded as "Water" were classified as HSG D.

Table 5: Hydrologic Soil Groups

NRCS Soil Classification Abbreviation	NRCS Soil Classification Name	Percent of Project Area Watershed	HSG	Percent of HSG for Watershed
Ca	Cahaba Fine Sandy Loam, 1 to 3 % Slopes	1.3%	B	5.2 %
Lt	Latonia Fine Sandy Loam	3.8%		
Rt	Ruston Fine Sandy Loam, 3 to 6 % Slopes	0.0%		
Aa	Abita Silt Loam, 0 to 2 % Slopes	0.3%	C	55.2%
AT	Arkabutla and Rosebloom Soils, Frequently Flooded	0.0%		
OB	Ouachita and Bib Soils, Frequently Flooded	1.9%		
Pr	Prentiss Fine Sandy Loam, 0 to 1% Slopes	9.7%		
Pt	Prentiss Fine Sandy Loam, 1 to 3 % Slopes	0.5%		
Sa	Savannah Fine Sandy Loam, 1 to 3 % Slopes	10.6%		
Sh	Savannah Fine Sandy Loam, 3 to 6 % Slopes	5.1%		
St	Stough Fine Sandy Loam	27.2%		
AR	Arat Silty Clay Loam	0.5%	D	39.1%
Bg	Brimstone-Guyton Silt Loams	0.1%		
Dp	Dumps	0.0%		
Gt	Guyton Silt Loam	0.8%		
Gy	Guyton Silt Loam, Occasionally Flooded	0.4%		
Mt	Myatt Fine Sandy Loam	20.7%		
My	Myatt Fine Sandy Loam, Frequently Flooded	16.6%		
Pg	Pits	0.0%		
W	Water	0.5%	W/D	0.5%

Source: NRCS 2010

Figure 12 Hydrologic Soil Group Map



3.4.4 Existing and Future CN Grids

The existing and future CN grids for the I-12 to Bush study area were created in ArcGIS with the HSG data and LULC data (discussed previously). For the recurrence interval storms analyzed (50-year and 100-year), the CN values represent the average antecedent moisture conditions (AMC II). The CNs used to estimate the runoff were determined from the TR-55 manual. *Table 6* gives a summary of the CN values used in relation to HSG and LULC classification for both the existing (2005) and future (2025) conditions.

Table 6: CN Values based on HSG and LULC Classifications

LULC Name	HSG B	HSG C	HSG D
Developed	89	92	93
Agricultural/Pasture/Rangeland	73	82	85
Forest	61	74	80
Shrub/Scrub	56	70	77
Water/Wetlands	98	98	98

* AMC-II CN values were obtained from the NRCS 210-VI-TR55 Second Ed., June 1986

The existing (2005) weighted CN values were calculated from the CN grid for each subbasin. The existing CN values ranged between 63 and 98, with an average value of 79. CN statistics can be found in *Table 7.* A map of the existing weighted CN value for each subbasin can be seen in *Figure 13*. A map of the existing CN grid can be found in Appendix A.

The future (2025) weighted CN values were also calculated based on the CN grid values for each subbasin. The future CN values ranged between 65 and 98, with an average value of 82. Even though the overall average CN of the project area increased for future conditions, there were some areas where the future CN experienced reduction in comparison to the existing conditions. This can be attributed to the future areas being designated as conservation areas, as well as the coarser detail of the future LULC map. The future CN estimated range can also be found in *Table 7* and a map of the future weighted CN values for each subbasin can be found in *Figure 14*. A map of the future CN grid can be found in *Appendix A*.

Table 7: CN Estimated Range for Existing and Future Conditions

Basin	Existing (2005) CN Estimated Range			Future (2025) CN Estimated Range		
	Minimum	Maximum	Average	Maximum	Minimum	Average
1	75	90	82	73	91	82
2	74	89	80	74	93	79
3	74	82	77	74	91	80
4	69	81	75	70	80	75
5	63	93	78	65	89	76
6	73	98	81	74	98	84
7	77	91	82	81	98	87
8	78	83	80	83	87	85
9	76	85	81	85	90	88
10	78	86	80	86	95	90
11	74	77	76	79	84	83
12	70	96	79	71	98	85
13	78	79	79	77	81	79
14	75	80	79	76	80	78
15	74	90	80	74	94	79
16	75	98	81	75	90	80
17	73	78	76	72	87	79
18	78	79	78	78	79	78
19	76	92	83	92	98	95

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Figure 13 Existing (2005) Curve Number (CN) Map

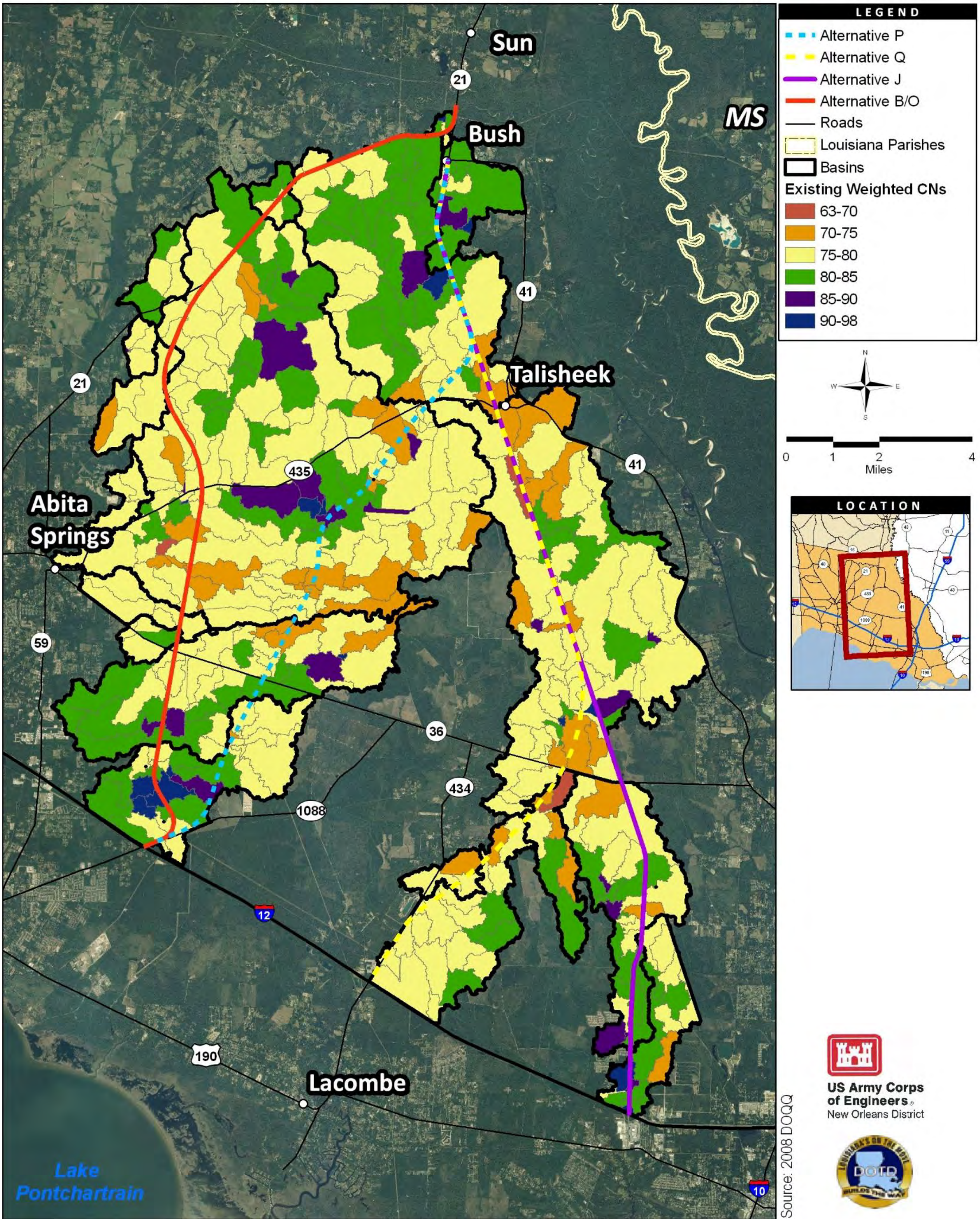
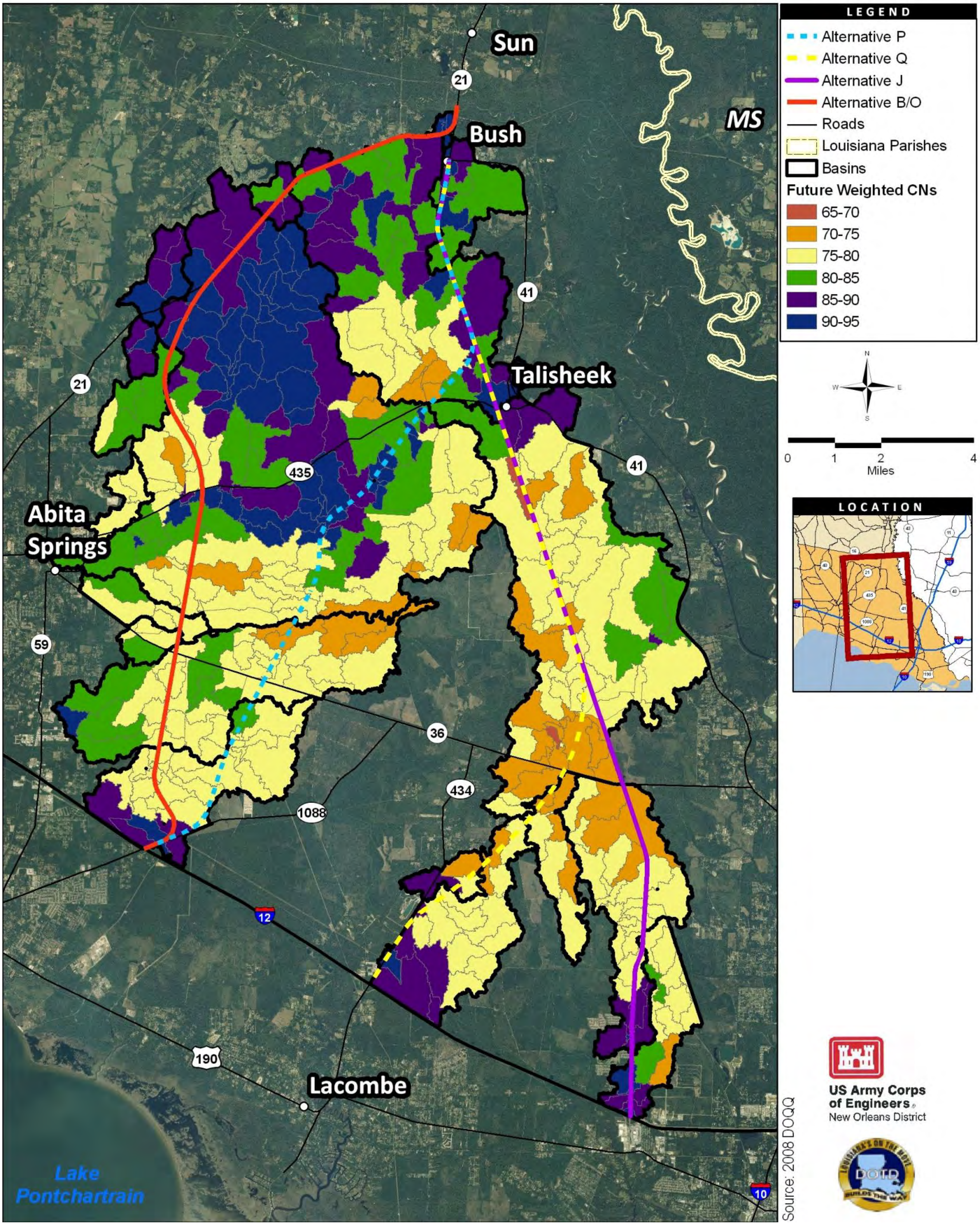


Figure 14 Future (2025) Curve Number (CN) Map



3.5 Transform Method (SCS Unit Hydrograph)

The SCS Unit Hydrograph Transform Method was used to calculate the basin runoff for the HEC-HMS models. In this method, the general hydrograph is scaled by the lag time to produce the unit hydrograph. The standard shape was used in this study and is defined as the length of time between the centroid of precipitation mass and the peak flow of the resulting hydrograph. For ungauged watersheds, the SCS suggests that the unit hydrograph lag time (t_{lag}) be related to the time of concentration (t_c), as (USACE, 2009):

$$t_{lag} = 0.6 * t_c \qquad \text{Equation 1}$$

As part of this analysis, the t_c was calculated using the following equation (LADOTD, 1987):

$$t_c = \frac{L^{0.8}(\frac{100}{CN}-9)^{0.7}}{1140*S^{0.5}} \qquad \text{Equation 2}$$

Where:
t_c = time of concentration, hrs
L = hydraulic length of watershed, feet
CN = weighted runoff curve number
S = average watershed land slope in percent

The hydraulic length of a watershed is the distance the runoff must traverse from the most distant portion of the watershed to the point under consideration. The average watershed land slope is calculated using the elevations along the hydraulic lengths of the watershed. A minimum slope of 0.1 percent was used. Calculations of t_c and t_{lag} for each subbasin (existing, future, and for each alternative) can be found in the *Appendix*.

