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Characterization of Peak Streamflows and Flood Inundation of Selected Areas in Louisiana, Texas, Arkansas, and Mississippi from Flood of March 2016

Scientific Investigations Report 2016–5162

U.S. Department of the Interior
U.S. Geological Survey

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SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Director

U.S. Geological Survey, Reston, Virginia: 2016

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Contents

Figures

Tables

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88) or the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to North American Datum of 1983 (NAD 83).

Elevation, as used in this report, refers to distance above the vertical datum.

Abbreviations

AEP	Annual exceedance probability
FEMA	Federal Emergency Management Agency
HWM	High-water mark
USGS	U.S. Geological Survey

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Abstract

Heavy rainfall occurred across Louisiana, Texas, Arkansas, and Mississippi in March 2016 as a result of a slow-moving southward dip in the jetstream, funneling tropical moisture into parts of the Gulf Coast States and the Mississippi River Valley. The storm caused major flooding in the northwestern and southeastern parts of Louisiana and in eastern Texas. Flooding also occurred in the Mississippi River Valley in Arkansas and Mississippi. Over 26 inches of rain were reported near Monroe, Louisiana, over the duration of the storm. In March 2016, U.S. Geological Survey (USGS) hydrographers made more than 500 streamflow measurements in Louisiana, Texas, Arkansas, and Mississippi. Many of those streamflow measurements were made to verify the accuracy of stage-streamflow relations at gaging stations operated by the USGS. Peak streamflows were the highest on record at 14 locations, and streamflows at 29 locations ranked in the top five for the period of record at USGS streamflow-gaging stations analyzed for this report. Following the storm, USGS hydrographers documented 451 high-water marks in Louisiana and on the western side of the Sabine River in Texas. Many of these high-water marks were used to create 19 flood-inundation maps for selected areas of Louisiana and Texas that experienced flooding in March 2016.

Introduction

Atmospheric moisture that originated over the Gulf of Mexico and circulated inland to Texas, Louisiana, Arkansas, and Mississippi from March 8 to 13, 2016, produced large rainfall amounts as much as 27 inches (in.) at some discrete monitoring locations (Weather Channel, 2016), and cumulative rainfall amounts compiled over larger areas (fig. 1) showed rainfall totals of about 24 in. The result was historic flooding in areas of Louisiana and Texas; damage was estimated to be $1.3 billion (National Centers for Environmental Information, 2016a) with at least four fatalities (National Centers for Environmental Information, 2016b). In the immediate aftermath of the March 2016 flood, the U.S. Geological Survey (USGS) and the Federal Emergency Management Agency (FEMA) initiated a cooperative study to evaluate the magnitude and extent of the flood and to update the annual exceedance probability statistics at select sites.

Purpose and Scope

This report presents (1) a description of the atmospheric conditions and the temporal and spatial patterns of rainfall that triggered the flooding in March 2016, (2) the analysis of peak-flow magnitudes and their statistical probability at 36 locations, and (3) documentation of flagged and surveyed high-water marks and geographic information system (GIS) analysis of the locations and elevations used to produce flood inundation (extent of flooding) maps for 12 heavily affected areas in Louisiana and Texas. The geographic scope of the report encompasses most of Louisiana as well as areas in eastern Texas, southern Arkansas, and western Mississippi. Flood probability statistics and associated inundation areas and peak water-surface elevations are used for infrastructure design, community planning, and for the protection of life and property.

Study Area

The study area includes parts of three physiographic sections: (1) the West Gulf Coastal Plain, (2) the Mississippi Alluvial Plain, and (3) the East Gulf Coastal Plain (Fenneman, 1946). The area generally consists of rolling hills in the northern parts of the study area and flat lands with swamps and marshes in the southern parts. Land-surface elevations within the affected areas range in elevation from about -1 to 400 feet (ft) relative to the North American Vertical Datum of 1988 (NAVD 88). The 30-year normal rainfall, from 1981 to 2010, in Louisiana varied from 49 in. in northwestern Louisiana to 68 in. in southern Louisiana (Durre and others, 2012).

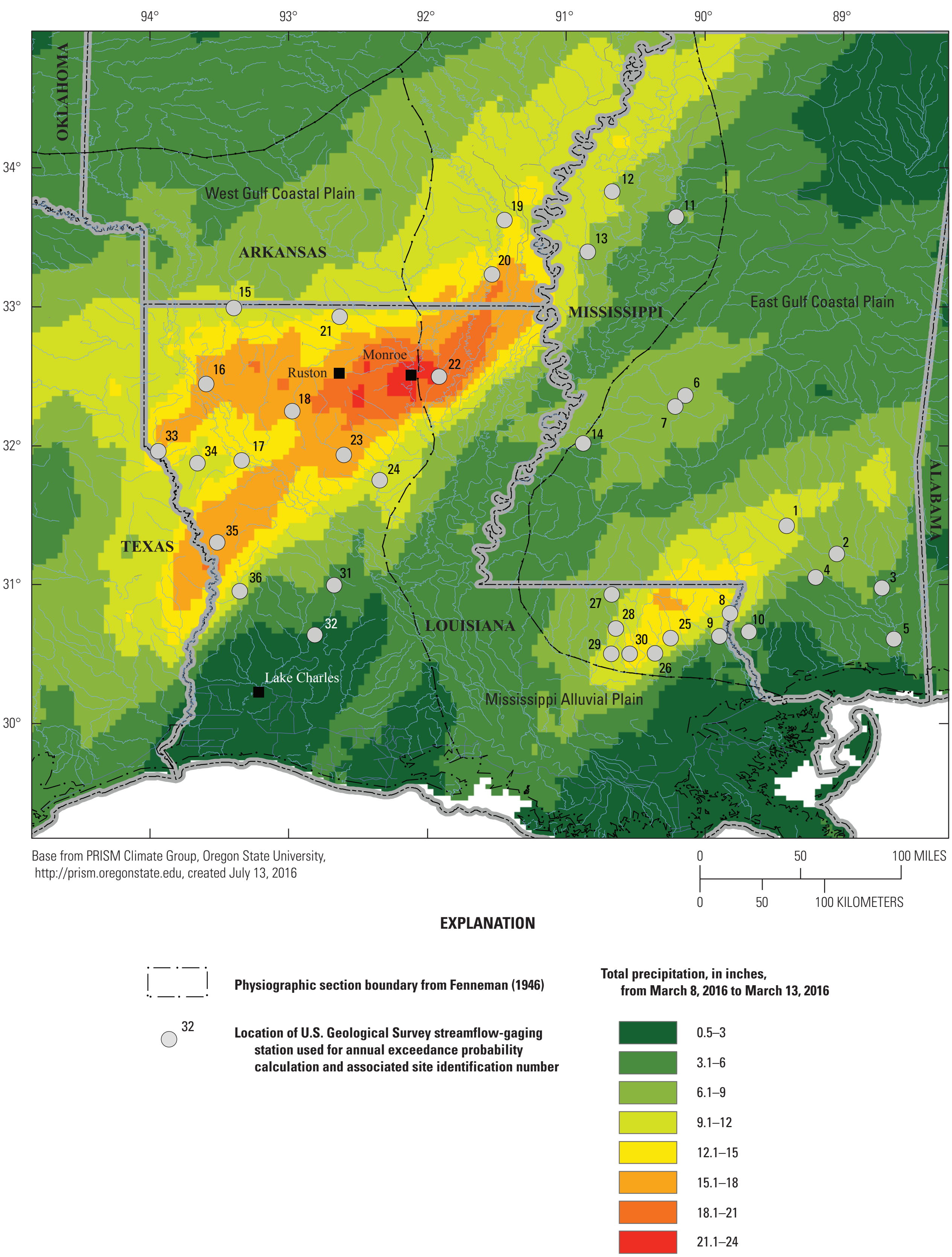


Figure 1. Cumulative rainfall from March 8 to 13, 2016, and location of U.S. Geological Survey streamflow-gaging stations used to calculate annual exceedance probabilities.

Weather Conditions Prior to and During the Flood

In March 2016, a large, slow-moving southward dip in the jetstream shifted eastward across Mexico and neared the U.S. Gulf Coast, funneling deep tropical moisture into parts of the Gulf Coast States and the Mississippi River Valley (Weather Channel, 2016). A low-pressure system existed near the base of the jetstream, and a flow of counterclockwise air around the system allowed for warm, moist air from the tropics to be continually funneled along the east side towards the gulf coast. This phenomenon, called the Maya Express, produced a stream of atmospheric moisture, also known as an atmospheric river, that originated over the Gulf of Mexico and circulated inland to Texas (Di Liberto, 2016).

The National Weather Service radar showed the heaviest band of rain across the north-central part of Louisiana. Atmospheric moisture values, referred to as precipitable water by meteorologists, broke a March record (or for any winter month) in Lake Charles (fig. 1), La., on March 10, 2016 (Weather Channel, 2016). Heavy rains also fell over the rest of Louisiana, eastern Texas (table 1), southern Arkansas, and western Mississippi. Four-day rainfall totals of about 20 in. and 18 in. were measured at the Monroe Regional Airport, Monroe (table 2; fig. 1) and Ruston, La., respectively (table 3; fig. 1).

Collection of High-Water Mark Data

High-water marks (HWMs) provide valuable data for understanding flood events (Koenig and others, 2016). The best HWMs are formed from small seeds or floating debris carried by floodwaters that adhere to smooth surfaces or lodge in tree bark to form a distinct line. Stain lines on buildings, fences, and other structures also provide excellent marks. The HWMs are best identified immediately following the peak stage because time and weather may alter evidence of the peak water line over time. The HWMs collected for this flood were made available through the USGS Short-Term Network (STN; http://water.usgs.gov/floods/FEV/), which is an online interface created to facilitate the dissemination of USGS field data.

The USGS field crews identified 451 HWMs (Koenig and others, 2016) in Louisiana and Texas with a depth above land surface measurement, in feet, and 265 HWMs were surveyed for elevation above land surface. Identification of HWMs began on March 17 and continued through April 22, 2016. A more permanent identification mark was established, such as a nail with a disk, a stake, a chiseled mark, or a paint line, after an acceptable HWM was identified. Written descriptions, sketches, photographs, and Global Positioning System (GPS) horizontal measurements obtained by using a hand-held GPS unit were made so the marks could easily be found later and surveyed to the NAVD 88.

Table 1. Rainfall totals reported from National Oceanic and Atmospheric Administration meteorological stations during floods in Louisiana and Texas, March 2016. (Information modified from http://www.srh.noaa.gov/shv/?n=flooding_march8-9_2016, accessed on July 3, 2016.)

Location	Rainfall amounts (inches)	Report time and date
Taylortown (7 miles east-southeast of Barksdale Air Force Base), Bossier Parish, Louisiana	18.39	7:00 a.m., 3/10/2016
Red River Research Station, Bossier City, Bossier Parish, Louisiana	16.8	7:00 a.m., 3/12/2016
Barksdale Air Force Base, Bossier Parish, Louisiana	18.84	7:00 a.m., 3/12/2016
Jamestown, Bienville Parish, Louisiana	15.72	7:00 a.m., 3/11/2016
Koran, Bossier Parish, Louisiana	15.35	7:00 a.m., 3/12/2016
Center, Shelby County, Texas	10.42	7:00 a.m., 3/12/2016
1 mile north of Homer, Claiborne Parish, Louisiana	14.66	7:00 a.m., 3/12/2016
Minden, Webster Parish, Louisiana	18.03	7:00 a.m., 3/12/2016
Arcadia, Bienville Parish, Louisiana	15.2	7:00 a.m., 3/12/2016
Swartz, Ouachita Parish, Louisiana	22.25	7:30 a.m., 3/11/2016
Longview, Gregg County, Texas	9.1	10:00 a.m., 3/12/2016
Tyler, Smith County, Texas	7.32	9:00 a.m., 3/12/2016
Monroe, Ouachita Parish, Louisiana	20.26	9:00 a.m., 3/12/2016
Columbia Lock and Dam, Columbia, Caldwell Parish, Louisiana	8.93	7:00 a.m., 3/12/2016
Southern Hills, Shreveport, Caddo Parish, Louisiana	13.14	7:00 a.m., 3/12/2016
Natchitoches, Natchitoches Parish, Louisiana	16.44	7:00 a.m., 3/12/2016
Marshall, Harrison County, Texas	10.76	7:00 a.m., 3/12/2016
Carthage, Panola County, Texas	11.13	7:00 a.m., 3/12/2016
Shreveport Regional Airport, Caddo Parish, Louisiana	11.51	9:00 a.m., 3/12/2016

During the mapping process, the HWMs that were used to create flood-inundation maps (Heal and Breaker, 2016) were identified and checked for location and elevation accuracy through comparison of field note diagrams and descriptions with aerial photography and detailed street and parcel maps.

Table 2. Total rainfall and associated annual exceedance probability, Monroe Regional Airport, Monroe, Louisiana.

[Data are from Louisiana State University Climate Center and National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 9, Version 2 Monroe RGNL A; Station ID: 16-6303]

Duration	March 2016 event		Previous record		Annual exceedance probability and total rainfall			
	Rainfall (inches)	Date	Rainfall (inches)	Date	0.04	0.02	0.01	0.002
10 days	22.27	3/8/2016	13.77	7/22/1933	12.6	14.3	16.0	20.5
4 days	20.66	3/8/2016	13.05	7/22/1933	10.5	12.1	13.8	18.2
2 days	16.48	3/8/2016	11.53	9/14/1978	9.18	10.6	12.2	16.4
1 day	10.86	3/9/2016	7.40	9/2/2008	7.83	9.12	10.5	14.4

Table 3. Total rainfall and associated annual exceedance probability, Louisiana Tech University, Ruston, Louisiana.

[Data are from Louisiana State University Climate Center and National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 9, Version 2 Ruston Louisiana Tech Station ID:16-8067]

Duration (in days)	March 2016 event		Previous record		Annual exceedance probability and total rainfall			
	Rainfall (inches)	Date	Rainfall (inches)	Date	0.04	0.02	0.01	0.002
10	19.02	3/9/2016	17.26	7/24/1933	12.7	14.4	16.3	21.2
4	17.95	3/9/2016	16.8	7/24/1933	10.5	12.2	13.9	18.6
2	16.9	3/9/2016	13.6	7/24/1933	9.23	10.7	12.3	16.7
1	11.84	3/9/2016	9.82	10/30/1941	7.88	9.19	10.6	14.6

Although an attempt was made for consistent recording of information, some data may be incomplete. The HWM data were taken from field notes made by different hydrographers on different days. In some cases, a HWM on a small tributary of a stream was recorded as being on the main stem of the larger stream.

Flood-Inundation Mapping

Flood-inundation maps were created using GIS for 19 areas in several communities in Louisiana and Texas. Flood-inundation maps depict the estimated areal extent and depth of flooding using HWMs collected by USGS hydrographers following the flood. The GIS methods used to create the flood-inundation maps follow those described in Musser and others (2016).

Uncertainties in the extent and depth of flood inundation are related to the number and spatial distribution of HWMs. In locations where HWMs are farther apart, there is a greater possibility of decreased accuracy of spatial interpretation of the extent and depth of flood inundation. Within a given mapped area, some extrapolation was performed beyond the most upstream and downstream HWMs. In many cases, the boundary was extended to some anthropogenic structure, such as a road or bridge crossing. Hydraulic models were not used to determine the extent or depth of flood inundation. Without the use of hydraulic models, changes in land-surface features in flood plains are not accounted for, and water flow dynamics, such as the timing of the flood and mixing of water between tributaries, are not characterized.

Probabilities of Peak Streamflows

The probability that a peak streamflow will occur at a given location in a given year is known as the annual exceedance probability (AEP) and is determined from the existing annual peak streamflow data at a streamflow-gaging station. An annual peak streamflow is the maximum instantaneous streamflow experienced at a streamflow-gaging station during a given water year (defined as October 1 for a given year through September 30 of the following year). Streamflow-gaging stations with the longest annual peak streamflow record are the most reliable for estimating AEPs. An AEP of 0.02 means that there is a 2-percent chance that a specific peak streamflow will occur at a given location in a given year. The recurrence interval for a given AEP is determined by dividing 1.00 by the AEP; therefore, an AEP of 0.02 is equivalent to a 50-year flood.

During the month of March 2016, USGS hydrographers made more than 500 streamflow measurements by using direct (Rantz and others, 1982a; Turnipseed and Sauer, 2010) and indirect (Benson and Dalrymple, 1967; Rantz and others, 1982b) methods at more than 375 locations. Many of those streamflow measurements were made to verify the accuracy of the stage-streamflow rating curve or to extend the stage-streamflow rating curve for a given streamflow-gaging station (Rantz and others, 1982a).

For selected streamflow-gaging stations, AEPs corresponding to peak streamflows that occurred during the March 2016 flood and streamflows associated with selected AEPs (0.10, 0.02, and 0.01) were estimated using the Expected Moments Algorithm (Cohn and others, 1997; Cohn and others, 2001) in the USGS PeakFQ program (Veilleux and others, 2014). Output results from the USGS PeakFQ program provided estimates for 15 specific AEPs ranging from 0.995 to 0.002. In order to estimate AEPs for specific peak streamflows that occurred during the March 2016 flood, the 15 specific AEPs and associated streamflows produced by PeakFQ were used to create generalized additive models (GAM) with integrated smoothness estimation (Wood, 2004, 2011) in R statistical software (R Core Team, 2016). The GAMs were then used to estimate the AEP associated with the peak streamflow from the March 2016 flood. For streamflow-gaging stations in Arkansas, AEP estimates computed using PeakFQ were then weighted with the regional regression equation estimates from Wagner and others (2016). The weighted streamflow estimates were then used to determine the AEPs associated with the March 2016 peak streamflow. For streamflow-gaging stations in Louisiana and Mississippi, AEP estimates were not weighted with regional regression equations owing to the availability of recent equations. Peak gage-height data and peak streamflow data from the March 2016 flood and the corresponding AEPs (in percent) were determined for 36 streamflow-gaging stations (fig. 1; tables 4 and 5).

Estimated Magnitudes and Flood Probabilities of Peak Streamflow

The flood-frequency statistics computed for this study are presented in table 5. Of the 36 streamflow-gaging stations analyzed for this study, 14 experienced a peak of record streamflow and 29 experienced peak streamflows that ranked in the top five for the period of record. The AEP estimates for the analyzed streamflow-gaging stations ranged from less than 0.2 to 10 percent. The number of years of peak streamflow record for analyzed streamflow-gaging stations ranged from 15 to 113, with a mean number of 57 years.

Flood-Inundation Maps

Nineteen flood-inundation maps were created for select locations in Louisiana and Texas (fig. 2). Each map presents the areal extent of the flood waters. The HWMs used to create the inundation maps and associated information can be accessed at the USGS STN website (http://water.usgs.gov/floods/FEV/) and are provided in Heal and Breaker (2016). Digital flood-inundation maps can be downloaded from ScienceBase (https://www.sciencebase.gov/catalog/item/57d96cd9e4b090824ffb0e4e).

Amite River

The Amite River has its headwaters in southwestern Mississippi and flows for approximately 117 miles (mi) to Lake Maurepas in southeastern Louisiana. Precipitation ranged from about 3 to 13 in. within the Amite River Basin over the duration of the storm. Multiple communities in Livingston and Ascension Parishes are located along a 28-mi reach of the Amite River, including Port Vincent, French Settlement, and Maurepas. A total of 15 HWMs, 14 of which are within the model area boundary, were identified along this reach, and 7 were surveyed and used to develop the inundation map (fig. 3). Depths of water at the HWMs ranged from 0.8 to 4.9 ft, and the elevations ranged from 2.9 to 16.4 ft above NAVD 88.

Bogue Chitto River

The Bogue Chitto River generally flows in a southeasterly direction, flowing into the Pearl River Canal. Precipitation ranged from about 6 to 17 in. within the Bogue Chitto River Basin over the duration of the storm. The 31-mi reach of the Bogue Chitto River mapped for this study flows through the communities of Franklinton in Washington Parish and Bush and Sun in St. Tammany Parish. The downstream boundary of the inundation map is the confluence with the Pearl River Canal. A total of 17 HWMs were identified along the Bogue Chitto River, and 11 of the HWMs were surveyed and used to develop the inundation map (fig. 4). The depths of water at the HWMs ranged from 0.2 to 7.9 ft, and the elevations ranged from 58.05 to 173.23 ft above NAVD 88. The USGS operates two streamflow-gaging stations on the Bogue Chitto River that were used in the analysis to create the inundation map: (1) Bogue Chitto River at Franklinton, La. (USGS 02491500), which recorded a peak stage of 21.81 ft gage datum and a water-surface elevation of 145.62 ft above NAVD 88 on March 12, 2016; and (2) Bogue Chitto River near Bush, La. (USGS 02492000), which recorded a peak stage of 20.53 ft gage datum and a water-surface elevation of 64.78 ft above NAVD 88 on March 13, 2016.

Table 4. Site identification number, station information, peak information, location, and drainage area of U.S. Geological Survey streamflow-gaging stations used for calculation of annual exceedance probability.

[ft^3/s, cubic feet per second; mi^2, square miles; nr, near; MS, Mississippi; LA, Louisiana; AR, Arkansas]

Site identification number (fig. 1)	Station number	Station name	Peak date	Peak gage height (feet above gage datum)	Peak streamflow (ft^3/s)	Latitude (decimal degrees)	Longitude (decimal degrees)	Drainage area (mi^2)
1	02472500	Bouie Creek nr Hattiesburg, MS	3/12/2016	26.13	27,100	31.425833	-89.414722	304
2	02474560	Leaf River nr New Augusta, MS	3/14/2016	31.23	63,800	31.221667	-89.053056	2,542
3	02479000	Pascagoula River at Merrill, MS	3/15/2016	27.95	121,000	30.978056	-88.726944	6,590
4	02479130	Black Creek nr Brooklyn, MS	3/12/2016	25.36	19,900	31.051944	-89.204167	355
5	02479310	Pascagoula River at Graham Ferry, MS	3/17/2016	18.61	137,000	30.610556	-88.641389	8,204
6	02485700	Hanging Moss Creek nr Jackson, MS	3/10/2016	19.43	4,530	32.365000	-90.144722	16.8
7	02486100	Lynch Creek at Jackson, MS	3/10/2016	17.31	6,010	32.284722	-90.215000	12.1
8	02489500	Pearl River near Bogalusa, LA	3/13/2016	22.75	133,000	30.793243	-89.820907	6,573
9	02492000	Bogue Chitto River near Bush, LA	3/12/2016	21.36	132,000	30.629356	-89.897296	1,213
10	02492360	West Hobolochitto Creek nr Mcneill, MS	3/16/2016	32.67	19,700	30.662222	-89.686111	175
11	07281600	Tallahatchie River at Money, MS	3/14/2016	23.67	19,700	33.651389	-90.211111	5,221
12	07288280	Big Sunflower River nr Merigold, MS	3/14/2016	36.07	11,000	33.832500	-90.670000	553
13	07288650	Bogue Phalia nr Leland, MS	3/14/2016	29.40	13,100	33.396667	-90.847778	484
14	07290650	Bayou Pierre nr Willows, MS	3/12/2016	26.26	50,500	32.018611	-90.878333	654
15	07348700	Bayou Dorcheat near Springhill, LA	3/11/2016	21.20	26,700	32.994581	-93.396560	605
16	07349860	Red Chute Bayou at Sligo, LA	3/11/2016	14.57	12,600	32.447376	-93.594620	980
17	07351750	Bayou Pierre near Lake End, LA	3/12/2016	34.51	13,500	31.894608	-93.341839	860
18	07352000	Saline Bayou near Lucky, LA	3/10/2016	16.80	24,100	32.250157	-92.976548	154
19	07364150	Bayou Bartholomew near McGehee, AR	3/17/2016	25.19	6,050	33.627778	-91.445833	576
20	07364185	Bayou Bartholomew near Portland, AR	3/15/2016	36.67	8,720	33.235556	-91.535556	1,110
21	07366200	Little Corney Bayou near Lillie, LA	3/10/2016	14.65	15,500	32.929306	-92.632931	208
22	07369000	Bayou Lafourche near Crew Lake, LA	3/12/2016	31.57	46,400	32.500000	-91.918056	361
23	07372050	Dugdemona River near Joyce, LA	3/12/2016	27.76	74,700	31.936944	-92.603333	740
24	07372200	Little River near Rochelle, LA	3/12/2016	49.77	133,000	31.754336	-92.344583	1,899
25	07375000	Tchefuncte River near Folsom, LA	3/11/2016	25.25	43,000	30.616022	-90.248695	103
26	07375500	Tangipahoa River at Robert, LA	3/12/2016	25.52	85,300	30.506580	-90.361752	646
27	07375800	Tickfaw River at Liverpool, LA	3/11/2016	12.47	16,800	30.930736	-90.673432	89.7
28	07375960	Tickfaw River at Montpelier, LA	3/11/2016	18.72	21,500	30.686297	-90.643151	220
29	07376000	Tickfaw River at Holden, LA	3/12/2016	20.23	16,700	30.503802	-90.677316	247
30	07376500	Natalbany River at Baptist, LA	3/11/2016	19.76	8,190	30.504358	-90.545924	79.5
31	08013000	Calcasieu River nr Glenmora, LA	3/12/2016	20.46	44,900	30.996667	-92.673611	499
32	08013500	Calcasieu River near Oberlin, LA	3/14/2016	22.88	35,900	30.640476	-92.814037	753
33	08023080	Bayou Grand Cane near Stanley, LA	3/9/2016	18.50	17,000	31.962723	-93.941161	72.5
34	08023400	Bayou San Patricio near Benson, LA	3/9/2016	19.92	11,500	31.875167	-93.658515	80.2
35	08025500	Bayou Toro near Toro, LA	3/10/2016	28.50	42,000	31.307127	-93.515730	148
36	08028000	Bayou Anacoco near Rosepine, LA	3/11/2016	29.01	61,900	30.952970	-93.352944	365

Table 5. Site identification number, station number, peak information, and estimated annual exceedance probablilities for selected U.S. Geological Survey streamflow-gaging stations in Louisiana, Arkansas, and Mississippi.

[AEP, annual exceedance probability; ft³/s, cubic feet per second; <, less than]

Site identification number (fig. 1)	Station number	Flood data: Rank	Flood data: Number of annual peaks in analysis	Flood data: Peak streamflow (ft³/s)	AEP for observed March 2016 flood: Estimate (in percent)	AEP for observed March 2016 flood: 66.7 percent confidence interval: Lower (in percent)	AEP for observed March 2016 flood: 66.7 percent confidence interval: Upper (in percent)	10 percent AEP (10-year recurrence): Estimate	10 percent AEP: 95 percent confidence interval: Lower	10 percent AEP: 95 percent confidence interval: Upper	2 percent AEP (50-year recurrence): Estimate	2 percent AEP: 95 percent confidence interval: Lower	2 percent AEP: 95 percent confidence interval: Upper	1 percent AEP (100-year recurrence): Estimate	1 percent AEP: 95 percent confidence interval: Lower	1 percent AEP: 95 percent confidence interval: Upper
1	02472500	5	79	27,100	2.00	2.0	9	16,600	13,800	20,800	27,400	21,400	39,600	32,600	24,300	50,500
2	02474560	6	39	63,800	10.00	9.0	20	65,400	52,200	82,100	103,000	78,400	146,000	122,000	89,900	184,000
3	02479000	10	113	121,000	10.00	6.0	10	120,000	107,000	139,000	179,000	152,000	232,000	207,000	171,000	284,000
4	02479130	6	47	19,900	6.00	7.0	20	17,000	14,000	22,100	27,200	21,000	42,200	32,300	24,000	54,500
5	02479310	1	23	137,000	5.00	0.6	8	117,000	97,100	156,000	156,000	124,000	248,000	172,000	133,000	296,000
6	02485700	2	52	4,530	4.00	1.0	6	4,100	3,720	4,600	4,830	4,360	5,740	5,050	4,510	6,210
7	02486100	6	60	6,010	7.00	6.0	10	5,670	5,080	6,570	7,440	6,430	9,600	8,200	6,940	11,100
8	02489500	1	78	133,000	0.50	0.2	2	82,000	73,400	94,800	111,000	95,600	145,000	123,000	103,000	171,000
9	02492000	2	79	132,000	0.20	0.8	4	53,600	44,800	67,100	86,200	67,800	122,000	101,000	76,500	152,000
10	02492360	3	51	19,700	4.00	2.0	9	14,500	11,600	19,900	24,700	18,300	42,900	29,900	21,200	58,400
11	07281600	2	20	19,700	10.00	3.0	20	19,900	18,800	21,800	21,500	20,100	25,300	22,100	20,400	26,800
12	07288280	1	24	11,000	1.00	0.5	7	8,490	7,410	10,500	10,600	8,930	14,900	11,400	9,450	17,100
13	07288650	1	34	13,100	0.30	0.4	5	9,540	8,770	10,900	11,300	10,100	14,200	12,800	10,600	15,800
14	07290650	6	58	50,500	10.00	6.0	10	50,200	43,500	60,900	71,200	58,800	98,900	80,500	64,800	120,000
15	07348700	4	59	26,700	6.00	3.0	10	21,100	16,400	29,200	37,800	27,300	62,800	46,000	31,800	83,100
16	07349860	1	36	12,600	0.20	0.4	5	5,810	4,840	7,620	8,420	6,620	13,000	9,620	7,360	16,200
17	07351750	2	36	13,500	4.00	2.0	9	11,800	10,500	13,900	14,600	12,700	18,700	15,700	13,400	20,900
18	07352000	1	76	24,100	0.70	0.2	2	9,050	7,170	12,200	17,000	12,500	27,600	21,200	14,900	37,500
19	07364150*	3	80	6,050	5.00	2.0	6	5,320	4,800	6,010	6,830	5,960	8,260	7,430	6,330	9,320
20	07364185*	1	17	8,720	3.00	0.8	10	7,340	7,980	9,330	7,810	8,920	11,500	7,850	9,170	12,400
21	07366200	4	61	15,500	3.00	3.0	9	10,100	8,020	13,800	18,000	13,300	29,700	21,900	15,500	39,500