3.6 Routing Method (Lag Method)

A reach is an element with one or more inflow and only one outflow and is typically used to model rivers and streams. The outflow is calculated using a routing method in order to simulate open channel flow. Topographic survey data typically provides reach data, such as channel cross sections, profile slopes, and channel roughness. However, since this EIS did not include the collection of this data, suppositions were made based on professional engineering judgment and on available LiDAR data.

Using the limited data, it was determined that the lag time method would be the most appropriate routing method. The lag time was calculated using Equation 1. The time of concentration was calculated by dividing the average channel velocity by the reach length. If a reach was observed on U.S. Topographic maps, thus indicating an existing channel, the velocity in the reach was approximated to be 5 feet per second. If the reach was not visible on the U.S. Topographic maps, the flow through the channel was surmised to be shallow concentrated (unpaved), and the velocity was calculated using the TR-55 equation located in Appendix F of the TR-55 Manual (NRCS 1986):

$$V = 16.1345 * s^{0.5}$$ Equation 3

Where: V = average velocity, ft/s
s = slope of the hydraulic grade, ft/ft

A table of all of the reach characteristics for the existing, future, and alternative models can be found in the *Appendix*.

Peak flows calculated based on the HEC-HMS models were compared to the FEMA models and Flood Insurance Study (FIS) data, where available. The routing standard, detailed previously, was modified for Basin 12- Abita Creek (discharges to Alternative B/O Structure 18) based on these comparisons. Even though the channels along this system were identifiable in topographic maps, the lag time was calculated with the premise of shallow concentrated flows. The original standard resulted in flows of approximately 20,000 cubic feet per second for the 50-year storm event. With the adjustment, the flows were reduced to 10,800 cubic feet per second, which was comparable to the discharges found in the FIS.

3.7 Meteorological Data

The HEC-HMS models were used to calculate the runoff for the 50-year and 100-year flood frequency storms. The 24-hour rainfall depths were obtained from the LADOTD Hydraulics Manual (Region 1) and distributed according to the SCS Type III distribution. These depths can be seen in *Table 8*.

Table 8: Storm Recurrence Interval and Depths

Storm	Depth (inches)
50-year 24-hour	11.1
100-year 24-hour	12.6

4.0 Hydraulics Analysis

The peak flows determined through HEC-HMS were used to size the proposed drainage structures. The structures were analyzed using the LADOTD HYDRWINT software series. The LADOTD Hydraulics Analysis of Culverts (HYDR1120) was used for culvert sizing, and the LADOTD Open Channel Flow (HYDR1140) was used to check the water surface elevation for bridges.

Considering the schematic level of design required at this point in the project and the lack of field data, the sizes and types of structures should be considered preliminary (and not for construction). However, these designs are sufficient for the line and grade study and to provide a construction cost estimate that can be incorporated into the total project costs. A more detailed hydraulic study will need to be completed on the proposed bridge structures using HEC-RAS or WSPRO during the design phase of this project in order to evaluate the 50-year and 100-year existing and constructed water surface profiles, as well as the 500-year storm scour analysis.

Major hydraulic crossings were sized for the 50-year storm event under future land use conditions. The criteria for determining whether a structure would be sized as a culvert or a bridge can be found in *Table 9*.

Table 9: Road Crossing Design Criteria

Design Discharge cfs	Structure Type
Below 250	Pipe Only
250-750	Pipe or Reinforced Concrete Box (RCB)
750-1,000	Pipe, RCB, or Bridge
Above 1,000	Bridge

Source: LADOTD Hydraulic Design Guidelines – Off-System Bridge Replacement and Rehabilitation Program

4.1 Major Cross Drain Culverts

LADOTD HYDR1120 Hydraulic Analysis of Culverts program was used as the primary designing mechanism to calculate the headwater and the outlet velocity at the major cross drain culvert locations. Culvert structures were sized based on LADOTD guidelines, which state that an allowable differential head (ADH) of one foot to one and a half (1.5) feet (LADOTD 1987 – Page 143) should be used in wetland areas. However, the upstream areas of many of the structures along the proposed alignments are a combination of wetland, agricultural, forest, and developed land; and have also been noted as areas of possible future development. Therefore, it was determined that the project area would be better defined as a Category 3 area as detailed in LADOTD Hydraulics Manual (LADOTD 1987 – Table 1.8). The project area is rural on the outskirts of a town with some existing development and expected future growth. It has a relative flat land (terrain representative of south Louisiana). Based on this assumption, the most important design criterion is the ADH, and was limited to one foot. The allowable headwater (AHW) was also checked as a design criterion to ensure that there was a minimum of one foot elevation difference from the edge of travel lane. The AHW was also checked to be no more than three feet above the top of the culvert. The proposed structures were also analyzed to ensure that the peak runoff for the 100-year storm event did not overtop the crown of the road.

The following assumptions were made for culvert calculations:

- There were only two types of culverts used for design: reinforced concrete pipe (RCP) or reinforced concrete box (RCB).
- All RCP structures are projecting from the fill, while RCB structures have a flat headwall.
- Structure length is 176 feet.
- The maximum number of pipes in a row is four (LADOTD *Hydraulic Design Standards* 7).
- Allowable Differential Head is less than one foot for the 50-year design storm.
- A standard uniform slope of 0.1% (0.001 ft/ft) for all major culverts was used. This assumption was based on the recommendation of LADOTD due to the generally flat channel slopes. Culverts are designed on the same slope as the natural streambed slope. Therefore, a complete survey should

be completed during the design phase of this project, and the major culverts should be reevaluated based on the channel slope data.

- Structures with high outlet velocities (greater than nine feet per second) shall require discharge erosion protection at the time of final design (LADOTD 1987).
- For low fills, a one foot minimum must be upheld between the edge of the travel lane and the allowable headwater elevations (LADOTD 1987).
- For high fills, a three foot maximum must be upheld between the top of the pipe and the average headwall elevations (LADOTD 1987).
- The crown elevation of the roadway must not be overtopped during the 100-year design storm.
- The tailwater elevation of the culverts was set to equal the culvert diameter.

Due to lack of field survey data, the channel inverts are unknown at this time. LiDAR data does not penetrate through the water surface. Therefore, the LiDAR elevation is not representative of the channel bottom. As such, the culvert inverts were estimated using the following equation:

$$Channel\ Invert = Crown\ Elevation - 4\ ft - Culvert\ Diameter \qquad \text{Equation 4}$$

The four feet of cover includes one foot of pavement material, one foot of base material, one foot of subbase material and one foot to ensure that the subbase does not become inundated. At locations where the culvert invert appeared to be higher than the LiDAR elevation, the culvert invert was reduced to equal the LiDAR invert.

4.2 Minor Cross Drain Culverts

According to the LADOTD Hydraulics Manual (page 73) on long continuous grades, which are unbroken by lateral outfalls, equalizers shall be used at intervals of approximately 1,000 to 1,500 feet. Equalizers should be 24-inch diameter pipes or round equivalent pipe arches. They must be installed at zero percent (0%) slopes. The purpose of the equalizer pipes is to distribute the flow between the channels on either side of the road. In the design phase of the project, a more detailed field investigation is needed to properly identify the best location for these equalizers. At this phase of the study, only the number of equalizer pipes for each alternative was determined based on distance between major structures.

4.3 Bridges

Bridges are recommended at locations where the peak runoff exceeds 1,000 cubic feet per second. Flows were calculated from the SCS method described within this report. Formally, this method should be applied to basins greater than 2,000 acres. However, it was appropriate to use the SCS method here since routing time was accounted for, and the area was subdivided into smaller subbasins. To further verify that this approach is appropriate, the USGS method was applied at bridge locations where the contributing drainage area was greater than 2,000 acres. The differences in flows between the SCS and USGS method were within a tolerable range, with majority of the locations showing that the SCS Method was a more conservative approach. The USGS flow calculations can be found in the *Appendix* for each alternative.

The bridge spans were sized using LADOTD HYDR1140 Open Channel Flow program. This is used only to provide a preliminary estimation of the bridge size. At the time of final design, a comprehensive hydraulic analysis of each bridge should be conducted using either WSPRO or HEC-RAS modeling software. Surveyed cross sections upstream and downstream of each proposed bridge structure will need to be obtained and the 50-year and 100-year existing conditions and constructed water surface elevations will need to be calculated. Additionally, a scour analysis will need to be completed for the 500-year storm event. A detailed FEMA no-rise analysis may also need to be completed at the bridge locations as part of the final design.

At the current EIS phase of this project, the following assumptions were made when the bridges were sized:

- The channel section is rectangular.
- Channel slope is based on the slope of the channel downstream of the proposed structure.
- The Manning's Roughness Coefficient n is 0.05, which represents an excavated channel in clay with the growth of weeds and grass (LADOTD 1987).
- Structure width is approximated using LiDAR data and finalized through analysis iterations and coordination with the line and grade team.

Elevations and flows were compared to the Preliminary (April 2008) FEMA USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) models, where available. Culverts and bridge crossings were also compared against structure crossings along existing highways. However, due to the width of the proposed roadway, many of the proposed crossings are not the same size as what is currently in the field. Structures for each alternative were numbered from south to north (starting from I-12 heading toward Bush).

4.4 Hydraulic Results for Alternatives

The channel crossings (culverts and bridges) are sized and presented in this section. A list of the structures for each alternative can be found in *Table 10*. All culverts were sized based on the surmise that the structure would be made of reinforced concrete (RCP or RCB). Supporting documents, such as summary tables, maps, and LADOTD calculations, can be found in the *Appendix* for each alternative as follows:

- *Appendix B* – Alternative B/O
- *Appendix C* – Alternative P
- *Appendix D* – Alternative Q
- *Appendix E* – Alternative J

Table 10: Structure Sizes

Structure No.	Structure Type			
	ALT B/O	ALT P	ALT Q	ALT J
1	2– 48" RCP	2 – 48" RCP	2 -48" RCP	1 – 60" RCP
2	3 – 60" RCP	2 – 60" RCP	1 – 42" RCP	425' Bridge
3	3 – 54" RCP	1 – 54" RCP	1 – 54" RCP	1 – 54" RCP
4	450' Bridge	1 – 54" RCP	2 – 60" RCP	1 – 54" RCP
5	1 – 42" RCP	140' Bridge	1 – 36" RCP	2 – 60" RCP
6	1 – 42" RCP	1 – 42" RCP	1 – 60" RCP	250' Bridge
7	1 – 54" RCP	2 – 54" RCP	1 – 60" RCP	1 – 54" RCP
8	450' Bridge	100' Bridge	1 – 48" RCP	450' Bridge
9	2 – 54" RCP	1 – 54" RCP	4 – 54" RCP	1 -30" RCP
10	2 – 48" RCP	2 – 48" RCP	500' Bridge	2 – 48" RCP
11	2 – 54" RCP	1 – 54" RCP	1 – 30" RCP	3 – 54" RCP
12	2 – 54" RCP	3 – 60" RCP	1 – 60" RCP	2 – 60" RCP
13	150' Bridge	1 – 48" RCP	2 – 48" RCP	3 – 54" RCP
14	300' Bridge	140' Bridge	3 – 8' x 5' RCB	2 – 60" RCP
15	540' Bridge	400' Bridge	450' Bridge	450' Bridge
16	1 – 60" RCP	340' Bridge	1 – 48" RCP	1 – 60" RCP
17	3 – 54" RCP	250' Bridge	1 – 54" RCP	1 – 60" RCP
18	450' Bridge	3 – 8' x 5' RCB	3 – 7' x 5' RCB	2 – 48" RCP
19	3 – 60" RCP	2 – 54" RCP	500' Bridge	3 – 8' x 5' RCB
20	4 – 60" RCP	3 – 7' x 5' RCB	2 – 60" RCP	450' Bridge
21	2 – 60" RCP	1 – 54" RCP	4 – 7' x 5' RCB	1 – 48" RCP
22	3 – 60" RCP	3 – 60" RCP	2 – 60" RCP	1 – 54" RCP
23	3 – 60" RCP	1 – 54" RCP	2 – 54" RCP	3 – 7' x 5' RCB
24	3 – 7' x 5' RCB	1 – 48" RCP	3 – 54" RCP	500' Bridge
25	4 – 8' x 5' RCB	1 – 30" RCP	1 – 60" RCP	2 – 60" RCP
26	500' Bridge	420' Bridge		4 – 7' x 5' RCB
27	4 – 8' x 5' RCB	3 – 54" RCP		2 – 60" RCP
28	3 - 8' x 5' RCB	4 – 8' x 5' RCB		2 – 54" RCP
29	4 – 60" RCP	4 – 7' x 5' RCB		3 – 54" RCP
30	1 – 60" RCP	2 – 60" RCP		1 – 60" RCP
31		2 – 54" RCP		
32		3 – 54" RCP		
33		1 – 60" RCP		
No. of Major Culverts	**23**	**26**	**22**	**24**
No. Bridges	**7**	**7**	**3**	**6**
Total No. of Major Structures	**30**	**33**	**25**	**30**
Total No. of Equalizer Culverts	**67**	**54**	**71**	**78**