Table 5. Site identification number, station number, peak information, and estimated annual exceedance probablilities for selected U.S. Geological Survey streamflow-gaging stations in Louisiana, Arkansas, and Mississippi.—Continued

[AEP, annual exceedance probability; ft³/s, cubic feet per second; <, less than]

Site identification number (fig. 1)	Station number	Flood data			AEP for observed March 2016 flood			Expected peak streamflows for selected AEP with 95 percent confidence intervals (ft³/s)								
								10 percent AEP (10-year recurrence)			2 percent AEP (50-year recurrence)			1 percent AEP (100-year recurrence)		
					Estimate (in percent)	66.7 percent confidence interval		Estimate	95 percent confidence interval		Estimate	95 percent confidence interval		Estimate	95 percent confidence interval	
		Rank	Number of annual peaks in analysis	Peak streamflow (ft³/s)		Lower (in percent)	Upper (in percent)		Lower	Upper		Lower	Upper		Lower	Upper
22	07369000	1	79	46,400	<0.20	0.2	2	24,900	22,800	27,900	32,000	28,500	38,500	35,000	30,600	43,700
23	07372050	1	15	74,700	0.80	0.9	10	30,200	19,200	65,000	55,800	32,100	186,000	69,500	38,000	280,000
24	07372200	1	58	133,000	0.90	0.2	3	58,000	45,400	80,100	104,000	75,900	177,000	128,000	89,600	240,000
25	07375000	1	73	43,000	0.50	0.2	2	13,300	10,300	18,600	26,900	19,000	46,600	34,400	23,200	66,100
26	07375500	1	78	85,300	0.40	0.2	2	36,500	30,200	46,400	60,400	46,900	87,800	71,400	53,400	111,000
27	07375800	5	61	16,800	7.00	4.0	10	13,700	10,200	20,200	28,200	19,200	52,400	36,000	23,400	75,300
28	07375960	3	44	21,500	6.00	3.0	10	17,500	13,600	24,400	29,300	21,200	49,200	34,900	24,300	63,900
29	07376000	6	76	16,700	6.00	4.0	10	13,800	11,600	17,200	21,700	17,200	30,500	25,200	19,300	37,500
30	07376500	4	73	8,190	3.00	3.0	8	6,070	5,240	7,350	8,960	7,400	12,300	10,200	8,230	14,800
31	08013000	5	73	44,900	4.00	4.0	10	32,800	27,000	41,900	53,400	41,500	77,500	62,700	47,100	97,100
32	08013500	5	80	35,900	8.00	3.0	9	33,300	28,000	41,600	52,200	41,700	73,100	60,800	47,200	90,000
33	08023080	1	36	17,000	1.00	0.4	5	9,260	7,040	13,500	15,300	10,900	27,400	18,200	12,400	35,700
34	08023400	6	53	11,500	9.00	6.0	20	10,700	8,060	15,400	20,300	14,000	35,800	25,200	16,600	49,200
35	08025500	1	59	42,000	0.90	0.2	3	14,800	11,000	22,200	31,600	21,100	62,400	41,400	26,200	93,600
36	08028000	2	65	61,900	2.00	0.9	5	29,700	22,000	44,400	65,000	43,400	126,000	85,700	54,200	188,000

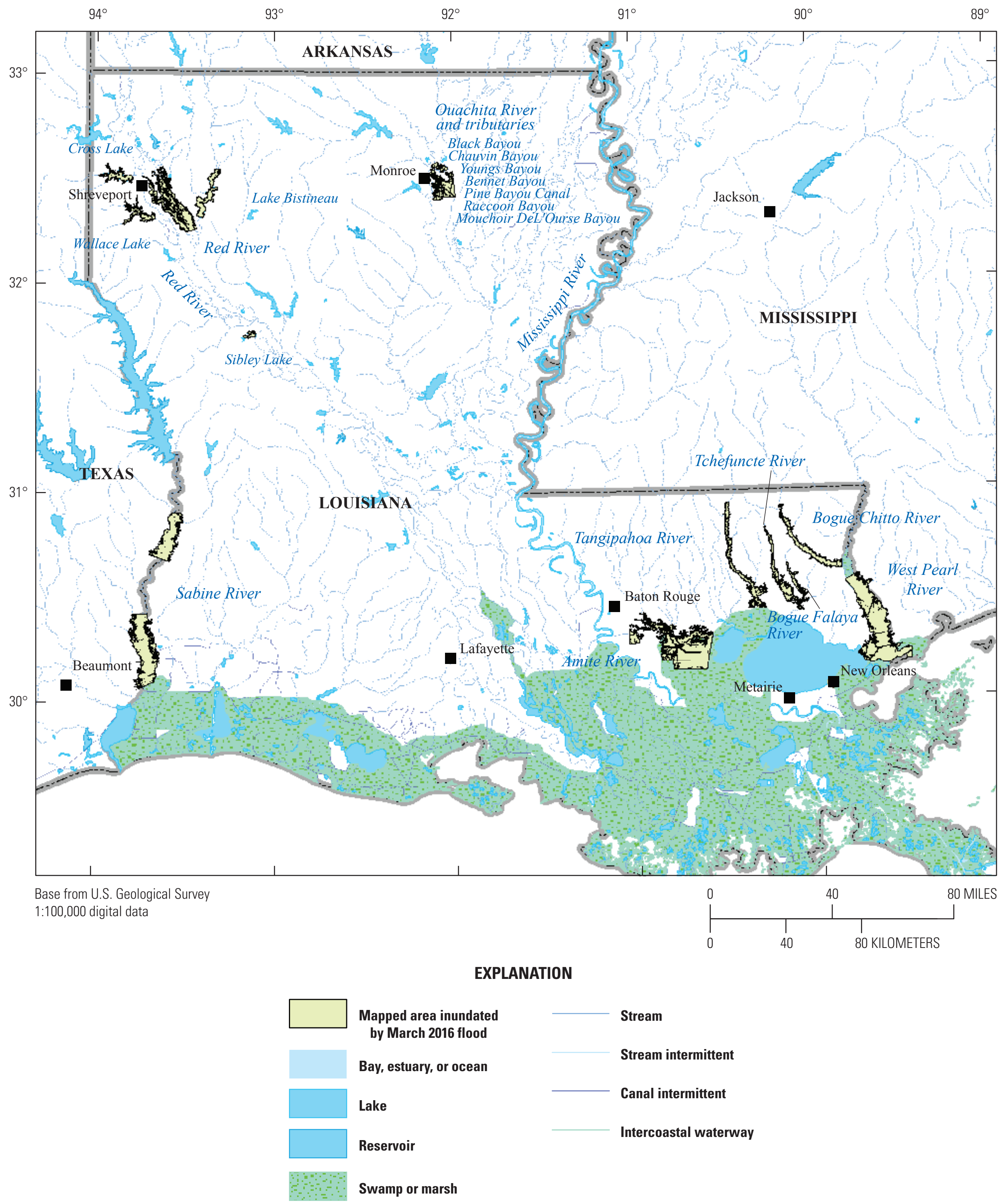


Figure 2. Areas in Louisiana, Mississippi, and Texas where maps were created showing the extent and depth of inundation during the March 2016 flood.

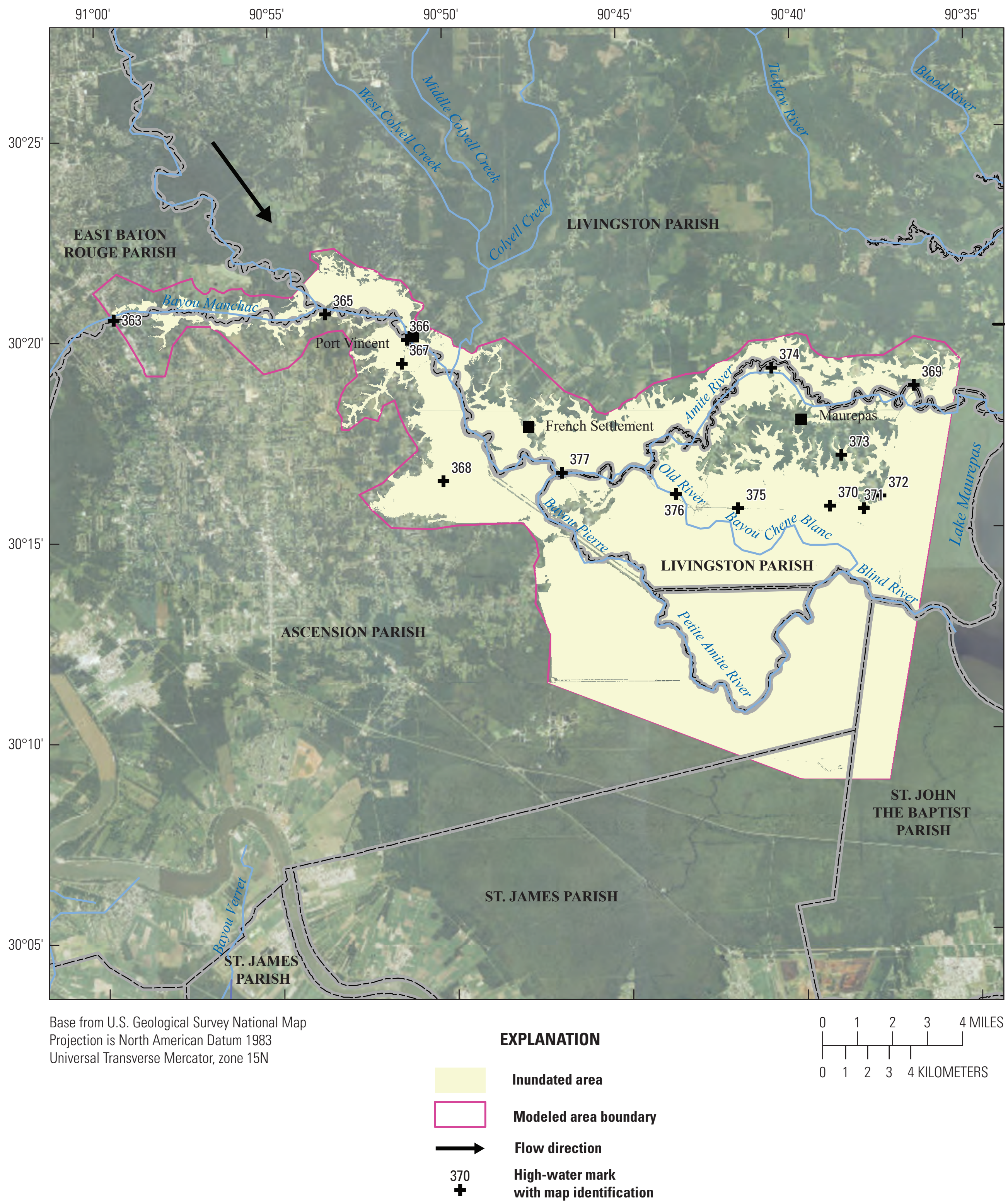


Figure 3. Flood inundation of an area of the Amite River, Louisiana, March 2016. See figure 2 for location.

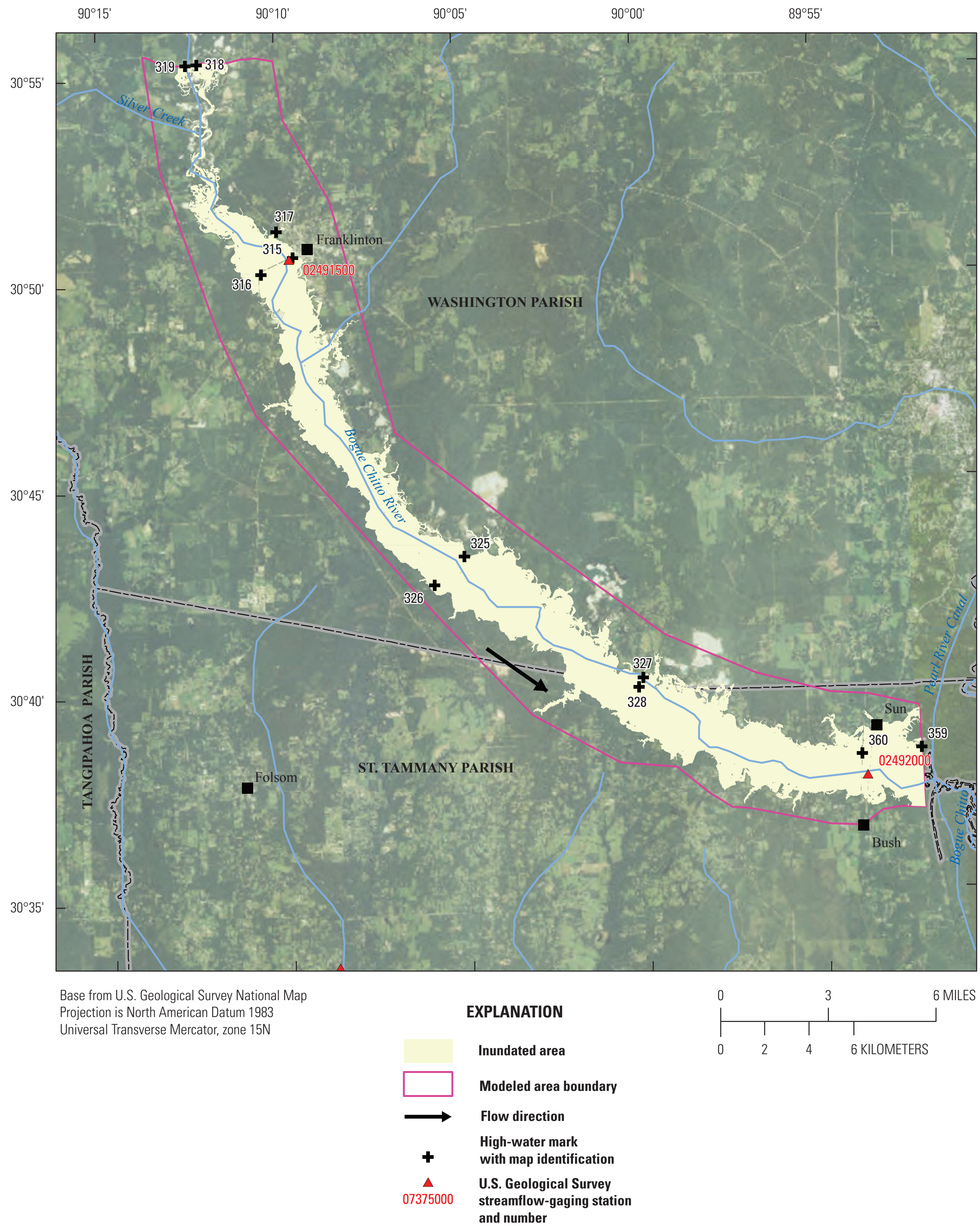


Figure 4. Flood inundation of an area of the Bogue Chitto River, Louisiana, March 2016. See figure 2 for location.

Bogue Falaya River

The Bogue Falaya River flows south through the communities of Folsom and Covington from the southern boundary of Washington Parish to St. Tammany Parish. Precipitation ranged from about 3 to 13 in. within the Bogue Falaya River Basin over the duration of the storm. Fifteen HWMs were identified and surveyed along a 16.5-mi reach through Folsom and Covington and were used to develop the inundation map (fig. 5). The depths of water at the HWMs ranged from 0.4 to 3.8 ft, and the elevations ranged from 7.4 to 106.2 ft above NAVD 88. Three gaging stations operated by the USGS in the study reach recorded peaks during the flooding: (1) a HWM was surveyed for Bogue Falaya River near Camp Covington, La. (USGS 07375105), which was damaged during the flooding, at a peak stage of 61.14 ft gage datum on March 11, 2016; (2) a HWM was surveyed for Bogue Falaya at Covington, La. (USGS 07375170), which also was damaged during the flooding, at a peak stage of 60.42 ft gage datum on March 11, 2016; and (3) Bogue Falaya River at Boston St. at Covington, La. (USGS 07375175), recorded a peak stage of 20.07 ft gage datum on March 12, 2016. The mapped inundation area for the Bogue Falaya River is uncertain near parts of its western boundary along Louisiana State Highway 25 because of a lack of HWM definition on the western side of the highway.

Cross Lake

Cross Lake is an 8,575-acre impoundment located in Caddo Parish. Precipitation ranged from about 10 to 12 in. within the Cross Lake Basin over the duration of the storm. Outflow from Cross Lake enters Twelvemile Bayou approximately 2.3 mi downstream. Twelvemile Bayou is a tributary to the Red River (fig. 2), which flows through the city of Shreveport. A total of 20 HWMs were identified along Cross Lake, and 7 of the HWMs were surveyed and used to develop the inundation map (fig. 6). The depths of water at the HWMs ranged from 0.0 to 5.6 ft, and the elevations ranged from 173.2 to 177.4 ft above NAVD 88. The USGS operates one gaging station on Cross Lake and three gaging stations on tributaries to the lake: (1) Cross Lake at Shreveport, La. (USGS 07344480), had a peak elevation of 177 ft above NAVD 88 on March 10, 2016; (2) Paw Paw Bayou near Greenwood, La. (USGS 07344450), had a peak elevation of 184.8 ft above NAVD 88 on March 9, 2016; and (3) Shettleworth Bayou near Blanchard, La. (USGS 07344460), had a peak elevation of 195.1 ft above NAVD 88 on March 9, 2016. The Cross Lake inundation map was modeled separately from the tributaries, and then the two were merged. Cross Bayou tributary was not mapped because of the long distance between HWMs.

Lake Bistineau

Lake Bistineau is an impoundment of Bayou Dorcheat, south of Minden, La., that forms part of the boundary between Bossier Parish and Bienville Parish. Precipitation ranged from about 7 to 13 in. within the Lake Bistineau Basin over the duration of the storm. Five HWMs were identified and surveyed within a 20.1-mi area of Lake Bistineau and were used to create the inundation map (fig. 7). Lake Bistineau near Ringgold, La. (USGS 07349250), recorded a peak stage of 20.16 ft gage datum on March 13, 2013. Over the duration of the storm, precipitation ranged from about 15 to 18 in. from the dam on Lake Bistineau, north to Minden, La., which is upstream from Lake Bistineau.

Ouachita River and Tributaries

The Ouachita River flows south through the community of Monroe in Ouachita Parish. During the March 2016 flood, 20.66 in. of precipitation were reported 5.3 mi east of downtown Monroe at the Monroe Regional Airport during the period March 8–11 (table 2). The 30-year normal for annual precipitation at the Monroe Regional Airport is 54.02 in. (Durre and others, 2012). Precipitation in the Ouachita River Basin ranged from about 3 to 26 in. over the duration of the storm.

The location and spatial extent of the March 2016 flood in Monroe, La. (fig. 8), was driven by the severity and areal extent of the rainfall and the location of the levees along the Ouachita River. The flood plain of the Ouachita River is controlled by several levees that were designed to protect the city of Monroe from flooding of the main channel. During the flood, the levees functioned as designed and contained the flow of the Ouachita River from the upstream drainage area (15,298 square miles); however, the majority of the precipitation fell outside of the stream drainage area over basins that contribute flow to the Ouachita River, primarily Youngs Bayou, to the east. This resulted in extensive flooding in Monroe, and surrounding areas in Ouachita Parish outside of the levee system were inundated by backwater from several tributaries within the city.

The streamflow-gaging station Ouachita River at West Monroe, La. (USGS 07367005), recorded a peak stage of 45.84 ft gage datum and streamflow of 76,900 cubic feet per second (ft^3/s) on March 25, 2016. A total of 123 HWMs were identified, and 57 of those were surveyed along seven tributaries to the Ouachita River. The surveyed HWMs were used to create five inundation maps of the city of Monroe: (1) Black Bayou Basin, (2) Chauvin Bayou Basin, (3) Pine Bayou Canal, (4) Raccoon Bayou and Mouchoir De L'Ourse Bayou, tributaries to Petticoat Bayou, and (5) Youngs Bayou and Bennet Bayou. The depths of water at the HWMs combined for all five areas ranged from 0.2 to 5.9 ft, and the elevations ranged from 63.5 to 79.3 ft above NAVD 88.

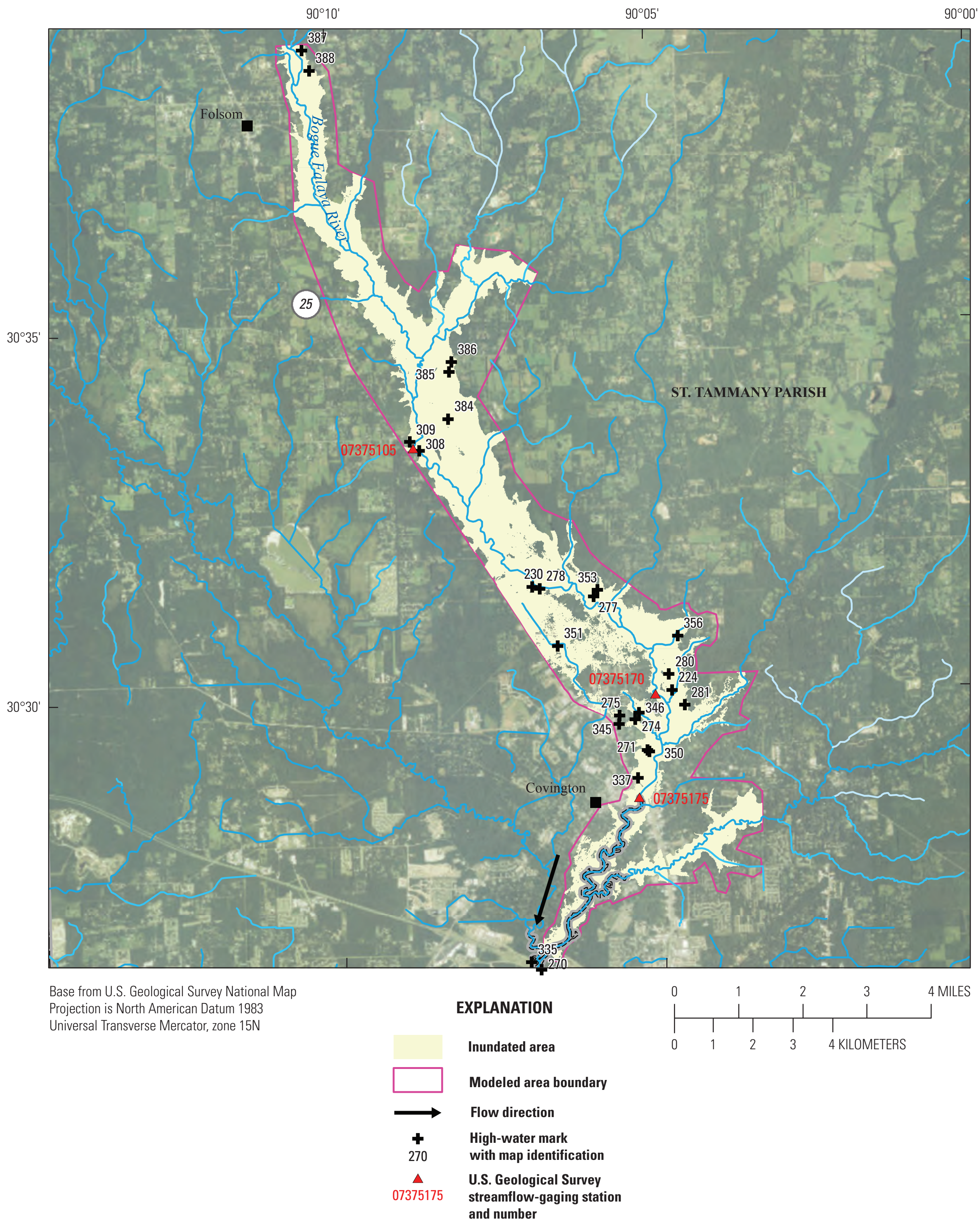


Figure 5. Flood inundation of an area of the Bogue Falaya River, Louisiana, March 2016. See figure 2 for location.

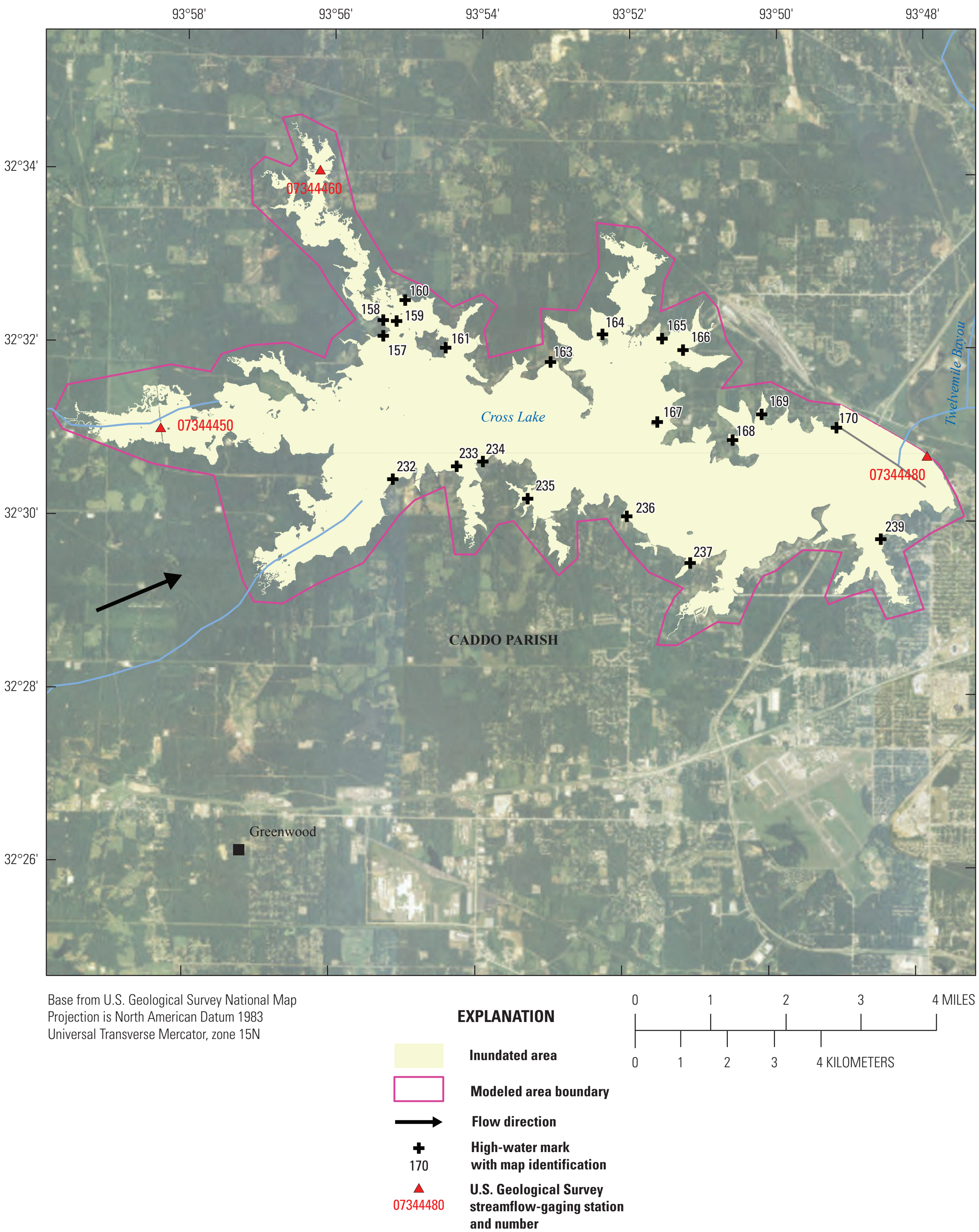


Figure 6. Flood inundation of an area of Cross Lake, Louisiana, March 2016. See figure 2 for location.