4.4.1 Alternative B/O

The hydrologic and hydraulic analyses determined that Alternative B/O crosses 30 waterways (*Figure 5*). In order to cross these waterways, Alternative B/O would need to include 23 culverts and 7 bridges. The locations of the seven bridges are listed in *Table 11*. A complete list of the structure sizes can be found in *Table 10*. A detailed analysis sheet showing slopes, inverts, differential head, and other culvert analysis data can be found in *Appendix B*. It was determined that 67 - 24" RCP or equivalent sized equalizer culverts would be needed along Alternative B/O.

Table 11: Alternative B/O Bridge Locations

Structure No.	Channel
4	Little Creek
8	Ponchitolawa Creek
13	English Branch
14	English Branch
15	English Branch
18	Abita Creek
26	Tenmile Branch

4.4.2 Alternative P

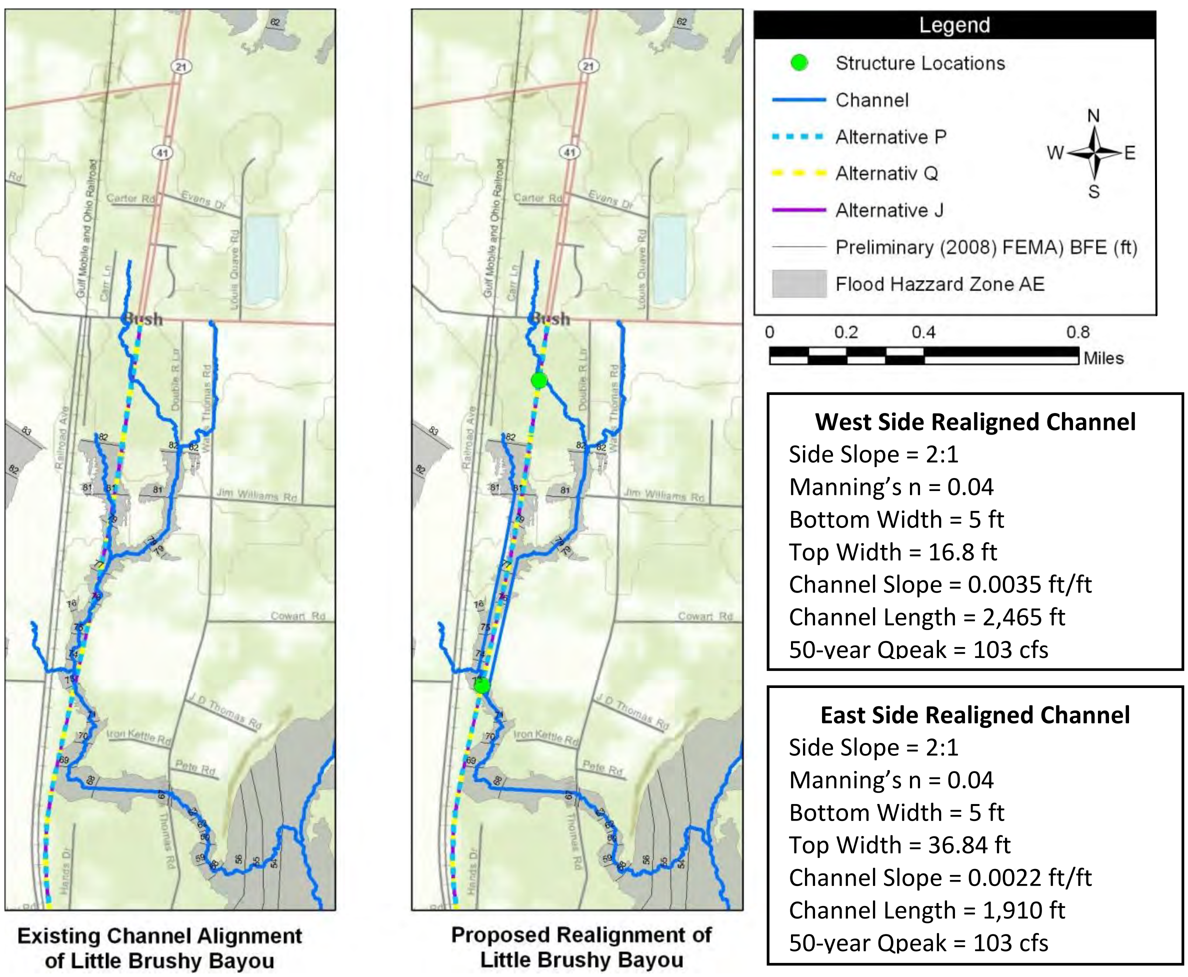
Alternative P crosses 33 channels which is the most out of the four alternative alignments (*Figure 6*). The structure crossings for Alternative P would consist of 26 culverts and 7 bridges. The location of the seven bridges can be found in *Table 12*. Bridge structure 8 had a 50-year peak flow rate of 955 cubic feet per second, which is less than the 1,000 cubic feet per second threshold established by LADOTD. Upstream of proposed structure 8, an existing structure is located along LA 36 (2 – 7' x 7' RCB - approximate size). Through field investigations, it appears that a relief culvert has been added (1 – 108" CMP – approximate size). Based on field investigations and the size of the existing upstream structure, it is recommended that structure 8 be sized as a bridge. A complete list of the structure sizes can be found in *Table 10*. A detailed analysis sheet showing slopes, inverts, differential head, and other culvert analysis data can be found in *Appendix C*. It was determined that 54 - 24" RCP or equivalent equalizer culverts would be needed along Alternative P.

Table 12: Alternative P Bridge Locations

Structure No.	Channel
5	Little Creek
8	Ponchitolawa Creek
14	English Branch
15	English Branch (FEMA Trib 1)
16	English Branch
17	Double Branch
26	Talisheek Creek

Along the northern portion of Alternative P, it is recommended that a stretch of Little Brushy Branch be realigned. The proposed alternative crosses the meandering channel in multiple locations, with the final location carrying an excess of 1,000 cubic feet per second for the future conditions. Therefore, realignment of the channel would allow the number of crossings to be minimized, as well as limit the number of bridge structures. The original and realigned channel along with the channel characteristics can be seen in *Figure 15.* The FEMA FIS and model for Little Brushy Bayou were used to compare the channel flows and the existing channel cross section. From the FEMA FIS, it was determined that the existing side slope of the channel had an approximate ratio of 2:1, which is also the minimum standard for LADOTD and was judged as reasonable. It was also identified that this channel does overtop its banks during the 100-year storm at its existing conditions (See FEMA Flood Hazard Zone AE). The new channel alignment would require a detailed study to be completed in order to determine the extent of the new flood zone location and floodway. The channels were each sized for the 50-year storm. Also observed through the FEMA model, the existing Little Brush Bayou channel does not remain in the banks for the 100-year storm event.

Figure 15: Little Brushy Bayou Channel Realignment



4.4.3 Alternative Q

Alternative Q crosses the least number of channels of the four alternative alignments. It includes 25 channel crossings, with 22 culverts and 3 bridges. The three bridge locations are listed in *Table 13*. A complete list of the structure sizes can be found in *Table 10*. A detailed analysis sheet showing slopes, inverts, differential head, and other culvert analysis data can be found in *Appendix D*. It was determined that 71 - 24" RCP or equivalent equalizer culverts would be needed along Alternative Q.

Table 13: Alternative Q Bridge Locations

Structure No.	Channel
10	Bayou Lacombe Tributary
15	Bayou Lacombe Tributary
19	Talisheek Creek

According to the Louisiana Department of Wildlife and Fisheries (LDWF), Bayou Lacombe is designated as a Scenic River. Therefore, the Alternative Q alignment was adjusted to ensure that it did not cross this channel.

The realignment of the Little Brushy Bayou channel detailed in Alternative P is also recommended along the northern portion of Alternative Q.

4.4.4 Alternative J

Alternative J includes 30 structures, with 6 bridges and 24 culverts. The six bridge locations are listed in *Table 14*. A complete list of the culvert and bridge crossings can be found in *Table 10*. A detailed analysis sheet showing slopes, inverts, differential head, and other culvert analysis data can be found in *Appendix E*. It was determined that 78 - 24" RCP or equivalent equalizer culverts would be needed along Alternative J.

Table 14: Alternative J Bridge Locations

Structure No.	Channel
2	Liberty Bayou Tributary
6	Liberty Bayou Tributary (FEMA Trib 3)
8	Liberty Bayou Tributary (FEMA Trib 3)
15	Bayou Lacombe Tributary
20	Bayou Lacombe Tributary
24	Talisheek Creek

The realignment of the Little Brushy Bayou channel detailed in Alternative P is also recommended along the northern portion of Alternative J.

4.5 Geomorphology

From a geomorphologic standpoint, there would be minimal to no impacts produced by any of the alternative alignments. Alternative P, Alternative Q, and Alternative J would require only minor stream adjustments. However, through proper engineering design, the impacts would be minimal. Protection has also been recommended near proposed structures where velocities exceed nine feet per second and possible erosion would occur. Further investigation on geomorphologic impacts would need to be completed at the design phase of this study.

4.6 Drainage Impact Conclusions

The impact of each structure crossing on the hydrology and hydraulics of the existing system is dependent on a number of factors. The impacts created by each bridge and culvert crossing can vary significantly based on the conditions at each location. As an example, two alternatives may cross the same channel at different locations and both require bridges, but the flows at the downstream location may be significantly greater, thus creating more impacts and requiring a much larger bridge. Another example is the limited impact from a culvert crossing located along an existing railroad corridor. This is due to the fact that the channel system has already been impacted by the existing crossing, even though the proposed improvements may increase the length and size of the structure. For this reason, each culvert and bridge crossing was analyzed based on existing conditions, size of structure, and design flows.

The following methodology was established to rank the impacts of each of the alternatives. Each bridge and culvert crossing was assigned a point value based on the type of structure, size of structure, and whether the structure would be new or replace an existing crossing.

The following equation was used to determine the points assigned to each structure crossing:

Bridge Score = Structure Type X New or Existing Structure X Length of Bridge/100 *Equation 5*

Culvert Score = Structure Type X New or Existing Structure X Width of Culverts/10 *Equation 6*

Structure Type:	Bridge = 2.0 Culvert = 1.0
New or Existing Structure:	New Structure = 1.0 Replace Existing Structure = 0.5

Example 1: Replace existing crossing on railroad alignment with 450 ft Bridge
2.0 (Bridge) X 0.5 (Existing Structure) X 450 LF/100 = 4.5 Points
Example 2: Construct two 4 ft Culverts on new alignment
1.0 (Culvert) X 1.0 (New structure) X 2 X 4 ft /10 = 0.8 Points

The following table shows the total number of bridges and culverts required for each alternative. It also identifies the number of structures within new alignment portions. The impacts to the channel system are directly related to the number of channel crossings, particularly those located on new undeveloped areas of a given alignment. The table also quantifies the total length of the bridges and width of culverts for each structure identified.