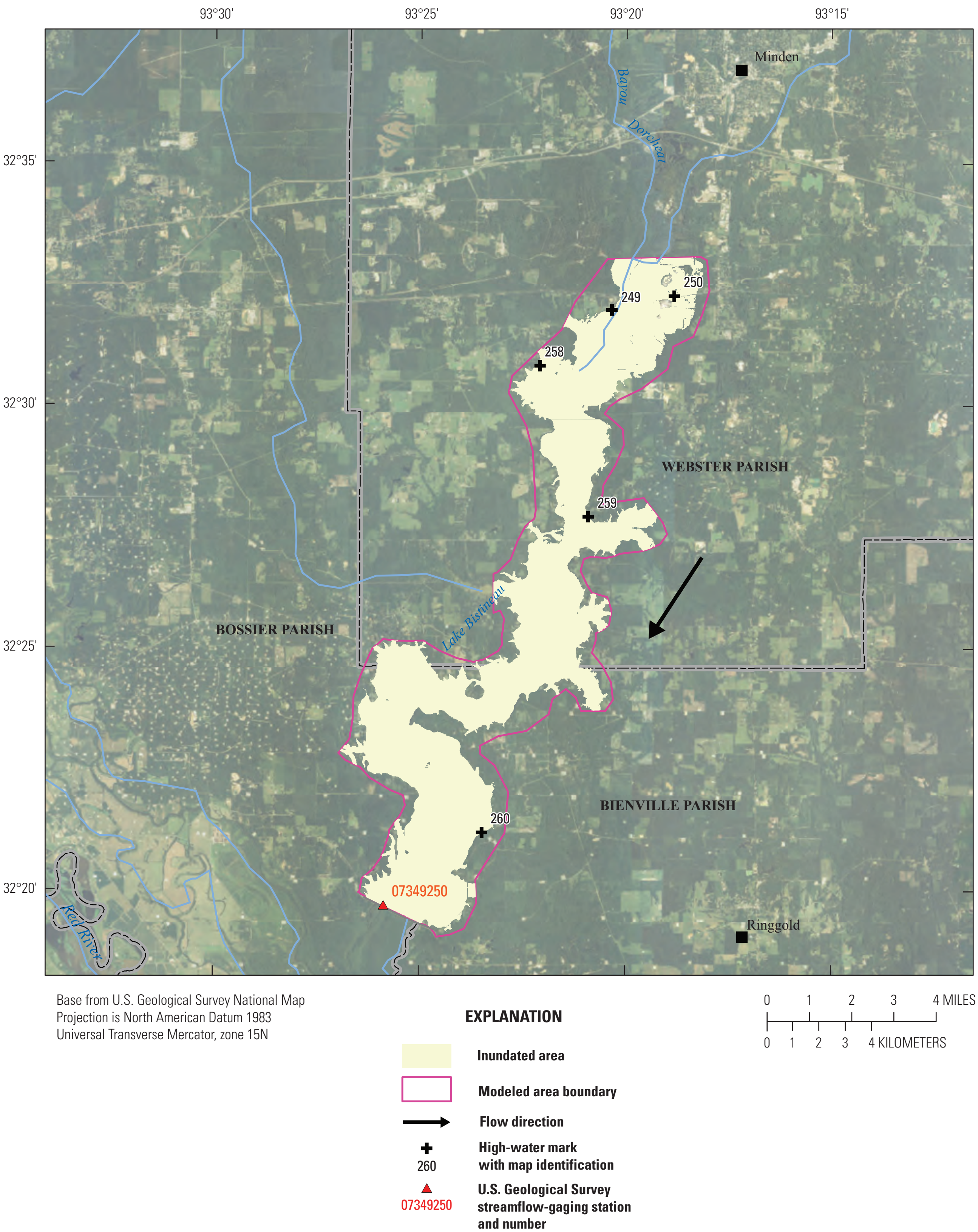


Figure 7. Flood inundation of an area of Lake Bistineau, Louisiana, March 2016. See figure 2 for location.

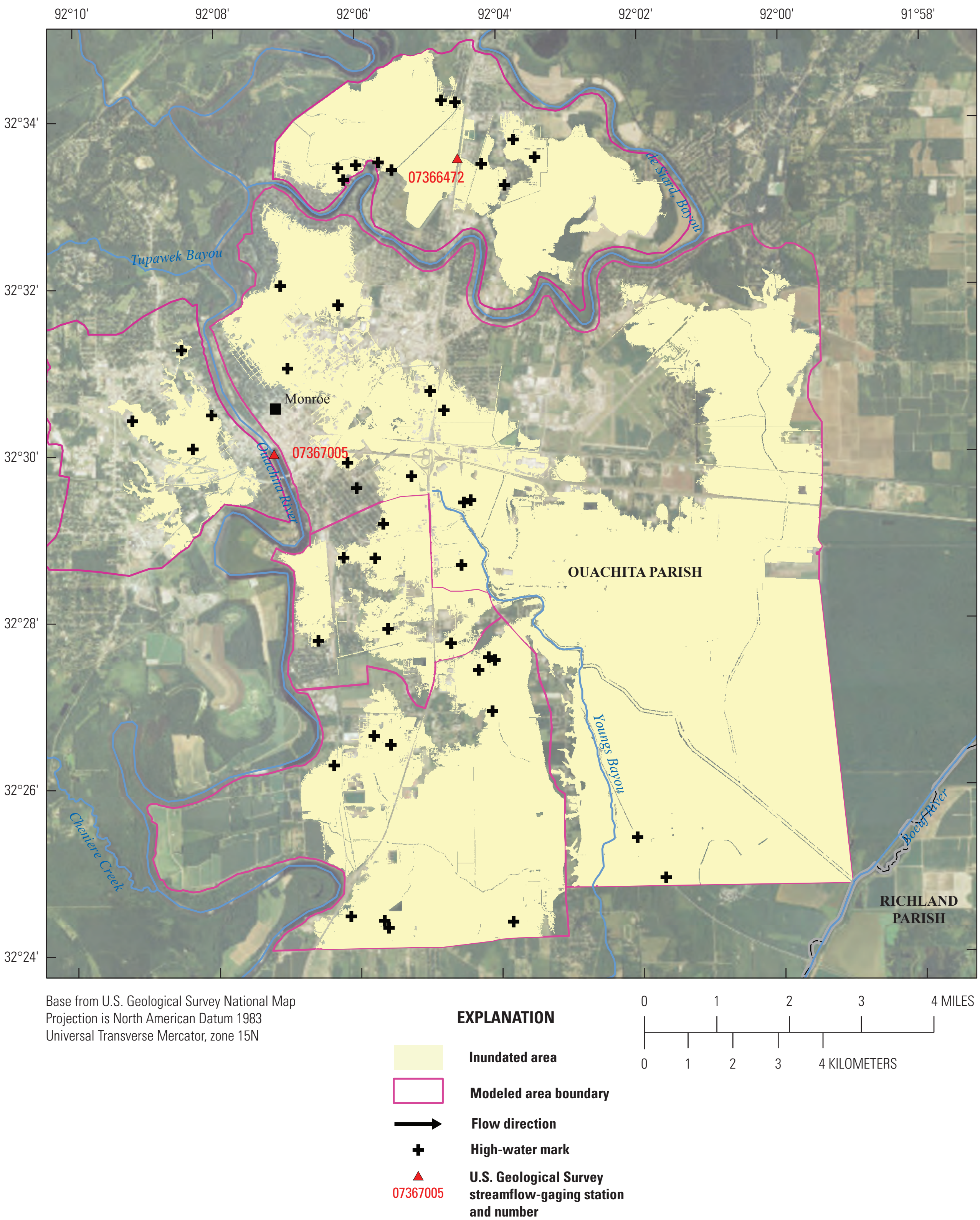


Figure 8. Flood inundation of areas around the Ouachita River in Monroe, Louisiana, March 2016. See figure 2 for location.

Black Bayou Basin

Black Bayou is a tributary to the Ouachita River, bound on the north and west by a natural ridge and on the east and south by the Ouachita River levee structure (fig. 9). It is controlled by a gate structure on the south levee, which connects it to the Ouachita River south of the streamflow-gaging station Ouachita River at West Monroe, La. (USGS 07367005; fig. 8). During flood events, water from the Black Bayou does not mix with water from other basins because it is contained by natural ridges and manmade levees. Nine HWMs were identified, six were surveyed along the 4.3-mi stream reach through West Monroe, and four were used to develop the inundation map. The depths of water at the HWMs ranged from 0.2 to 5.9 ft, and the elevations ranged from 71.89 to 79.31 ft above NAVD 88.

Chauvin Bayou Basin

Chauvin Bayou is bound on the north, east, and south by Bayou de Siard and flows through the middle of a meander bend of Bayou de Siard. This tributary joins the Ouachita River 0.21 mi upstream from where Bayou de Siard flows into the Ouachita River. On the west, Chauvin Bayou is bound by levee structures and a gate that connects it to the Ouachita River. A levee also divides Chauvin Bayou from the Ouachita River at USGS streamflow-gaging station Chauvin Bayou at Monroe, La. (USGS 07366472), which recorded a peak stage of 41.13 ft on March 18, 2016. Fifty-one HWMs were identified and 11 were surveyed along the 5.2-mi stream reach through the meander of Bayou de Siard in Monroe, and 10 were used to develop the inundation map (fig. 10). The depths of water at the HWMs ranged from 0.25 to 2.91 ft, and the elevations ranged from 68.43 to 72.08 ft above NAVD 88.

Pine Bayou Canal

Pine Bayou Canal is located in Ouachita Parish in the city of Monroe (fig. 8). The canal flows east and is a tributary to Youngs Bayou (fig. 8). During flood events, water from Pine Bayou Canal can mix with water from other basins to the north and south. Eleven HWMs were identified along a 3-mi reach of Pine Bayou Canal, and five were surveyed and used to develop the inundation map of the basin (fig. 11). The depths of water at the HWMs ranged from 0.8 to 2.1 ft, and the elevations ranged from 69.0 to 75.3 ft above NAVD 88.

Raccoon Bayou and Mouchoir De L’Ourse Bayou

Raccoon Bayou and Mouchoir De L’Ourse Bayou are located in Ouachita Parish in the city of Monroe. Both bayous flow in a southeastern direction. Flows in Raccoon Bayou and Mouchoir De L’Ourse Bayou can intermingle with other basins to the north and south. Seven HWMs were identified along a 5.9-mi reach of Mouchoir De L’Ourse Bayou, and 12 HWMs were identified along a 3.0-mi reach of Raccoon Bayou. A total of nine HWMs were surveyed and used to develop a combined inundation map for these basins (fig. 12). The depths of water at the HWMs ranged from 0.4 to 2.4 ft, and the elevations ranged from 67.8 to 72.3 ft above NAVD 88.

Youngs Bayou and Bennet Bayou (includes Gourd Bayou)

Youngs Bayou and Bennet Bayou are located in Ouachita Parish at the city of Monroe (fig. 8). Bennet Bayou flows south and is a tributary to Youngs Bayou. Youngs Bayou flows in a southeastern direction. During flood events, they share a common flood plain and their flows intermingle. Twenty-four HWMs were identified along an 11.6-mi reach of Youngs Bayou, and three HWMs were identified along a 4.4-mi reach of Bennet Bayou. Seventeen of these HWMs were surveyed and used to create a combined flood inundation map (fig. 13). The depths of water at the HWMs ranged from 0.2 to 2.3 ft, and the elevations ranged from 64.6 to 78.9 ft above NAVD 88. A limited number of HWMs were recovered south of Interstate 20. Two of these HWMs appeared to be incorrect based on photographs and comparison to other elevations in connected basins. The flood profile indicated that these two HWMs were too low; therefore, they were not used in this analysis. Omitting these two HWMs improved agreement between the inundation map of these three bayous and the adjoining basins.

Pearl River

The Pearl River is approximately 444 mi long, has its headwaters in central Mississippi, and flows south along the border of Louisiana and Mississippi for approximately 75 mi. Precipitation ranged from about 2 to 13 in. within the Pearl River Basin over the duration of the storm. The Pearl River empties into Lake Borgne east of Slidell, La., continues into the Mississippi Sound, and eventually flows into the Gulf of Mexico. The mapped inundation reach flows 30 mi through the communities of St. Tammany Parish and the city of Slidell, La. A total of 18 HWMs were identified along the Pearl River, and 15 were surveyed and used to create the flood-inundation map (fig. 14). The depths of water at the HWMs ranged from 0.2 to 9.5 ft, and the elevations ranged from 2.38 to 35.3 ft above NAVD 88. The USGS operates one streamflow-gaging station on the Pearl River and three streamflow-gaging stations on nearby streams that were used to create the inundation depth map: (1) Pearl River at Pearl River, La. (USGS 02492600), had a peak elevation of 20.57 ft above NAVD 88 on March 14, 2016; (2) Wilson Slough near Walkiah Bluff, Miss. (USGS 02492111), had a peak elevation of 46.08 ft above NAVD 88 on March 13, 2016; (3) Bayou Liberty near Slidell, La. (USGS 07374581), had a peak elevation of 4.2 ft above NAVD 88; and (4) Rigolets at Highway 90 near Slidell, La. (USGS 301001089442600), had a peak elevation of 3.38 ft above NAVD 88 on March 10, 2016.