Table 15: Bridge and Culvert Summary Table

	ALTERNATIVE B/O				ALTERNATIVE P				ALTERNATIVE Q				ALTERNATIVE J			
	Str. No.	No. of Pipes	Str. Width (ft)	Points	Str. No.	No. of Pipes	Str. Width (ft)	Points	Str. No.	No. of Pipes	Str. Width (ft)	Points	Str. No.	No. of Pipes	Str. Width (ft)	Points
BRIDGES	4		450	9	5		140	2.8	10		500	10	2		425	4.25
	8		450	9	8		100	2	15		450	4.5	6		250	2.5
	13		150	3	14		140	2.8	19		500	5	8		450	9
	14		300	6	15		400	8					15		450	4.5
	15		540	10.8	16		340	6.8					20		450	4.5
	18		450	9	17		250	5					24		500	5
	26		500	5	26		420	8.4								
CULVERTS	1	2	4	0.4	1	2	4	0.4	1	2	4	0.4	1	1	5	0.25
	2	3	5	0.75	2	2	5	0.5	2	1	3.5	0.35	3	1	4.5	0.23
	3	3	4.5	1.35	3	1	4.5	0.45	3	1	4.5	0.45	4	1	4.5	0.23
	5	1	3.5	0.35	4	1	4.5	0.45	4	2	5	1	5	2	5	0.5
	6	1	3.5	0.35	6	1	3.5	0.35	5	1	3	0.3	7	1	4.5	0.45
	7	1	4.5	0.45	7	2	4.5	0.9	6	1	5	0.5	9	1	2.5	0.25
	9	2	4.5	0.9	9	1	4.5	0.45	7	1	5	0.5	10	2	4	0.8
	10	2	4	0.8	10	2	4	0.8	8	1	4	0.4	11	3	4.5	1.35
	11	2	4.5	0.9	11	1	4.5	0.45	9	4	4.5	1.8	12	2	5	1
	12	2	4.5	0.9	12	3	5	1.5	11	1	2.5	0.25	13	3	4.5	0.68
	16	1	5	0.5	13	1	4	0.4	12	1	5	0.25	14	2	5	0.5
	17	3	4.5	1.35	18	3	8	2.4	13	2	4	0.4	16	1	5	0.25
	19	3	5	1.5	19	2	4.5	0.9	14	3	8	1.2	17	1	5	0.25
	20	4	5	2	20	3	7	2.1	16	1	4	0.2	18	2	4	0.4
	21	2	5	1	21	1	4.5	0.45	17	1	4.5	0.23	19	3	8	1.2
	22	3	5	1.5	22	3	5	1.5	18	3	7	1.05	21	1	4	0.2
	23	3	5	1.5	23	1	4.5	0.45	20	2	5	0.5	22	1	4.5	0.23
	24	3	7	2.1	24	1	4	0.4	21	4	7	1.4	23	3	7	1.05
	25	4	8	1.6	25	1	2.5	0.25	22	2	5	0.5	25	2	5	0.5
	27	4	8	1.6	27	3	4.5	1.35	23	2	4.5	0.45	26	4	7	1.4
	28	3	8	1.2	28	4	8	3.2	24	3	4.5	0.68	27	2	5	0.5
	29	4	5	1	29	4	7	1.4	25	1	5	0.25	28	2	4.5	0.45
	30	1	5	0.25	30	2	5	0.5					29	3	4.5	0.68
					31	2	4.5	0.45					30	1	5	0.25
					32	3	4.5	0.68								
					33	1	5	0.25								
	TOTAL POINTS =			76.05	TOTAL POINTS =			58.73	TOTAL POINTS =			32.55	TOTAL POINTS =			43.325

= Structures located on an existing road alignment or railroad corridor where there is an existing crossing.

Table 16 summarizes the results of the hydrologic and hydraulic impact analysis and provides the ranking for each alternative:

Table 16: Hydrologic and Hydraulic Analysis Results

Alternative	Total Points	Ranking
ALT Q	32.55	1
ALT J	43.33	2
ALT P	58.73	3
ALT B/O	76.05	4

Based on the drainage impact analysis, Alternative Q would pose the least amount of impact to the natural channel systems. This alternative includes the least number of major structure crossings (25 crossings) and only three bridge crossings. Much of the alignment also follows existing roadway and railroad alignments. Thus, many of the structures for this alternative will be replacements of existing structure crossings.

Ranked second, third and fourth are Alternatives J, P, and B/O, respectively *(Table 16)*. Alternative J is the eastern most alternative and has the second least impacts. The majority of the alignment follows Airport Road and the abandoned railroad corridor alignment, requiring only one (1) bridge and five (5) culverts on a new alignment.

Alternatives P and B/O both have greater lengths of roadway on new alignments, which increases the impacts to the existing drainage characteristics of the project area. The project area also drains in a northeast to southwest direction, which results in increased flows for the western alternatives and requires larger structure crossings.

5.0 Wetland Impact Analysis

5.1 Introduction

This section provides an analysis for the indirect impact of the proposed alignments on the natural overland sheet flow patterns. Field inspection of the project area indicates that a significant interaction exists between the floodplain and wetland areas and the drainage channel network. There is also evidence of inter-basin exchange during larger rain events. Therefore, an appropriate modeling tool for this study should capture the exchange of flow between the overland areas and the channels. The analysis tool should also dynamically integrate these flow regimes. A one and two-dimensional coupled modeling approach (MIKE FLOOD) is suitable tool for this application. It has been previously used for modeling the flow exchange between wetlands, open water bodies and channel network systems. This software has been developed by the Danish Hydraulic Institute (DHI). MIKE FLOOD integrates the one-dimensional model (1D) MIKE 11 and the two-dimensional (2D) model MIKE 21 into a single modeling package (*Figure 16*).

A brief description of MIKE FLOOD is provided below:

- It captures the flow exchange between floodplains and channels. This is accomplished through lateral links along the banks of the channel network;
- It includes flow through bridges, culverts and other types of read crossings;
- It interacts efficiently with standard GIS packages to facilitate visualizing the results, and
- It includes an efficient and easy to use graphical interface for data preparation, processing, and analysis.

MIKE FLOOD takes advantage of the available capabilities of the channel models (MIKE11) and the overland model (MIKE21). A list summarizing these capabilities is included below:

MIKE11:

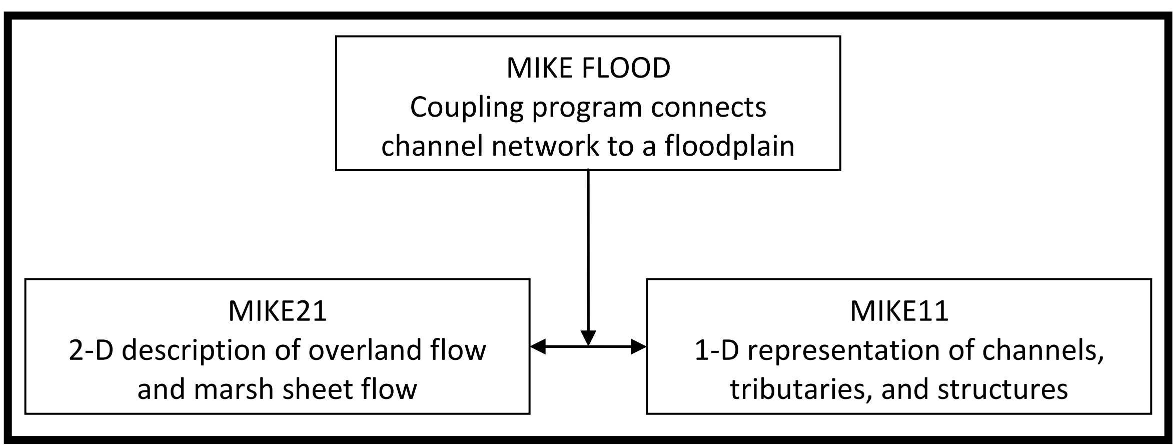
- Fully tested modeling capability of various road crossing structures;
- Ability to model complex channel networks;
- Linkage to rainfall and runoff programs;
- Ability to model sediment and water quality constituents, and
- Computational efficiency.

MIKE21:

- Ability to model overland flow, shallow lakes, ponds, and other open water bodies;
- Wetting and drying capability to model overland inundation, and
- Ability to model sediment and water quality constituents.

For more details on the model capabilities and features see (DHI, 2011)

Figure 16: Schematic Diagram of MIKE FLOOD Model Setup



5.2 Model Setup

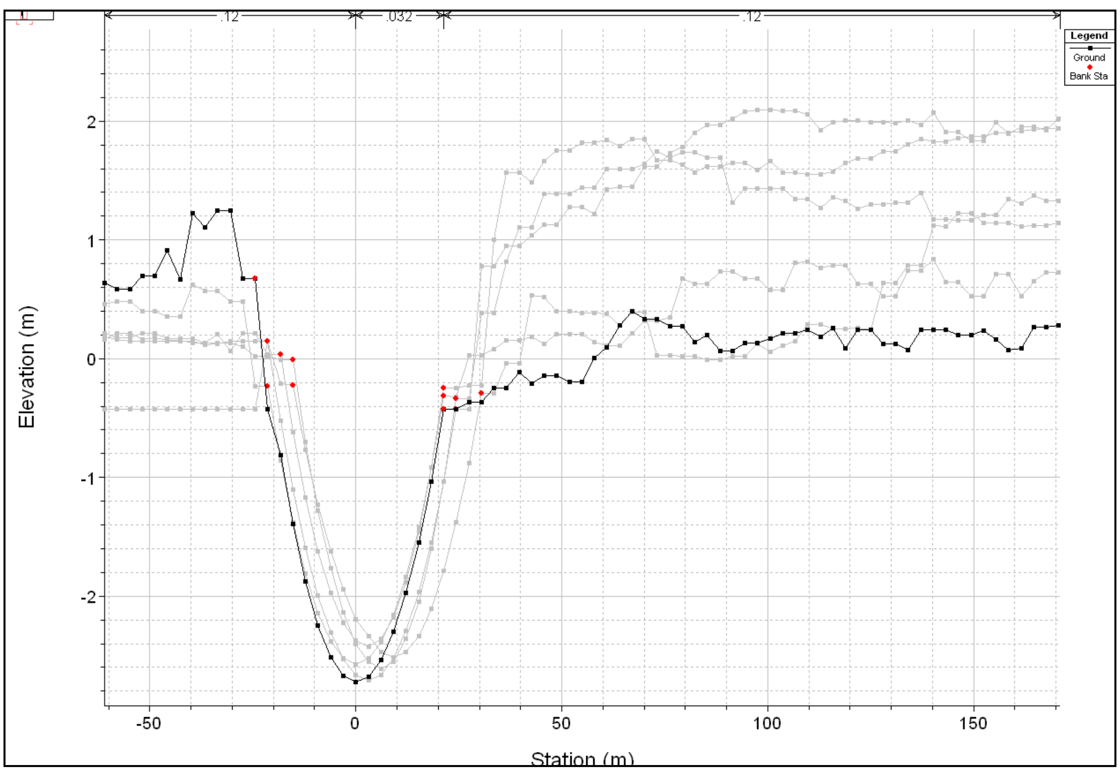
5.2.1 MIKE 11 Channel Model Setup

The MIKE 11 channel alignments were digitized directly from the geo-referenced DOQQ imagery, topographic maps, and LiDAR data. This was done in order to capture the reach lengths of each channel, and to account for channel loops (areas where inter-basin exchange occurs). A total of 178 channel branches were included in the MIKE 11 model spanning 381 stream miles.

Cross section cut-lines were extracted from LiDAR data, and channel inverts were estimated based on FEMA HEC-RAS models. In areas lacking FEMA data, channel widths were estimated from aerial photography and overall channel shapes were assumed to follow generic parabolic shape *(Figure 17*). A total of 7,409 cross sections were extracted from disconnected LiDAR datasets. Cross-sections were estimated assuming a piecewise quadratic cross-section at each location. Invert elevations were set based on typical depths for comparable streams and depths were allowed to increase linearly downstream. The inverts were checked against FEMA model geometry for general agreement.