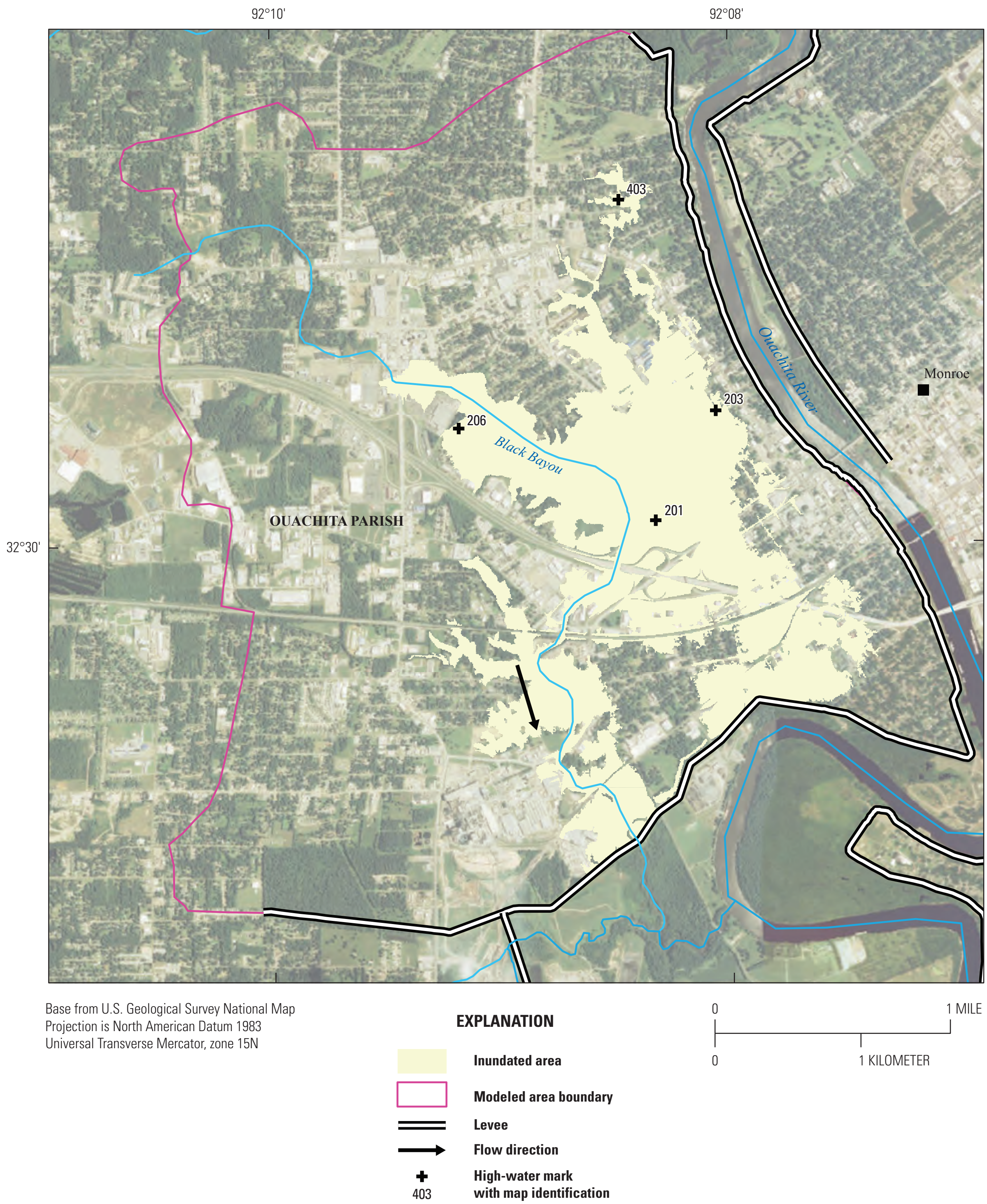
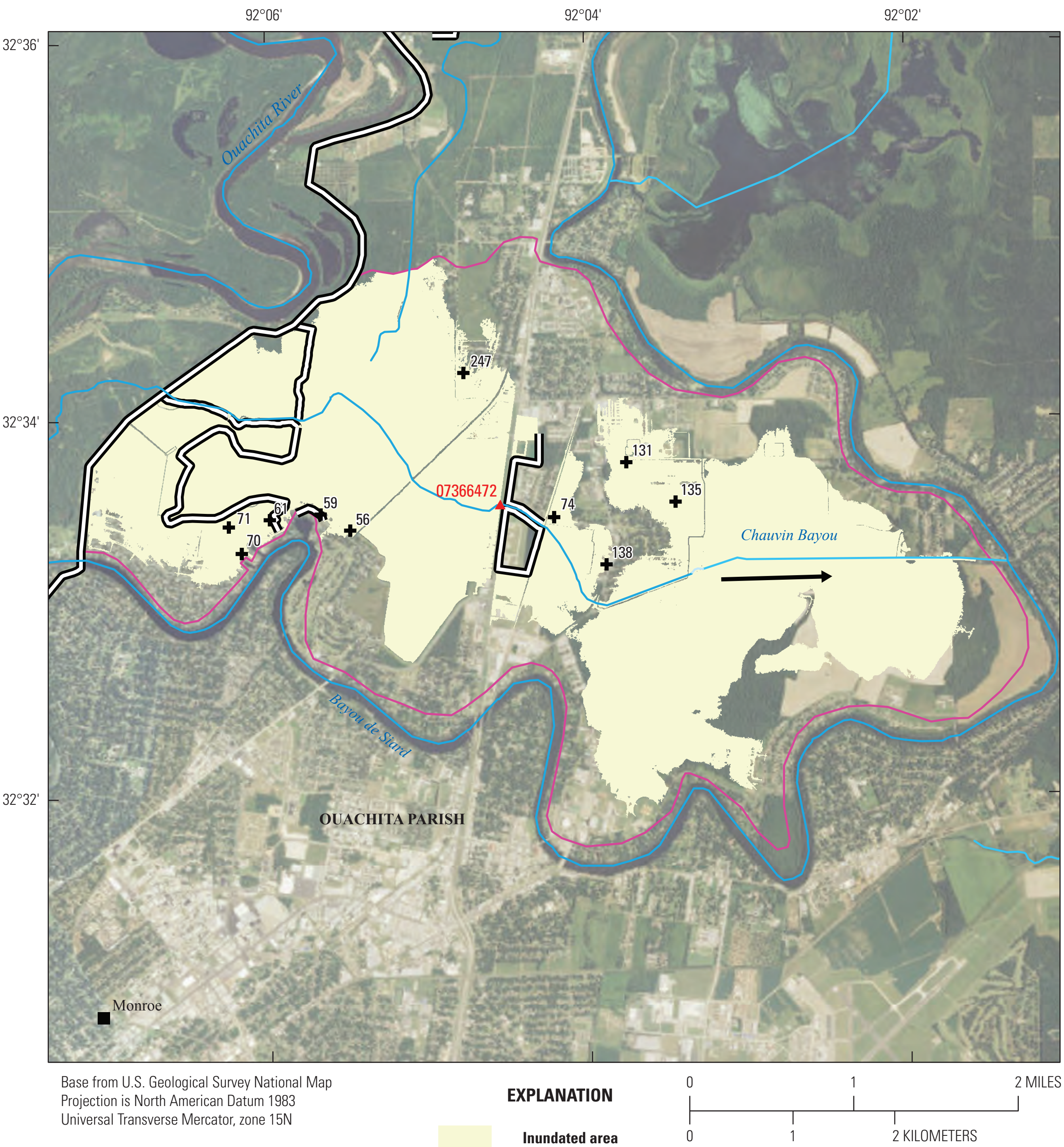


Figure 9. Flood inundation of an area of Black Bayou, a tributary to the Ouachita River, Louisiana, March 2016. See figure 2 for location.



EXPLANATION

- Inundated area
- Modeled area boundary
- Flow direction
- Levee
- High-water mark with map identification (59)
- U.S. Geological Survey streamflow-gaging station and number (07366472)

Figure 10. Flood inundation of an area of Chauvin Bayou, a tributary to the Ouachita River, Louisiana, March 2016. See figure 2 for location.

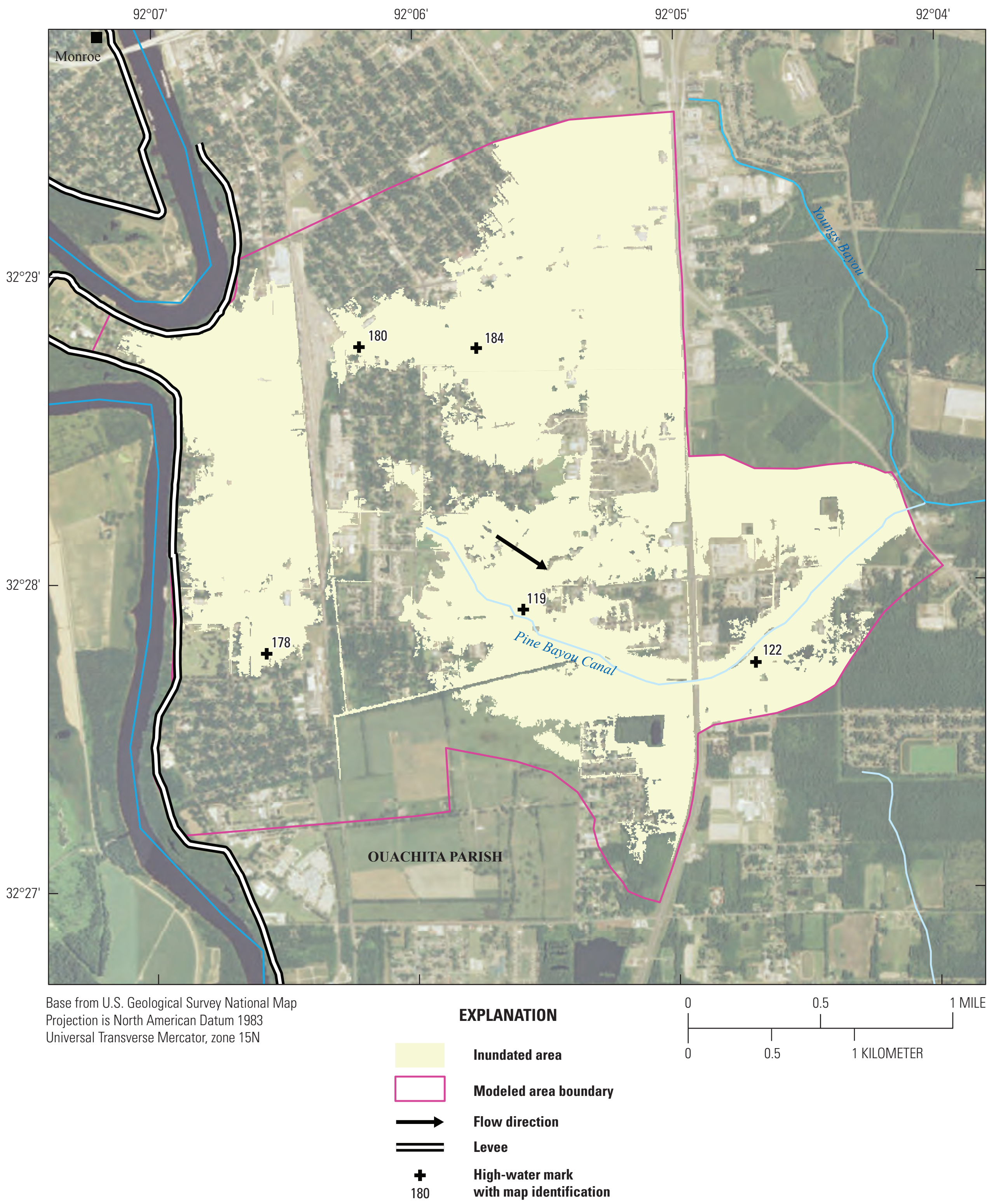


Figure 11. Flood inundation of an area of Pine Bayou Canal, a tributary to the Ouachita River, Louisiana, March 2016. See figure 2 for location.

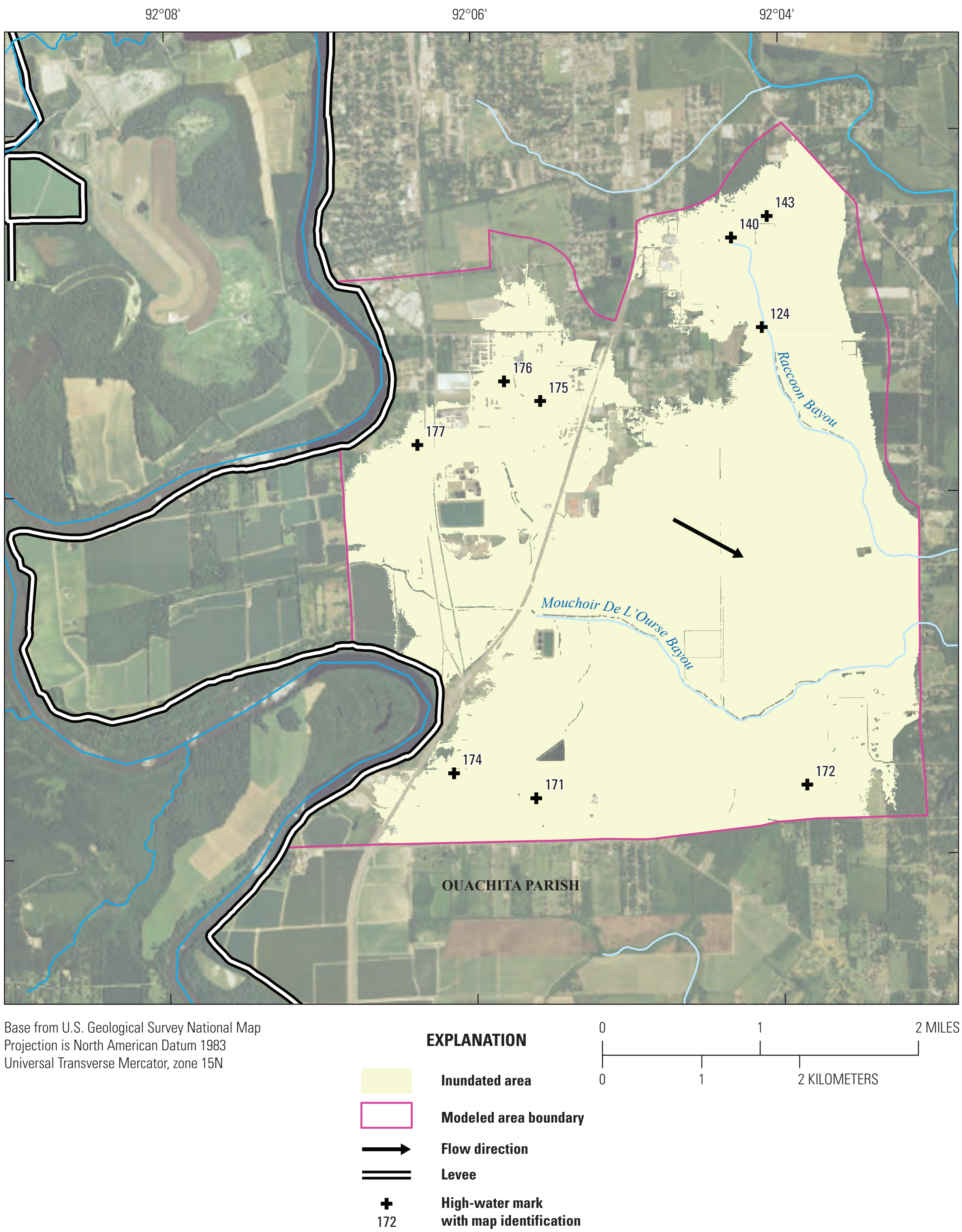


Figure 12. Flood inundation of the areas of Raccoon Bayou and Mouchoir De L'Ourse Bayou, Louisiana, March 2016. See figure 2 for location.

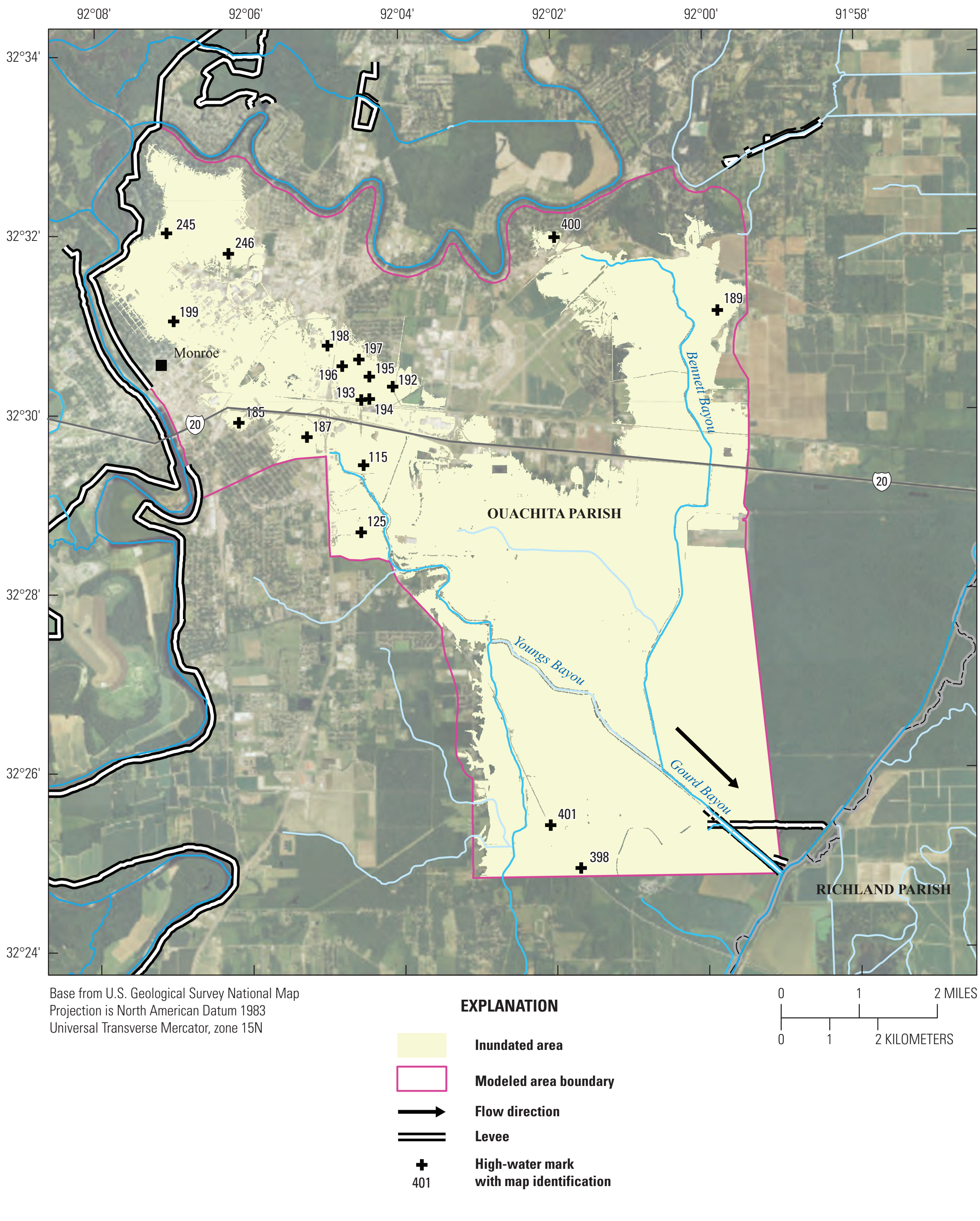


Figure 13. Flood inundation of the areas of Youngs Bayou and Bennet Bayou (includes Gourd Bayou), a tributary to the Ouachita River, Louisiana, March 2016. See figure 2 for location.