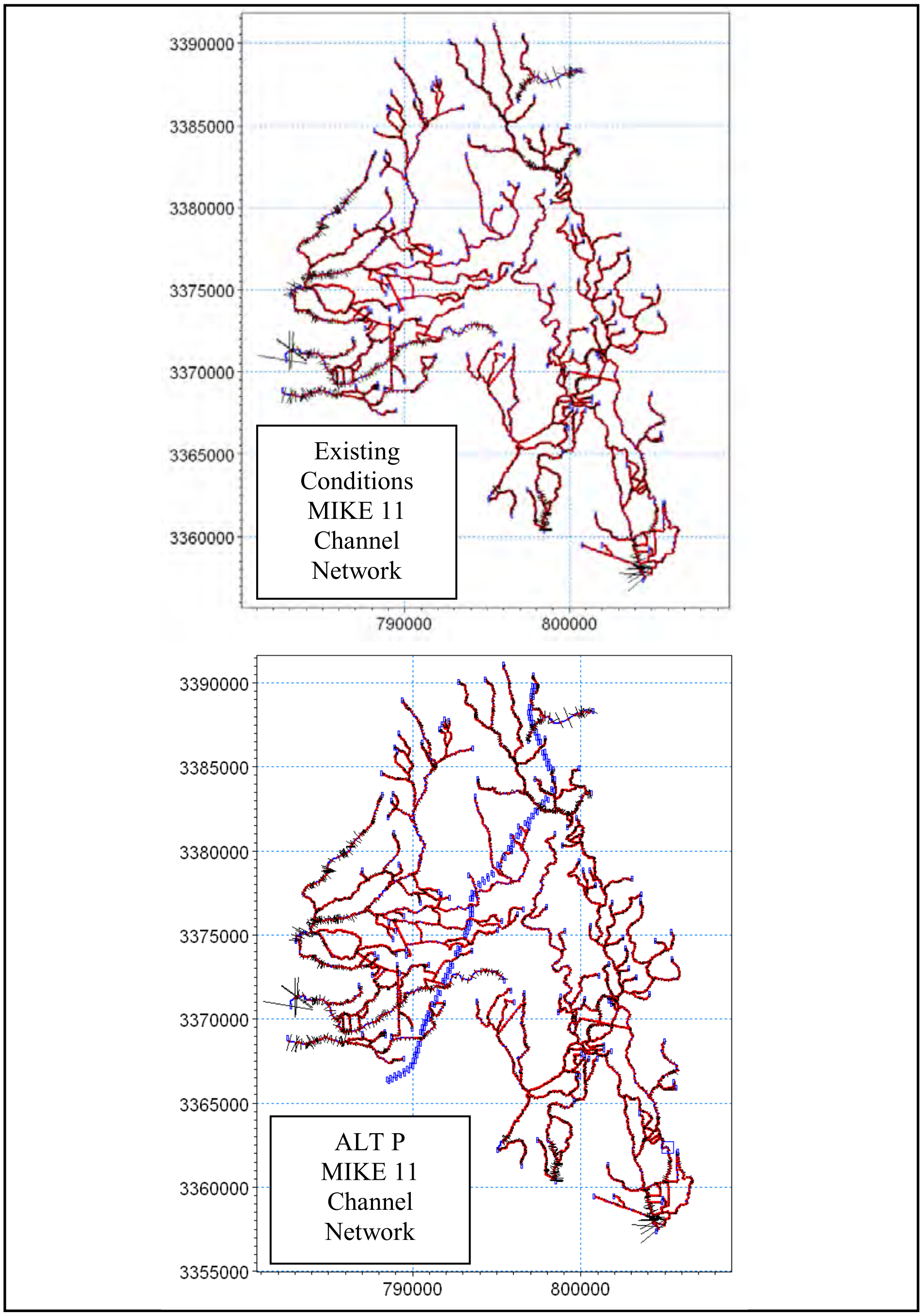
In the absence of detailed field measurements and survey data, the embankments for the hydraulic structure crossings within the system were estimated and included in the channels' cross-section geometry. In general, major bridge crossings are designed not to overtop for the 100-year storm. Over 150 existing structures were identified and included in the model.

Figure 17: Estimated Channel Cross Sections on Liberty Bayou south of I-12



The proposed equalizer culverts for each alternative alignment were included in this modeling effort. The equalizer culverts directly impact the interaction between a given alignment and the overland sheet flow. Thus it was critical to include these equalizer culverts. However, to gain computational speed-up, and since all the inline road crossing structures were designed for the 50 year storm and not overtop for the 100-year storm, they were not included this wetland impact analysis modeling component. To formally test that appropriateness of this assumption, numerical simulations were performed with and without these structures. The difference was negligible and indicative of the appropriateness of this assumption. *Figure 18* shows the MIKE 11 channel network for the Alternative P alignment. The other alignments, namely Alternative B/O, Alternative Q, and Alternative J were setup similarly. A global Manning's coefficient of 0.033 was assumed for all channels.

Figure 18: MIKE 11 Channel Networks

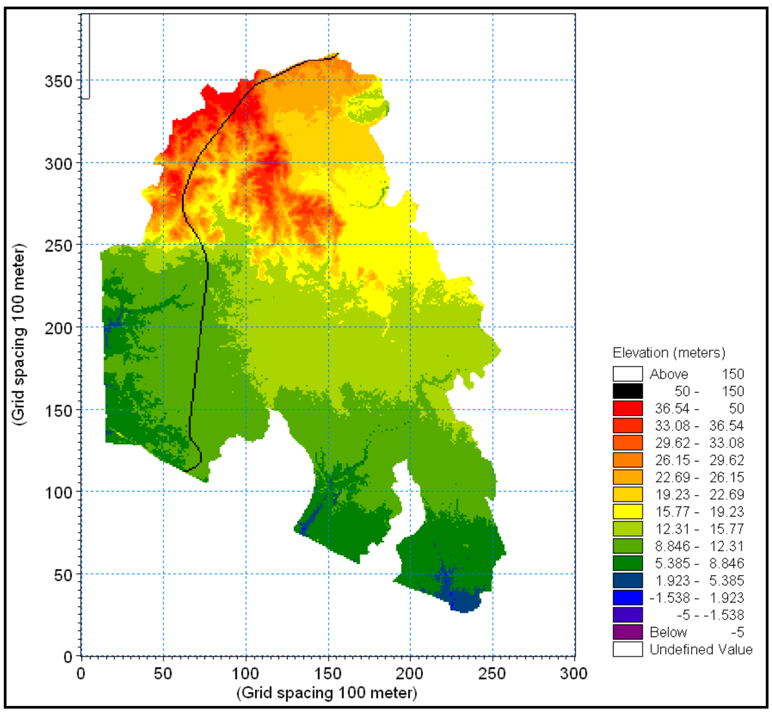


5.2.2 MIKE 21 Setup

A two-dimensional grid was setup to capture the overland areas. The pixel size (spatial resolution) of this grid is an important factor. It affects the model's ability to resolve the flow spatial variability. Given the uncertainty of the exact channel dimensions and how it connects with the overland areas, a 100 meter x 100 meter grid was deemed adequate. Numerical simulations were performed with various spatial resolutions to ensure stability of the model results for the various grid sizes.

The drainage basin delineated and presented earlier in this report was used to locate the boundaries of this wetland impact analysis modeling effort. It was assumed that each of the alternative alignments would be set at a grade such that road-overtopping would not occur for the 100-year storm event. It was also assumed that the only transfer of water across the alignments would occur either through the channels or through the culvert equalizers. The topographic grid was adjusted for each alignment alternative. An example of the topographic grid including one of the alternative alignments is shown in *Figure 19*. A constant Manning's coefficient of 0.33 was assumed for the overland areas to reflect resistance caused by the dense brush and forests within the study area.

Figure 19: Alternative B/O Bathymetry Grid (100 m x 100 m)



5.2.3 MIKE Flood Setup

The channel network and overland areas were linked in order to capture the flow exchange between the drainage channel network and the overland areas (see *Figure 20*). Under the current setup, the model run time is 12 hours of computational time for a four-day storm event.

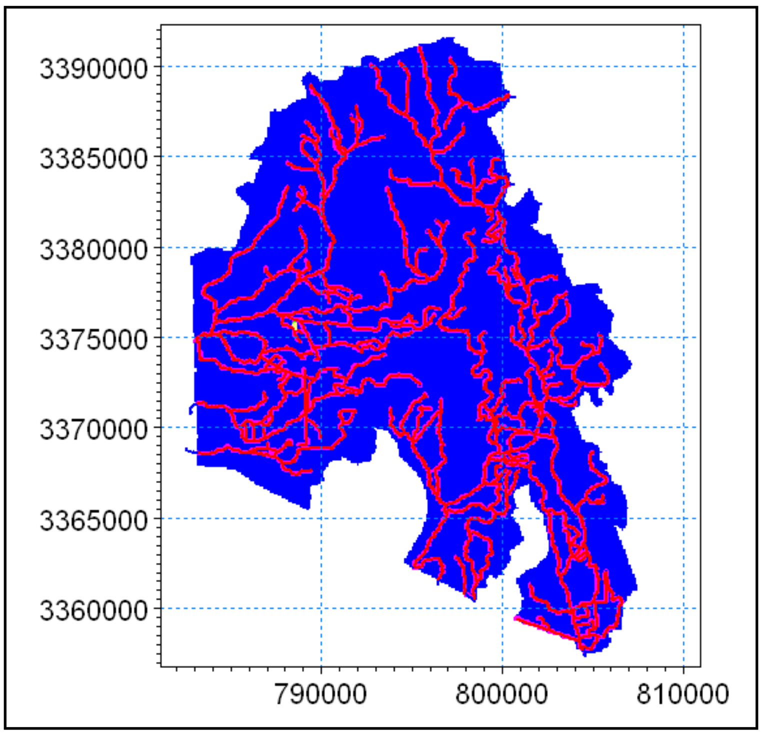
The MIKE FLOOD model was setup for the five alternatives.

1) No Build Alternative - Existing Conditions
2) Alternative B/O
3) Alternative P
4) Alternative Q
5) Alternative J

Before assessing the indirect wetland impact of any of the alternative alignments, the No Build Alternative-Existing Conditions was verified against the April 2008 Preliminary FEMA FIRM maps. The 100-year SCS Type III frequency storm was used as the rainfall boundary condition. For tail-water boundary conditions, the April 2008 FEMA BFE values at each outlet location were used. This verification approach does not provide full assessment of the model performance. However, in absence of any stage or discharge field measurements, the Base Flood Elevations (BFE) provided in the FEMA maps is the best available date to assess the model performance.

MIKE-FLOOD peak discharges were compared to those included in the FEMA Flood Insurance Study (FIS). Similarly, the MIKE-FLOOD maximum water level elevations were compared to the Base Flood Elevations (BFE) for the 100-year storm event. Overall, the MIKE-FLOOD model compared favorably to the FEMA peak discharges, BFE, and extent of the overland flooding and drainage pattern within the project area.

Figure 20: MIKE FLOOD Layout (Coupled MIKE 11 and MIKE 21)



5.3 Wetland Impact Results

The construction of roads across streams and wetlands areas, especially in shallow systems such as eastern St. Tammany Parish, may alter the natural drainage pattern and specifically the flow exchange between streams and surrounding wetland areas. The impact may cover large areas around the road alignment (Wright 2006). Full mitigation of such impacts or pursuing damage-sensitive construction alternatives can be challenging, time-consuming and costly. Therefore, it is critical to assess the potential indirect impact of roadways on wetland areas. A list of common hydrologic stressors on urban wetlands is provided below (Wright 2006):

- Changes to topography and canopy
- Changes to the inundation (Ponding)
- Increased Hydrologic Drought of Riparian Wetlands
- Changes to Water Level Fluctuations
- Increased Flow Constrictions
- Changes to Sedimentation and Nutrient Loading

These hydrologic stressors were evaluated individually for each alternative to determine the indirect impact to the wetland areas located outside of each alignment's 250 feet of right-of-way. All analyses were performed on the entire drainage system to determine the total impacts. These results were then filtered to focus on the impacts to wetland areas.

Through coordination with Tetra Tech, Inc. and the governmental agencies involved in this project, the wetland areas were determined using hydric soil classifications and LiDAR data (*Figure 21)*. These wetland areas were used for analysis purposes herein. It should be noted that the wetland areas identified in this report may not match with areas classified as wetlands in other publications. In order to properly classify an area as a wetland a complete field investigation and wetland delineation outside of the alternative right-of-ways is needed. Such extensive field investigation was beyond the scope of this EIS, but is recommended for future phases of this project.

In order to present a comparative analysis and ranking system for each alternative, a normalized scale was used for each hydrologic stressor. The normalized procedure is based on Equation 7:

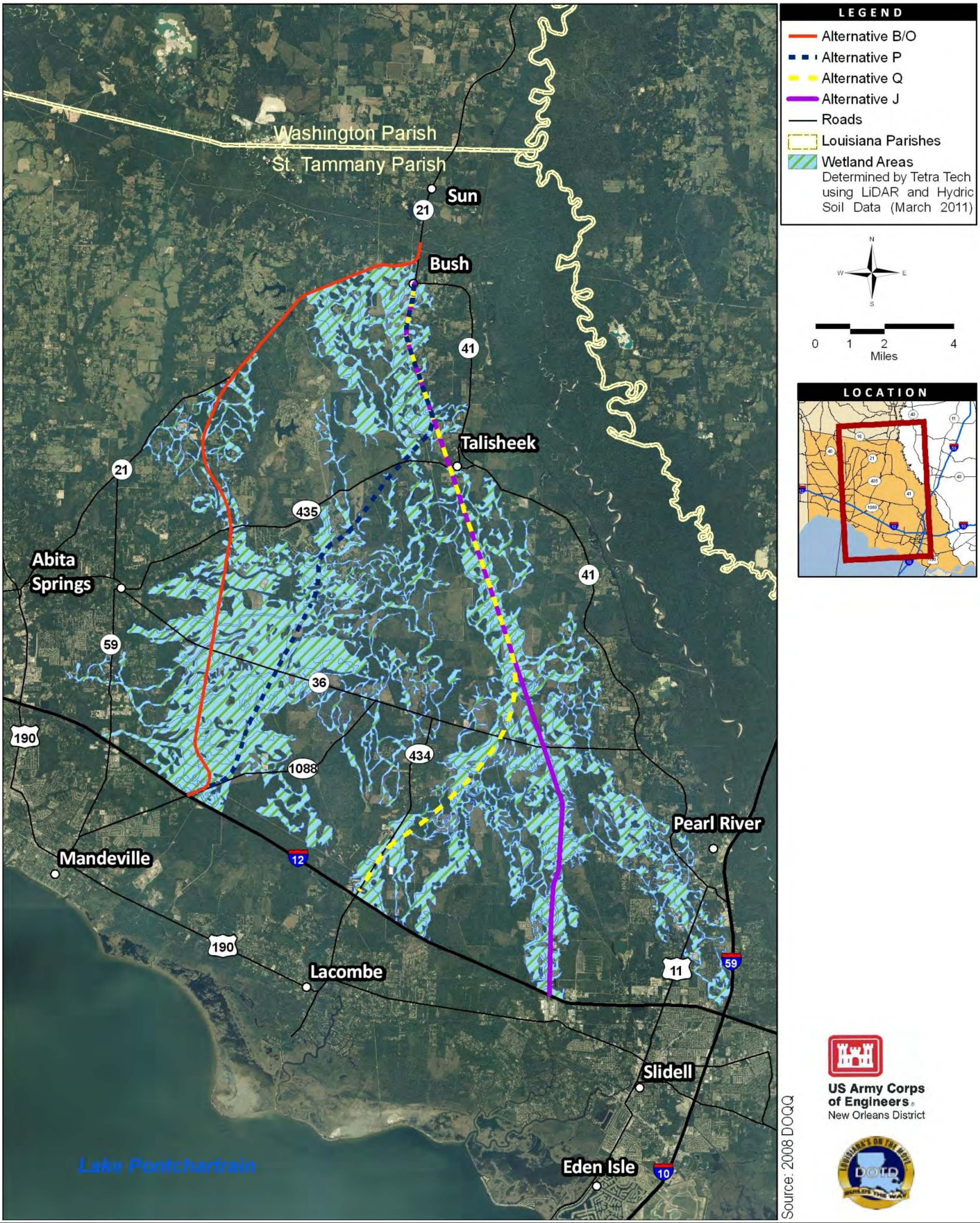
$$Normalize\ Score = \left(\frac{alternative\ value}{\max alternative\ value}\right) * 10 \qquad \text{Equation 7}$$

The "alternative value" here represents the specific hydrologic stressor being considered, e.g. wetland acreage impacted, or linear miles of clearing canopy for a given alignment. This scoring system is designed such that an alternative with no impact would receive a score of zero and the alternative with the largest impact would receive a score of ten (*Table 17*).

Table 17: Definition of Normalized Values

Normalized Value	Definition
0	No Impact
10	Largest Impact

Figure 21 Wetland Areas Identified Through Hydric Soil Classifications and LiDAR Data



5.3.1 Impact on Topography and Canopy

Constructing a new roadway may require clearing of canopy and vegetation along its path. Alignments constructed on undeveloped terrain change the existing canopy and topography. Whereas, alignments constructed on existing roadways or abandoned rail beds pose no additional impact to the surrounding environment. Each of the alternative alignments considered here was assessed to determine the length of roadway constructed on undeveloped land. *Table 18* summarizes these results.

Table 18: Score of Impact on Topography and Canopy for the various Roadway Alignments based on the Length of New Roadway

Rank	Alternative	Length of New Roadway (Miles)	Normalized Score
1	ALT J	5.4	3.6
2	ALT Q	8.7	5.9
3	ALT B/O	12.5	8.4
4	ALT P	14.8	10

As shown in *Table 18*, Alternative J and Alternative Q scored best in this category since they had the shortest length of new roadway placed on undeveloped terrain. Conversely, Alternative B/O and Alternative P have the longest length of new roadway on undeveloped terrain and hence scored the worst.

In addition to the impact on canopy and topography by each alignment, it is important to take into account the direct impacts of each alignment on the wetlands within its right-of-way. The wetland area along the length of each alignment was delineated by Tetra Tech, Inc. and can be found in the *Waters of the United States Delineation Reports – I-12 to Bush Environmental Impact Statement* dated December 2010. These results are summarized in *Table 19*.

Table 19: Direct Wetland Impacts within the 250 ft Right-of-Way of each Alternative (*Waters of the United States Delineation Report – I-12 to Bush Environmental Impact Statement, 2010)*

Rank	Alternative	Direct Wetland Impacts Acres	Normalized Score
1	ALT Q	305	7.9
2	ALT P	358	9.3
2	ALT J	373	9.7
4	ALT B/O	385	10

5.3.2 Impact on Inundation (Ponding)

Changes to the extent or inundation (ponding) duration of wetland areas may occur when obstructions such as roadways alter the natural sheet flow of water. Altering the ponding duration (increase or reduction) leads to changes, often undesirable, in wetland type, function, and quality, as well as to the native plants and animals (Wright, 2006).

The duration an area remains submerged is a critical parameter that impacts the functionality of wetlands. Fenstermaker and Tetra Tech, Inc. contacted wetland scientists and researchers to determine the critical duration that would alter the functionality of a wetland. An exact duration was not agreed on among the scientists. The range varied from three to seven days.

Historical records of precipitation were obtained from three rainfall stations located within St. Tammany Parish (Slidell, Abita Springs, and Covington, Louisiana). These stations recorded data from 1900 to 2010, with a common period of 1973 to 2010. A statistical analysis on the rainfall data was performed (see *Figure 22*). Based on the available records, the average monthly rainfall for the St. Tammany area is approximately 5.2 inches. A typical month during the growing season with an average precipitation of 5.2 inches was selected to investigate the impact of each alternative alignment on the inundation (ponding) pattern of the surrounding wetland areas (*Figure 22*).

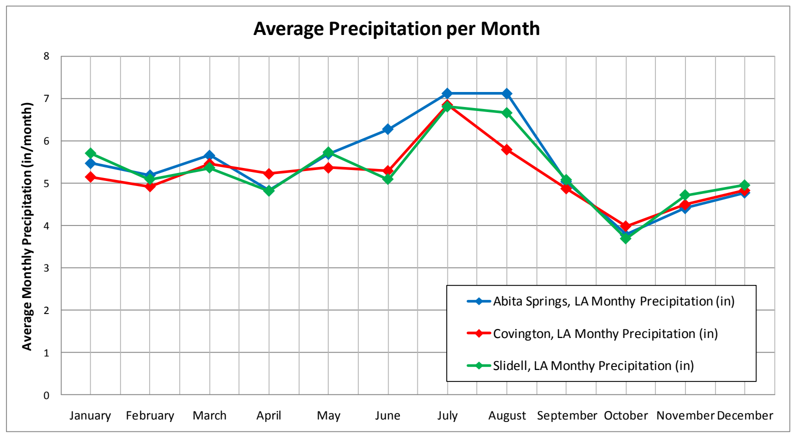
Figure 22: Precipitation Statistics and Average Monthly Precipitation

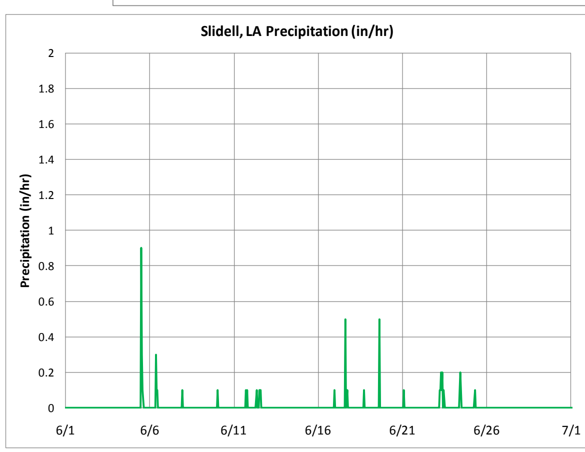
Statistical Averages:

- Wet Days = 109 days/year
- Dry Days = 251 days/year
- Daily = 0.2 in/day
- Monthly = 5.2 in/month
- Yearly = 62.7 in/yr

Longest Drought = 51 days

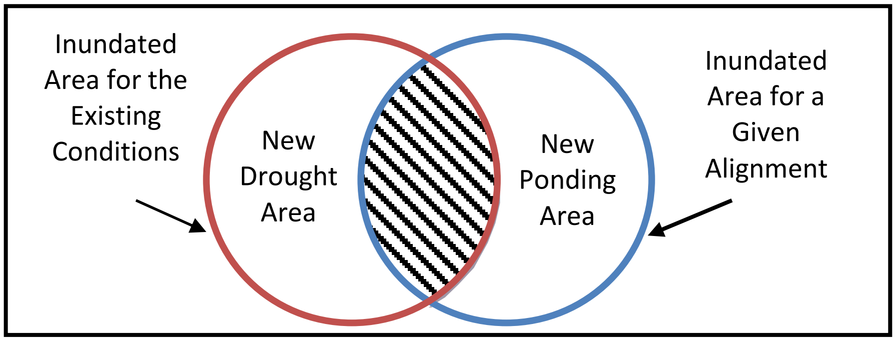
Longest Wet Period = 15 days





The inundation of wetland areas were analyzed for the existing conditions and compared to each alternative alignment. *Figure 23* illustrates how each alignment may impact the wetland inundation. Ponding was defined as areas inundated for three consecutive days with a depth greater than 0.025 meters. The change (expressed in acreage) to the inundated areas is used to express the impact of a given alignment. As shown in *Figure 23*, the comparison between the existing conditions and a given alignment reveals areas that have not been impacted, new inundated areas, and areas that have been drained as a result of constructing a given alignment. This analysis was repeated with adjusting the definition of ponding to five then again to seven days.

Figure 23: Schematic of How the Impact on Ponding and Drought Was Computed for a Given Alignment



The results for the three, five, and seven-day inundation analyses are summarized in *Table 20, Table 21*, and *Table 22,* respectively. *Figure 24* shows the areas where the wetland inundation (ponding) has been impacted. In *Figure 24*, the inundation duration used was seven days. Maps with inundation durations defined as three and five days can be found in the *Appendix*. Overall, the analysis shows that the ponding duration is not a critical factor in terms of identifying the acreage of wetlands impacted. The inundation analysis also shows that Alternative P and Alternative Q have the best score whereas Alternative J and Alternative B/O have the worst score.