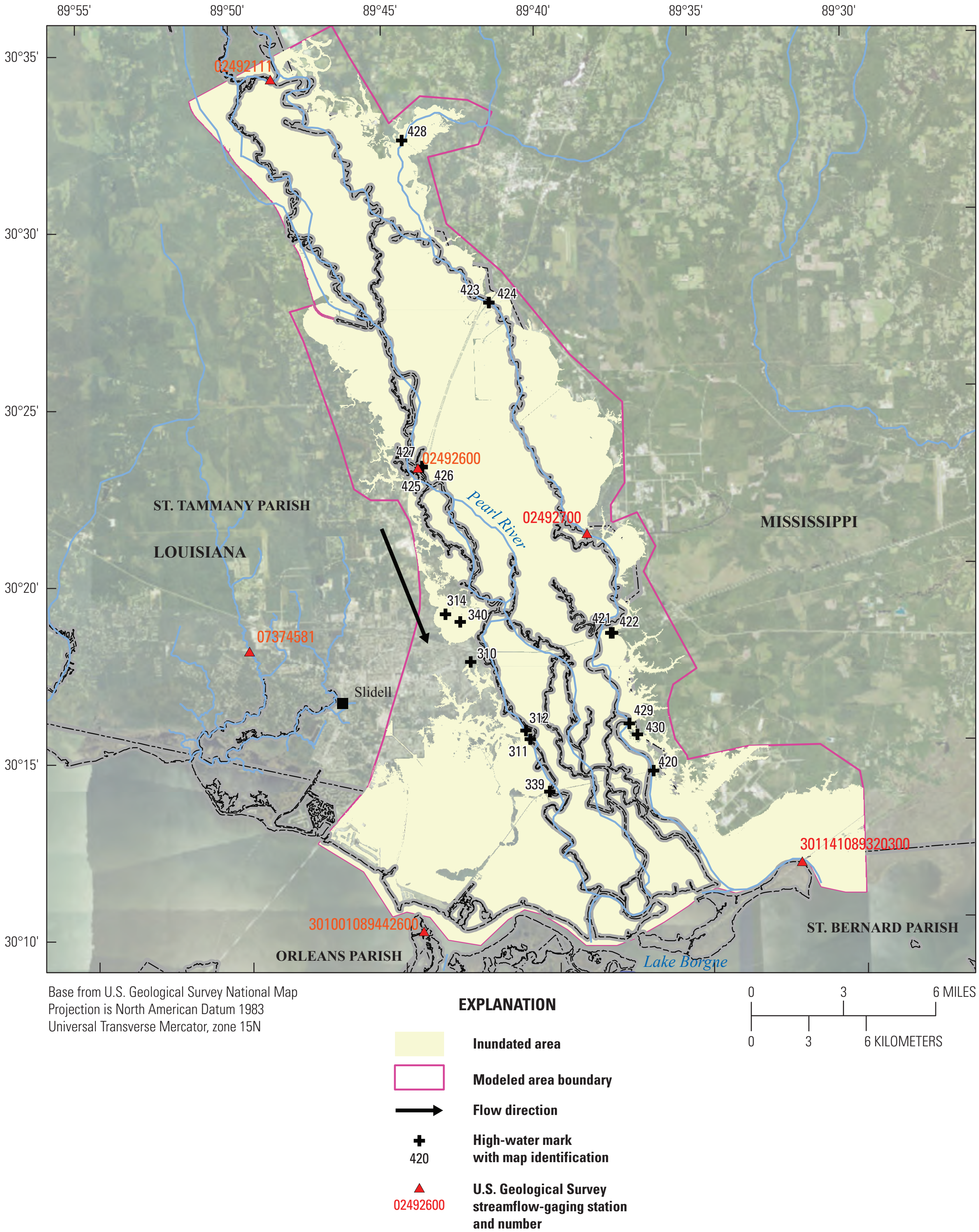


Figure 14. Flood inundation of an area of Pearl River, Louisiana, March 2016. See figure 2 for location.

Red River and Wallace Lake

The Red River flows southeast through the city of Shreveport in Bossier and Caddo Parishes, Louisiana (fig. 15). Wallace Lake is a 2,300-acre lake located 14 mi southeast of Shreveport (near the community of Keithville) in the Cypress Bayou Basin that straddles Caddo and De Soto Parishes (fig. 16). The extent and depth of flooding were mapped for a 22-mi reach of the Red River and a 13-5 mi section of Wallace Lake.

Along the Red River, a total of 25 HWMs were identified, and 8 were surveyed and used to create the inundation map. Precipitation exceeded 18 in. within the Red River Basin over the duration of the storm. The inundation reach of the Red River was separated into two river reaches using the boundary of the levee along the Red River to divide the inundation extent for the Red River and Flat River (fig. 15). The depths of water at the HWMs ranged from 0.28 to 3.9 ft, and the elevations ranged from 150.1 to 165.2 ft above NAVD 88. Three streamflow-gaging stations were used in the analysis of the Red River reach: (1) Bayou Pierre at Shreveport, La. (USGS 07350700), recorded a peak stage of 23.31 ft gage datum and an elevation of 158.8 ft above NAVD 88 on March 9, 2016; (2) Wallace Lake near Shreveport, La. (USGS 07351550, operated by the U.S. Army Corps of Engineers), is at the outflow of Wallace Lake and recorded a peak stage of 160.23 ft gage datum on March 9, 2016 (fig. 16); and (3) Red River at Shreveport, La. (USGS 07348500, operated by the U.S. Army Corps of Engineers), recorded a peak stage of 31.79 ft gage datum and an elevation of 163.27 ft above NAVD 88 on March 15, 2016.

A total of five HWMs were identified along Wallace Lake and four of the HWMs were surveyed and used to create the inundation map (fig. 16). Precipitation ranged from about 11 to 17 in. within the Wallace Lake Basin over the duration of the storm. Water depths at the HWMs ranged from 0.0 to 4.0 ft, and the elevations ranged from 158.4 to 161.7 ft above NAVD 88.

Sabine River

The Sabine River flows south from the eastern side of Texas to Sabine Lake and forms the border between Texas and Louisiana for 265 mi. Twenty-two HWMs were identified and surveyed along a 79.9-mi reach; however, two smaller reaches of the Sabine River were the focus of inundation mapping. Precipitation ranged from about 1 to 22 in. within the Sabine River Basin over the duration of the storm.

Near Merryville, La., the depths of water at the 12 HWMs used for the mapped inundation area ranged from 0.83 to 9.2 ft, and the elevations ranged from 60.1 to 115 ft above NAVD 88. Of the 12 HWMs collected along this section of the Sabine River, 10 were used to create the inundation map (fig. 17) and 3 were located within the areal extent of the inundation map. One streamflow-gaging station operated by the USGS within the mapped area, Sabine River near Bon Wier, Tex. (USGS 08028500), recorded a peak stage of 60.42 ft gage datum on March 13, 2016, and a peak streamflow of 278,000 ft^3/s.

Around Orange, Tex., the depths of water at the eight HWMs, four of which were located within the areal extent of the inundation map, used to develop the inundation map ranged from 1.1 to 4.4 ft, and the elevations ranged from 10.2 to 25.1 ft above NAVD 88. One streamflow-gaging station operated by the USGS within the mapped area was used to create the inundation map (fig. 18). Sabine River (at Navy Pier) at Orange, Tex. (USGS 08030540), recorded a peak stage of 7.62 ft gage datum on March 17, 2016.

Sibley Lake

Sibley Lake is an impoundment of Rio Hondo and Youngs Bayou, which lies to the west of downtown Natchitoches, La., in Natchitoches Parish. From the dam on Sibley Lake west to the headwaters of Youngs Bayou, total precipitation was about 17 in. over the duration of the storm. Four HWMs were identified and surveyed along a 3.8-mi part of Sibley Lake and were used in the creation of the inundation map (fig. 19). The depths of water at the HWMs ranged from 0 to 5.1 ft, and the elevations ranged from 123.53 to 123.8 ft above NAVD 88.

Tangipahoa River

The Tangipahoa River flows south through Tangipahoa Parish into Lake Pontchartrain. The extent of the inundation map is a 40-mi reach of the Tangipahoa River from Kentwood to Ponchatoula/Hammond in Tangipahoa Parish. Precipitation ranged from about 7 to 13 in. within the Tangipahoa River Basin over the duration of the storm. A total of 62 HWMs were identified along the Tangipahoa River, and 50 were surveyed and used to create the inundation map (fig. 20). The depths of water at the HWMs ranged from 0.15 to 8.4 ft, and the elevations ranged from 16.06 to 196.38 ft above NAVD 88. The USGS operates four streamflow-gaging stations on the Tangipahoa River that were used in the creation of the inundation maps: (1) Tangipahoa River near Kentwood, La. (USGS 07375300), recorded a peak stage of 14.11 ft gage datum and a water-surface elevation of 194.18 ft above the National Geodetic Vertical Datum of 1929 (NGVD 29) on March 11, 2016; (2) Tangipahoa River near Amite, La. (USGS 07375430), recorded a peak stage of 23.27 ft gage datum and water-surface elevation of 103.27 ft above NAVD 88 on March 12, 2016; (3) Tangipahoa River at Robert, La. (USGS 07375500), recorded a peak stage of 25.31 ft gage datum and water-surface elevation of 31.91 ft above NAVD 88 on March 12, 2016; and (4) Tangipahoa River near Ponchatoula, La. (USGS 07375650), recorded a peak stage of 20.41 ft gage datum and water-surface elevation of 23.10 ft above NAVD 88 on March 12, 2016.

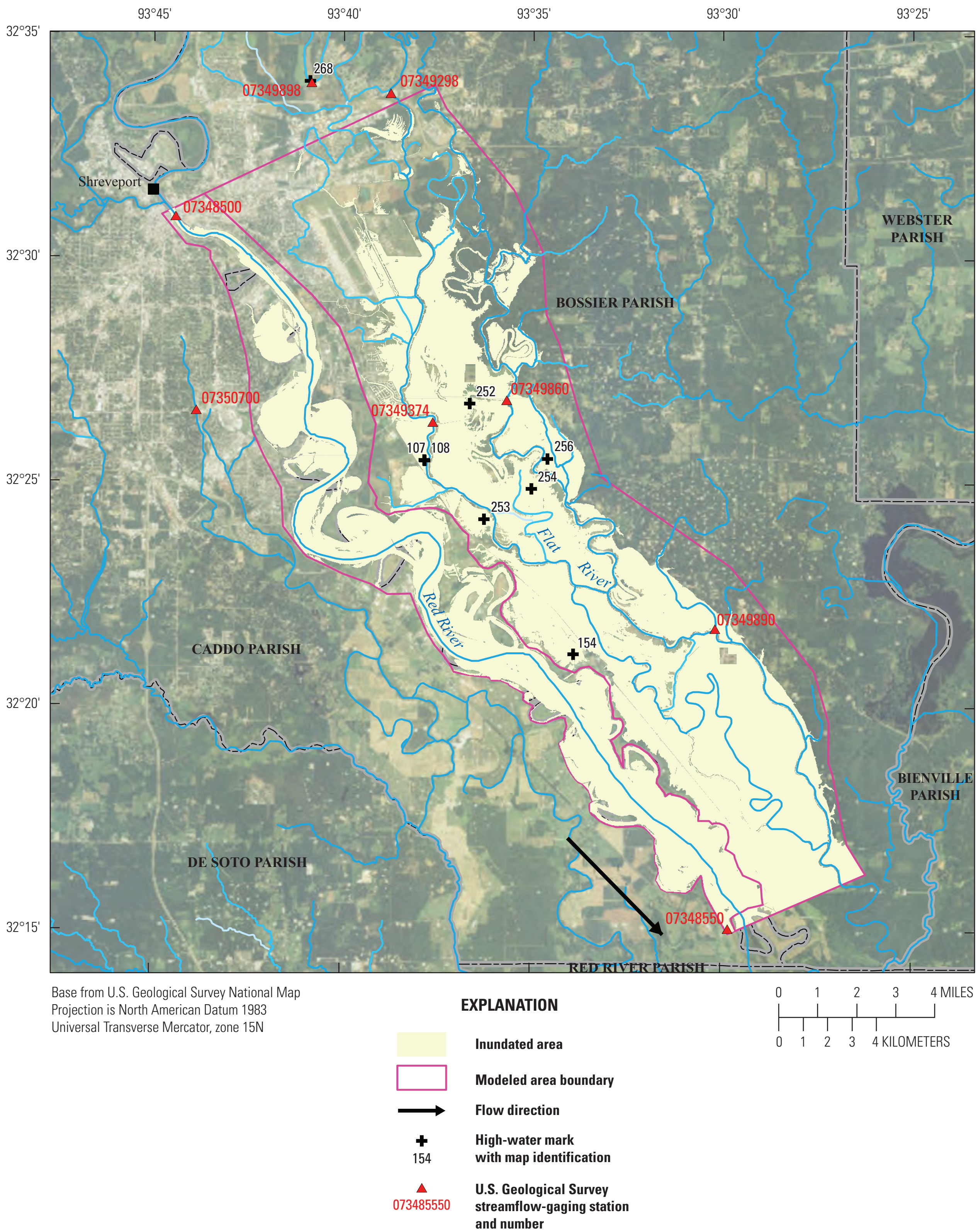


Figure 15. Flood inundation of an area of Red River, Louisiana, March 2016. See figure 2 for location.