Table 20: Inundation impact and Scoring Analysis: Three Days Inundation Duration

Rank	Alternative	Increase in Wetland Inundation (Acres)	Normalized Score
1	ALT P	240	5.6
2	ALT Q	290	6.8
3	ALT J	406	9.5
4	ALT B/O	427	10

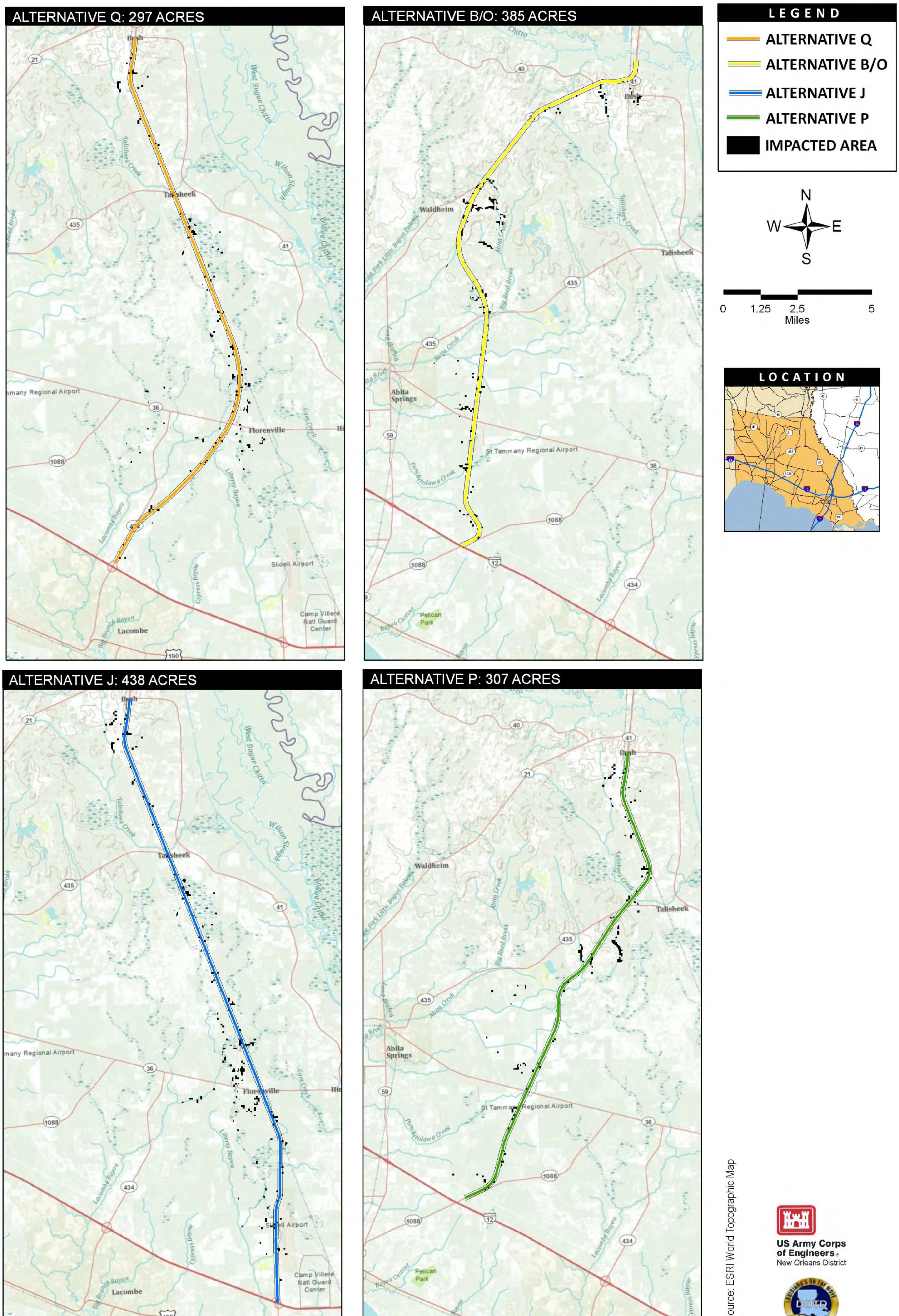
Table 21: Inundation impact and Scoring Analysis: Five Days Inundation Duration

Rank	Alternative	Increase in Wetland Inundation (Acres)	Normalized Score
1	ALT P	264	5.5
2	ALT Q	268	5.6
3	ALT J	396	8.3
4	ALT B/O	477	10

Table 22: Inundation impact and Scoring Analysis: Seven Days Inundation Duration

Rank	Alternative	Increase in Wetland Inundation (Acres)	Normalized Score
1	ALT P	297	6.8
2	ALT Q	307	7.0
3	ALT B/O	385	8.8
4	ALT J	438	10

Figure 24 Results of the Inundation Impact Analysis. The Inundation Duration is Defined as Seven Consecutive Days.



5.3.3 Hydrologic Drought Impact Analysis

Hydrologic drought events are defined as wetland areas that remain dry for three consecutive days. To investigate the sensitivity of the results to the duration of the drought used herein, the same analysis was repeated with adjusting the drought duration to five and seven days.

The hydrologic drought analysis counted the acres of wetlands experiencing hydrologic drought as a result of a given alignment compared to the existing conditions. A summary of the results can be seen in *Table 23, Table 24*, and *Table 25*. *Figure 25* shows wetland areas experiencing seven day drought for all four proposed alignments. As can be seen, the drought areas are primarily located along the alignments. Maps with drought durations defined as three and five days can be found in the *Appendix*.

Table 23: Hydrologic Drought Impact and Scoring Analysis: Three Days Hydrologic Drought Duration

Rank	Alternative	Increase in Wetland Drought (Acres)	Normalized Score
1	ALT Q	126	4.8
2	ALT P	149	5.7
3	ALT B/O	238	9.1
4	ALT J	261	10

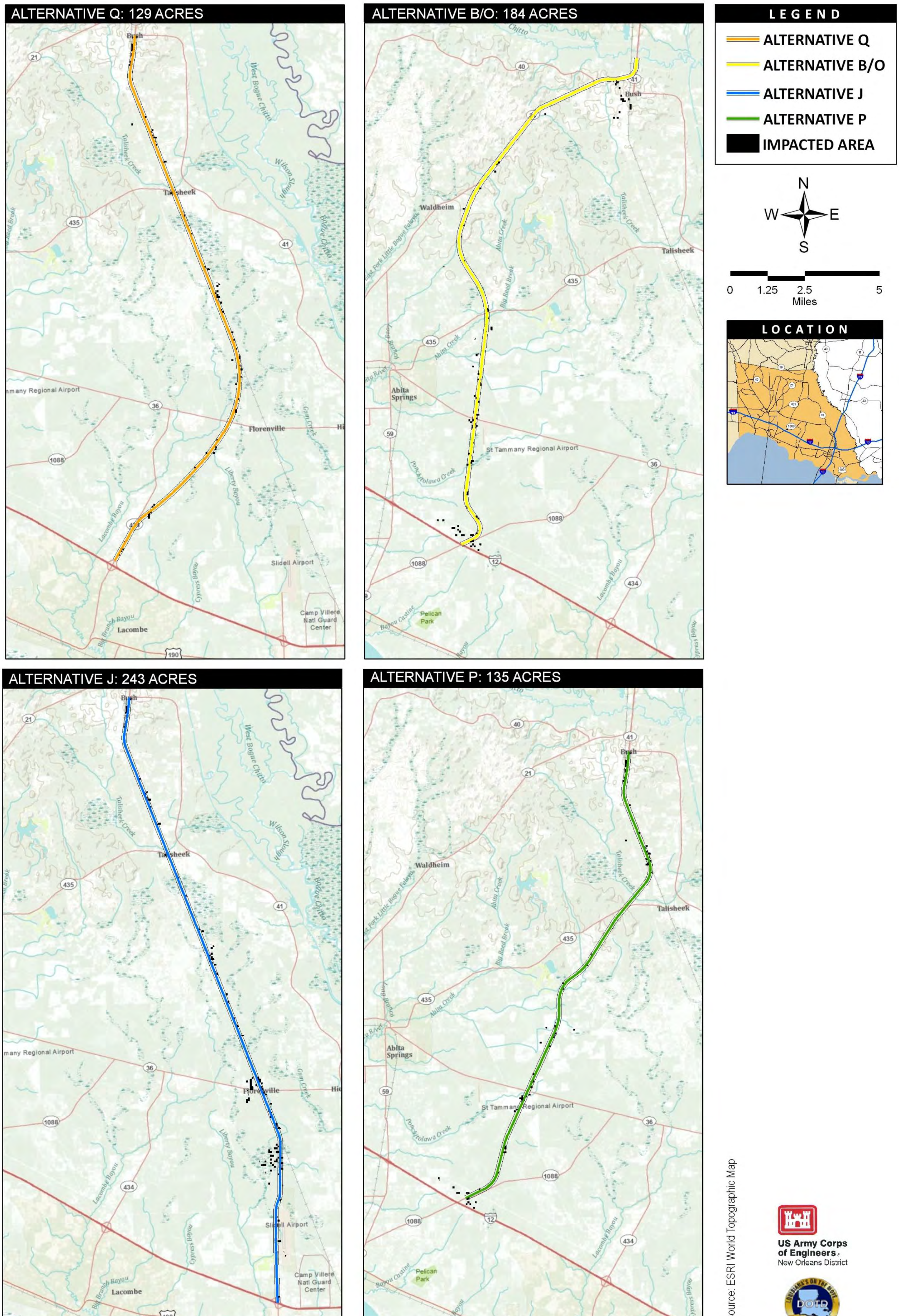
Table 24: Hydrologic Drought Impact and Scoring Analysis: Five Days Hydrologic Drought Duration

Rank	Alternative	Increase in Wetland Drought (Acres)	Normalized Score
1	ALT Q	124	5.2
2	ALT P	134	5.6
3	ALT B/O	181	7.6
4	ALT J	239	10

Table 25: Hydrologic Drought Impact and Scoring Analysis: Seven Days Hydrologic Drought Duration

Rank	Alternative	Increase in Wetland Drought (Acres)	Normalized Score
1	ALT Q	129	5.3
2	ALT P	135	5.6
3	ALT B/O	184	7.6
4	ALT J	243	10

Figure 25 Results of the Hydrologic Drought Impact Analysis. The Hydrologic Drought Duration is Defined as Seven Consecutive Days.



5.3.4 Water Level Fluctuations Impact Analysis

Water level fluctuation (WLF) is defined as the difference in maximum and minimum water levels in a wetland for a given period of time. This is often used to quantify a wetland's hydro period (Wright, 2006). Water level typically increases in response to moderate or large storm events, but quickly returns to base levels. These changes in water level are commonly referred to as the "bounce" in water levels during and after a storm event. Research has shown that changes in WLF on wetlands have caused a consistent decline in diversity and often an increase in invasive species (Wright 2006).

The WLF impact analysis was performed for the 2, 25, and 100-year storm events. The total rainfall accumulations for each storm are shown in *Table 26*. The tailwater values at the outlet of the drainage basins were estimated using the St. Tammany Parish Preliminary FEMA FIS profile data.

Table 26: Frequency Storm Precipitation

Frequency Storm	Rainfall Depth Inches
2-Year	4.8
25-Year	9.6
100-Year	12.6

Changes to the WLF patterns between the existing conditions and each alternative were determined. A change in the WLF was registered only if it exceeded a 0.025 meters (whether an increase or decrease). The total area registering such a change was tallied up for each alternative. This tolerance was set based on the resolution and sensitivity of the numerical model. The wetland areas that experienced a change in the WLF can be found in *Table 27, Table 28,* and *Table 29*, respectively. *Figure 26* shows the wetland areas that experienced changes in WLF for the 2-year storm event. Similar maps for the 25-year and 100-year storm events can be found in the *Appendix*.

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Figure 26 Wetland Areas that Experienced Changes in Water Level Fluctuations for the 2-Year Storm Event

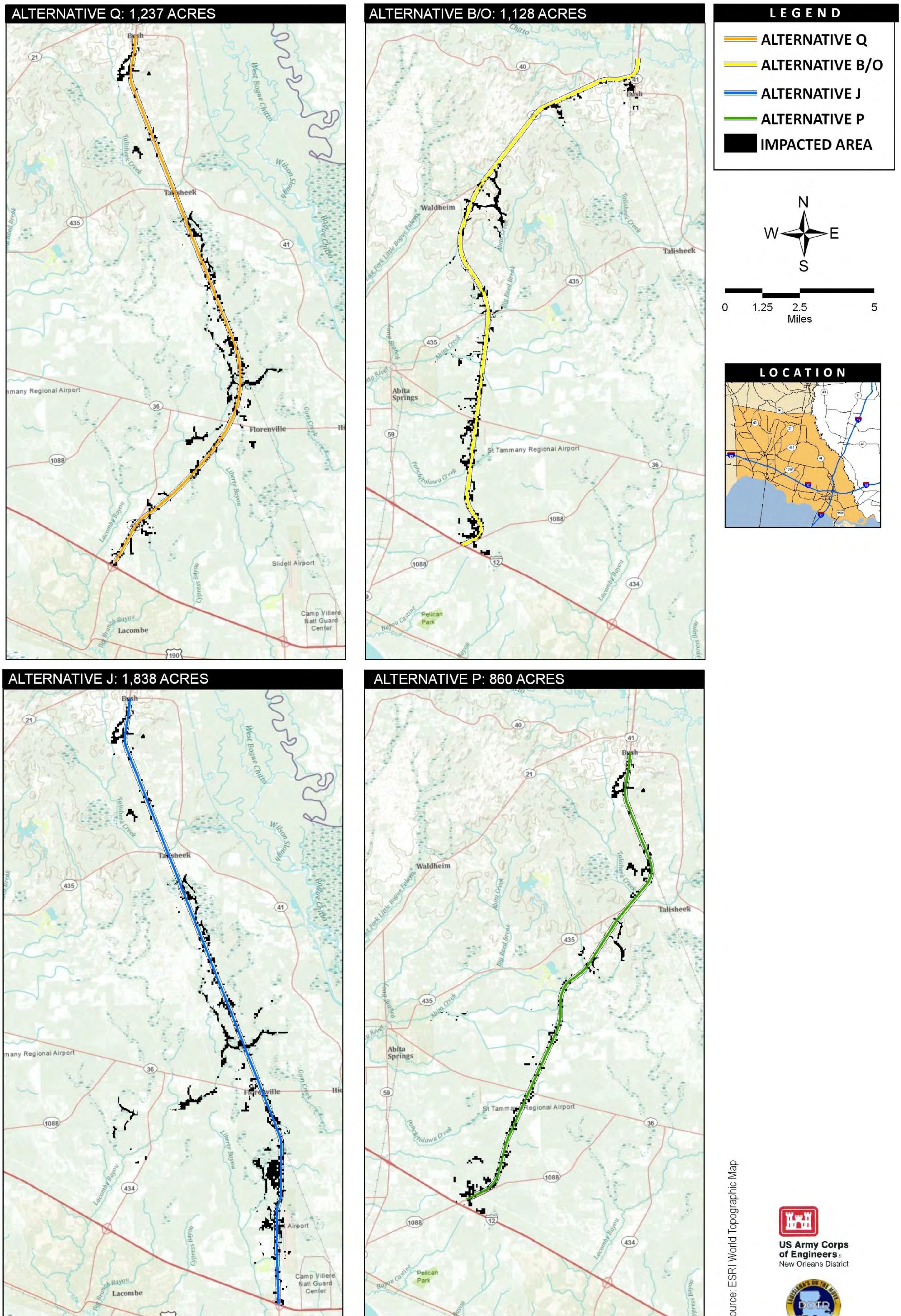


Table 27: Water Level Fluctuations Impact and Scoring Analysis for the 100-Year Storm

Rank	Alternative	WLF Impacted Wetland Areas (Acres)	Normalized Score
1	ALT Q	2,302	6.2
2	ALT B/O	2,353	6.4
3	ALT P	2,408	6.5
4	ALT J	3,685	10

Table 28: Water Level Fluctuations Impact and Scoring Analysis for the 25-Year Storm

Rank	Alternative	WLF Impacted Wetland Areas (Acres)	Normalized Score
1	ALT P	1,534	5.7
2	ALT Q	1,626	6.0
3	ALT B/O	1,773	6.6
4	ALT J	2,700	10

Table 29: Water Level Fluctuations Impact and Scoring Analysis for the 2-Year Storm

Rank	Alternative	WLF Impacted Wetland Areas (Acres)	Normalized Score
1	ALT P	860	4.7
2	ALT B/O	1,128	6.1
3	ALT Q	1,237	6.7
4	ALT J	1,838	10

5.3.5 Flow Constrictions Impact Analysis

The most common type of flow constriction is caused by the placement of hydrologic structures to convey water underneath a roadway. The hydrologic changes associated with flow constrictions contribute to increase in ponding, drought, and water level fluctuations both upstream and downstream of the hydraulic structures (Wright 2006).

In this study, all road crossings were designed according to LADOTD standards for the 50-year storm event (future conditions) with a one foot allowable differential head. Detailed road crossing analysis was done and presented in Section 4.6 and summarized in *Table 15*. A normalized scoring was computed for each alternative and is shown in *Table 30*.

Table 30: Flow Constriction Impact and Scoring and Analysis

Rank	Alternative	Culvert Analysis Score	Normalized Score
1	ALT Q	33	4.3
2	ALT J	43	5.7
3	ALT P	59	7.7
4	ALT B/O	76	10

5.3.6 Changes to Sedimentation and Nutrient Loading

Changes to sedimentation and nutrient loading within channels may occur as a result of urbanization and other alterations to a natural wetland system. These changes are directly tied to velocities and other hydraulic parameters within the streams. Since no channel surveys are available at this phase, it is not possible to quantify the indirect impacts on wetlands due to sediment deposition, pollutant accumulation, or nutrient discharges. However, these stressors must be investigated at the design phase when detailed information is available.

5.4 Summary of Wetland Impacts

Three primary indicators of hydrologic stress were analyzed for each alternative. They included (2-YR WLF), increased ponding (7 day inundation), and decreased ponding (7 day drought), as defined previously. It should be noted that a wetland area could be affected by more than stressor. Hence, the impacted areas from ponding, drought, and WLF should not be simply added. The total indirect wetland impacted area was determined by merging the impacted wetland areas for the seven day inundation duration and drought periods and the areas that showed change in WLF for the 2-year storm event. The total indirect wetland impacted area was calculated using GIS. The total area was the union of the three separate stress indicators. All subsequent acreages and ranking criteria were calculated based on the union, or total stress caused by a given alignment. A summary table of the total indirect wetland impacted acreage can be found in *Table 31.* Maps showing the areas where indirect wetland impacts occurred can be found in *Figure 27*.

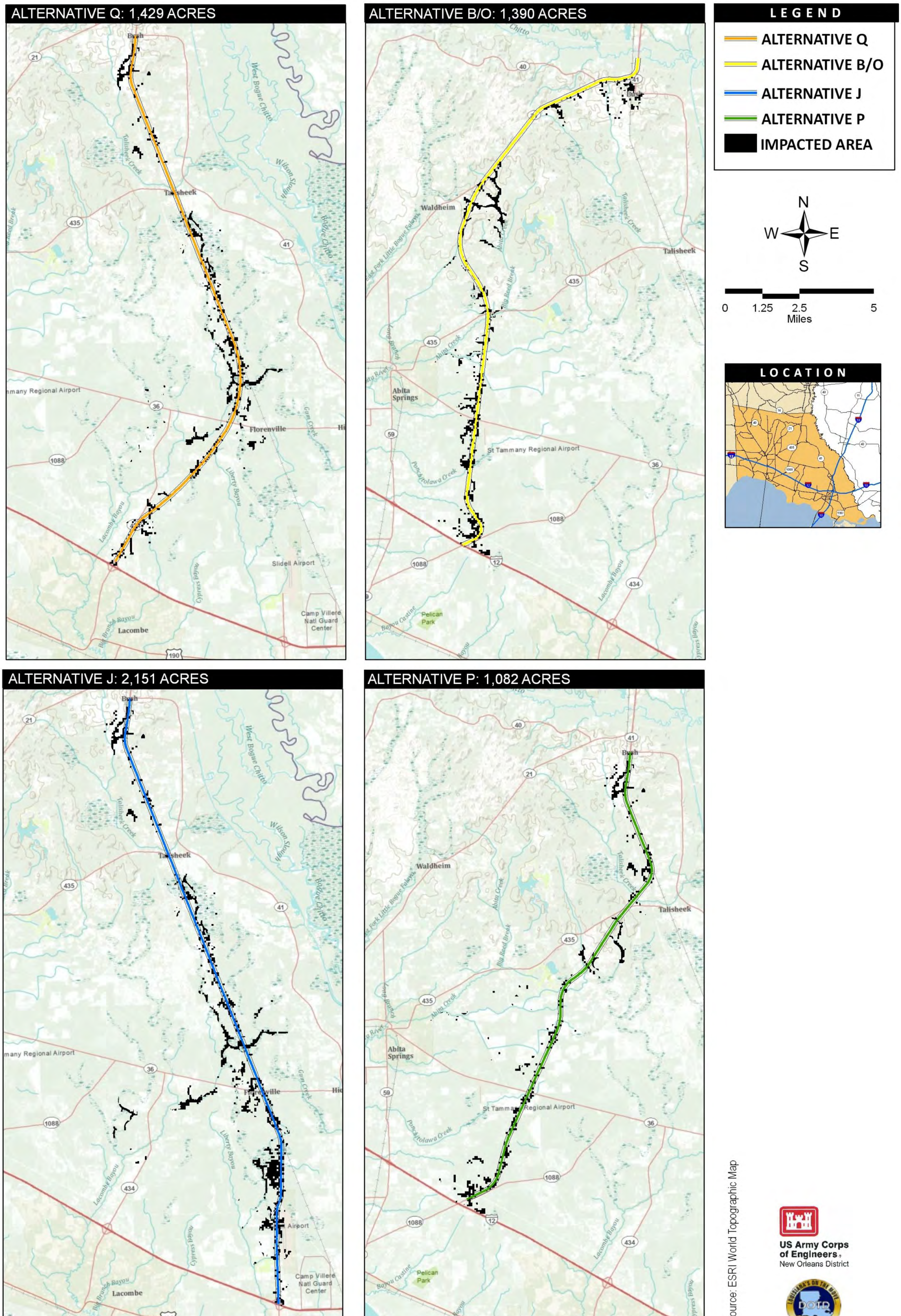
Table 31: Summary Table of Indirect Wetland Impacts Acreages

Rank	Alt	Total Indirect Wetland Impacts Based on the 2 YR WLF, 7 Day Inundation, and 7 Day Drought Results (acres)	Normalized Score
1	P	1,082	5.0
2	B/O	1,390	6.5
3	Q	1,429	6.6
4	J	2,151	10.0

Alternative P ranks the highest with the least wetland area impacted. Alternative P passes through virgin territory and may appear to impact large areas of wetlands. However, the topography of land where this alignment passes is fairly steep and thus it drains efficiently with or without the alignment in place. This is evident in the small amount of wetland acreage impacted by this alignment.

Alternative B/O and Alternative Q showed similar indirect wetland impacts, while Alternative J showed the most. Alternative B/O passes through a ridge on the northern edge of the project area (along HWY 21). The topography of the local area around that alternative is steep. Moreover, most of the overland areas downstream of that alternative are not classified as wetlands. Thus it did not impact large amount of wetland acreage. Alternative J scored lower than Alternative Q even though their northern portion shares the same alignment. The southern portion of Alternative J intercepts two low gradient basins, namely Bayou Lacombe and Bayou Liberty. That added significantly to the total wetland areas impacted by Alternative J, hence the lower ranking.

Figure 27 Indirect Wetland Impact Areas Based on the 7 Consecutive Days Inundation and Drought Analysis and the 2-Year Water Level Fluctuation Analysis.



These acreages are estimates based on the model results presented within this report. At the EIS phase of this study these acreages should be used for comparative purposes only. A more thorough hydrologic analysis including topographic surveys, grid refinement, and field visits will be required during the design phase to refine the preliminary acreages presented herein.

The cumulative impact of each alignment was determined by adding the normalized scores for the hydrologic stressors. The normalized scores that are shown in *Table 31* were used to represent the indirect wetland impacts for the seven day inundation (ponding) and drought and the 2-year WLF results. A summary of the scoring system is shown in *Table 32*. It was assumed here that all hydrologic stressors have equal weight.

Table 32: Summary Table of Indirect Wetland Impacts based on Normalized Scores

Rank	Alt	Length of New Roadway Score	Direct Wetland Impacts within the ROW Score	Indirect Wetland Impacts Outside of the ROW Score	Culvert Analysis Score	Total Points
1	Q	5.9	7.9	6.6	4.3	24.7
3	J	3.6	9.7	10	5.7	29
2	P	10	9.3	5	7.7	32
4	B/O	8.4	10	6.5	10	34.9

6.0 Conclusions

A drainage and wetland impact analysis was performed for four alternative alignments, namely Alternative P, J, Q, and B/O. The analysis included three main components, drainage, direct wetland impact, and indirect wetland impact analyses. A simple ranking system was adopted herein to rank the four alternatives. An equal weight was given to each factor included in the analysis. Based on the ranking system, Alternative Q is the most favorable alternative (*Table 33*). Alternative J and Alternative P ranked second and third; while Alternative B/O showed the most impacts from a hydraulic and wetland stand point. It should be noted that this ranking is limited to drainage and wetland impact analyses. These alternative routes may score differently in other technical areas (e.g. traffic analysis, or line and grade) and hence these rankings alone do not constitute a final endorsement of any given alignment.

Table 33: H & H and Indirect Wetland Impact Results

Alternative	Overall Ranking
ALT Q	1
ALT J	2
ALT P	3
ALT B/O	4

7.0 References

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