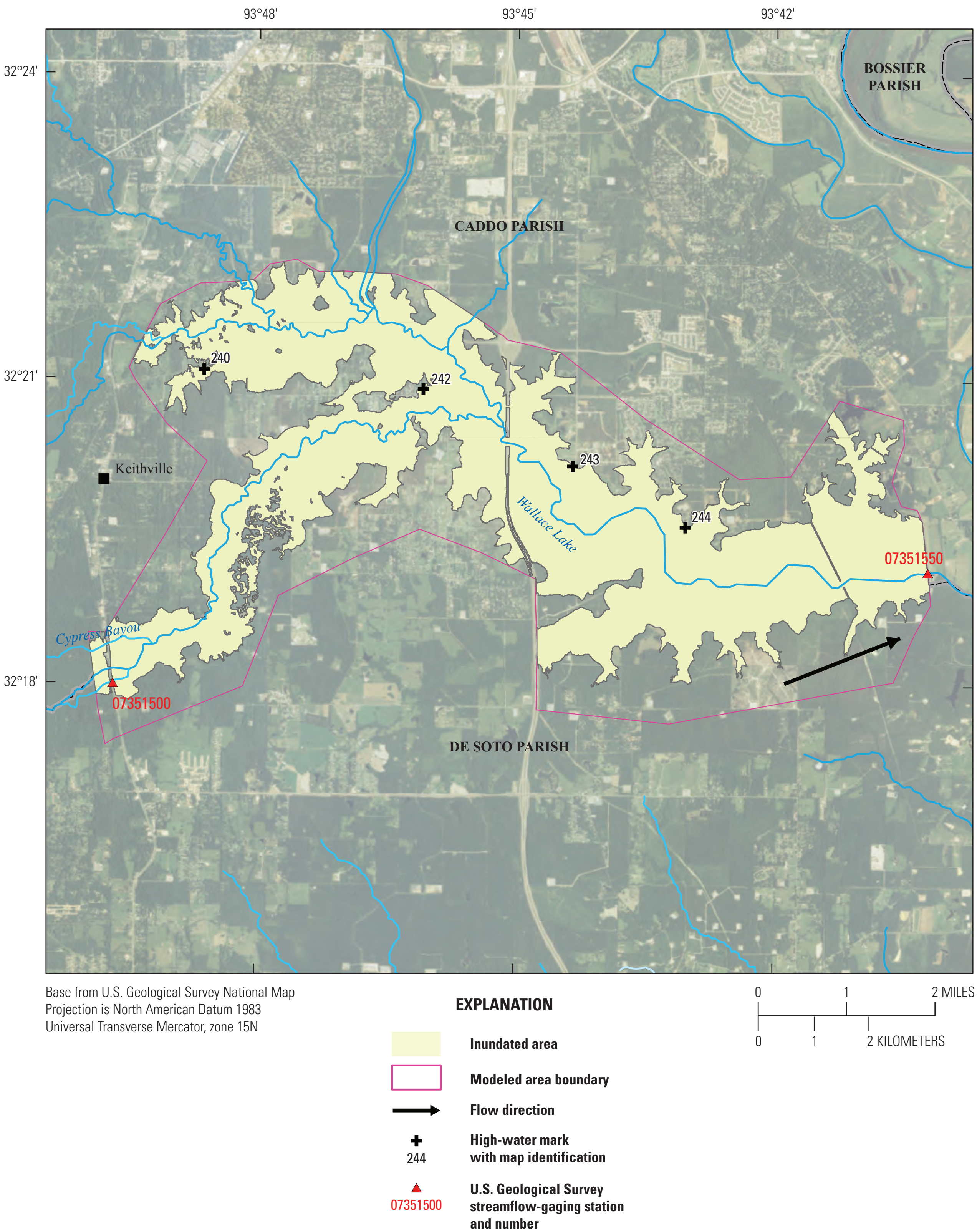


Figure 16. Flood inundation of an area of Wallace Lake, Louisiana, March 2016. See figure 2 for location.

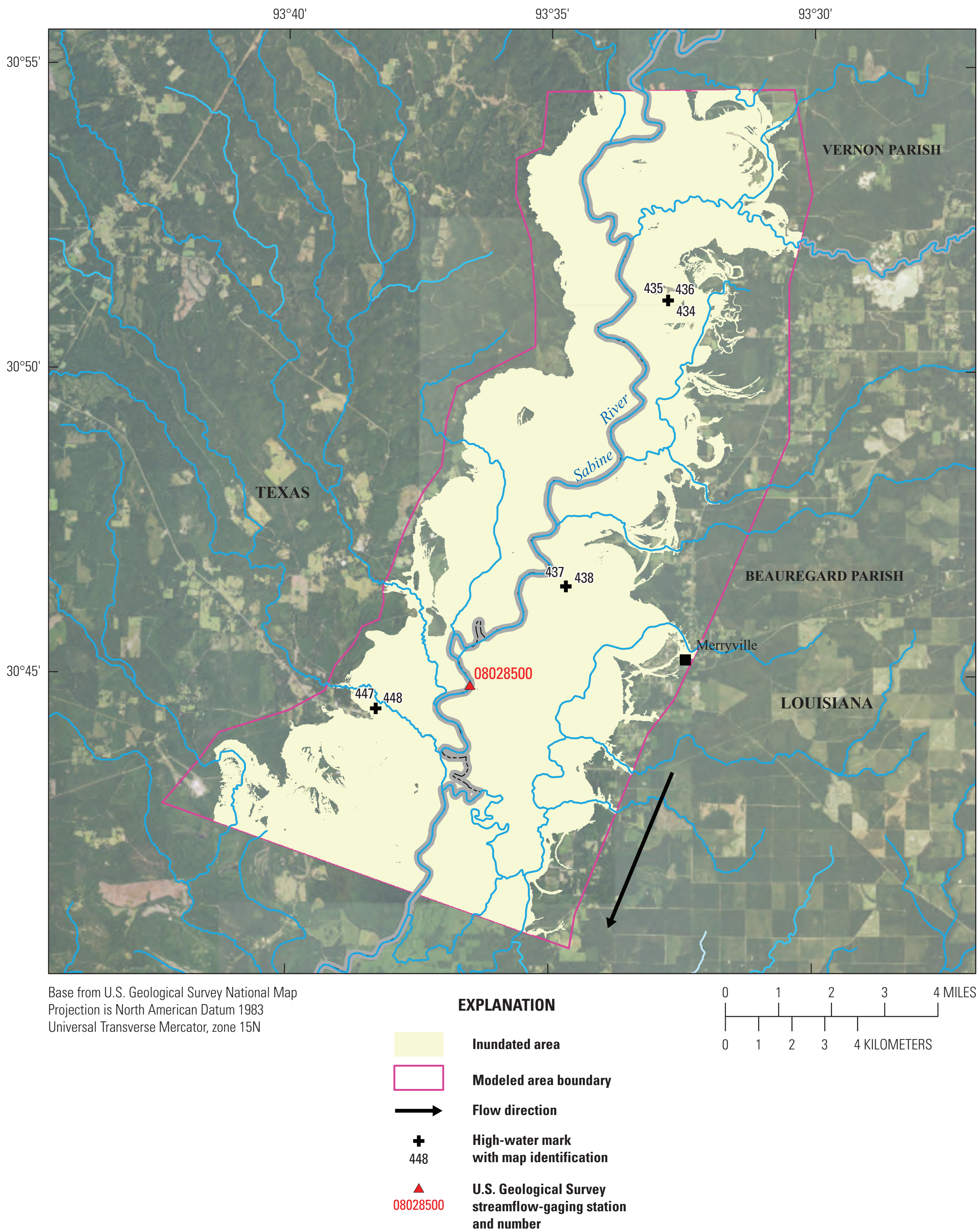


Figure 17. Flood inundation of an area of the Sabine River, Louisiana and Texas, March 2016. See figure 2 for location.

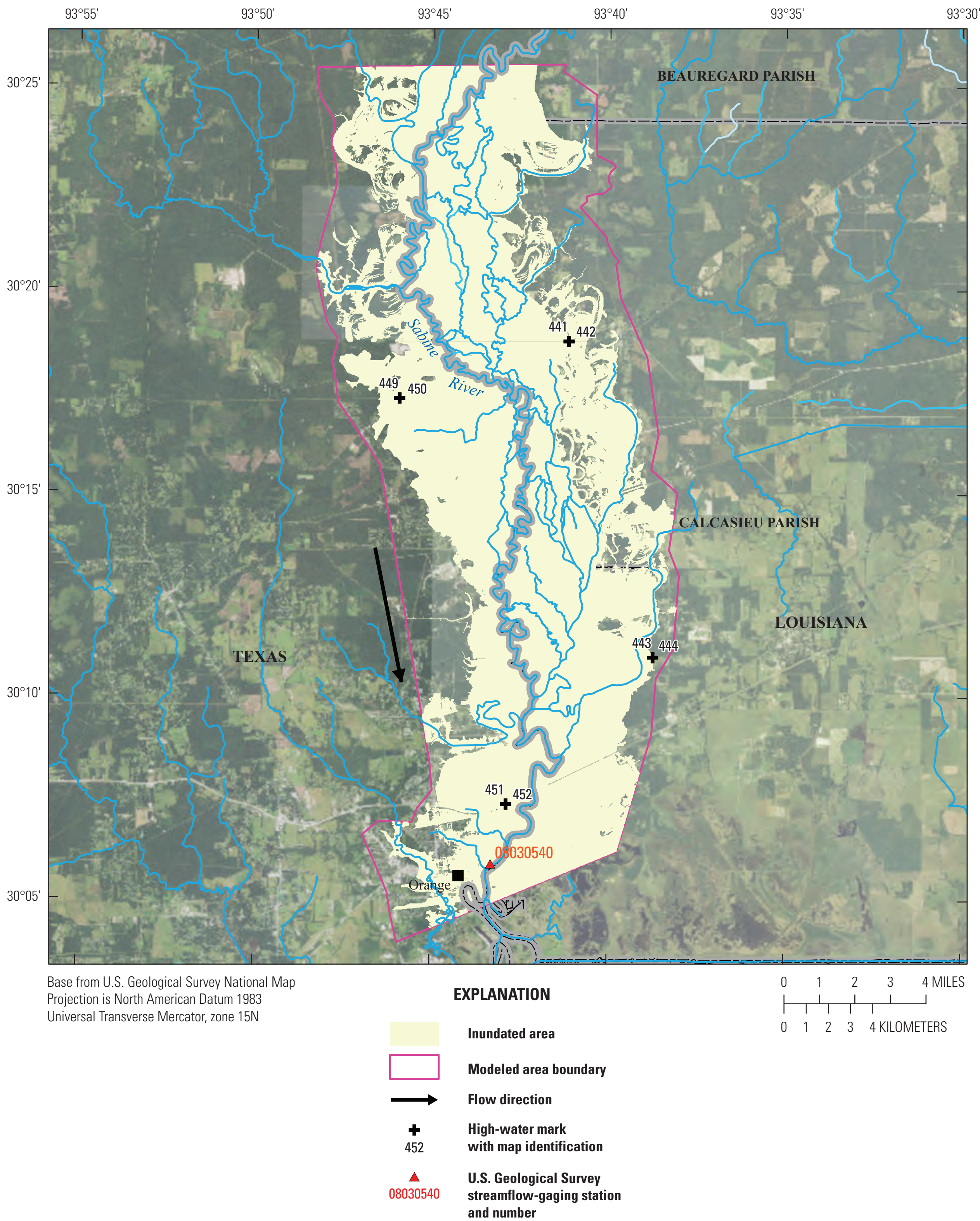


Figure 18. Flood inundation of an area of the Sabine River, Texas and Louisiana, March 2016. See figure 2 for location.

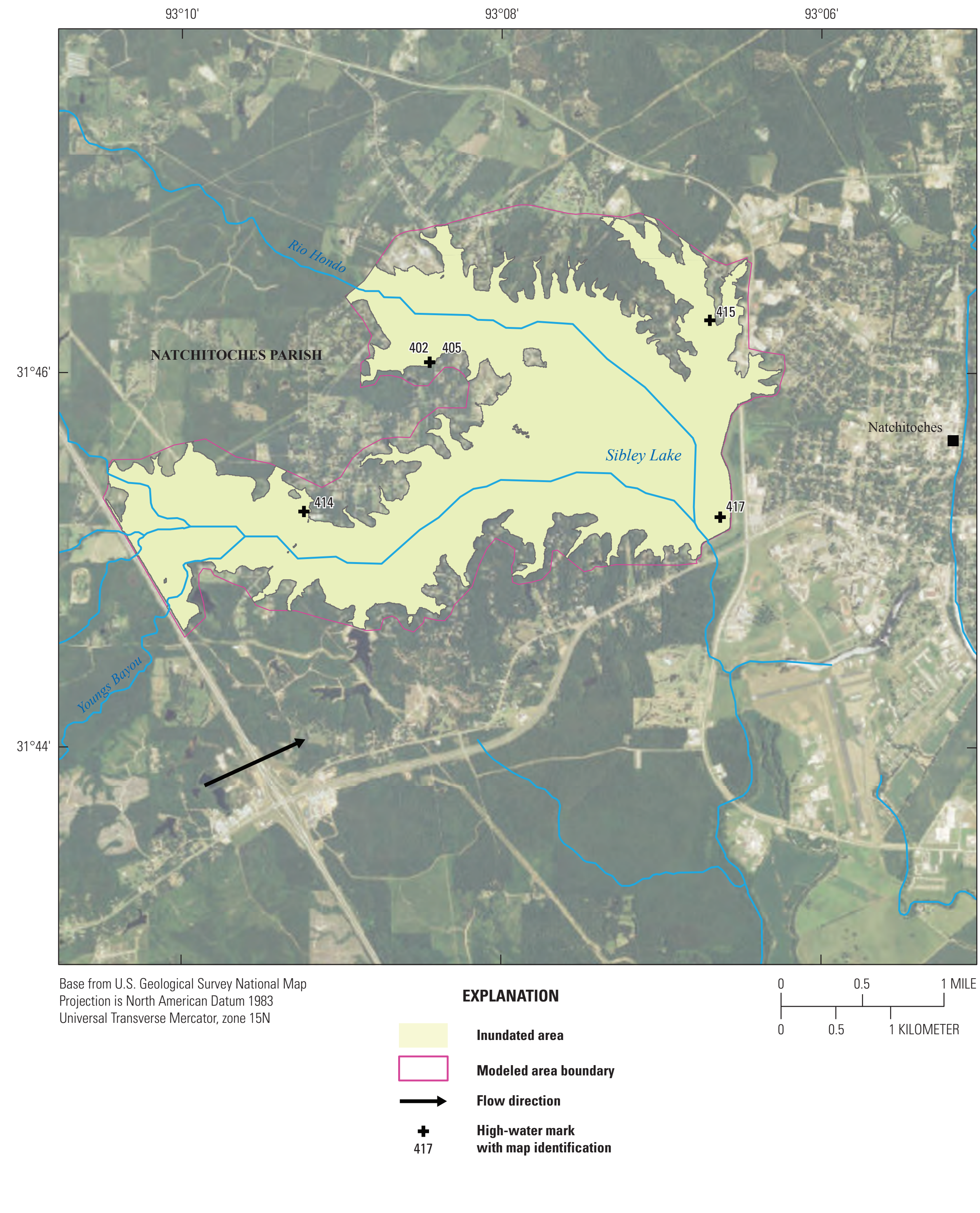


Figure 19. Flood inundation of an area of Sibley Lake, Louisiana, March 2016. See figure 2 for location.

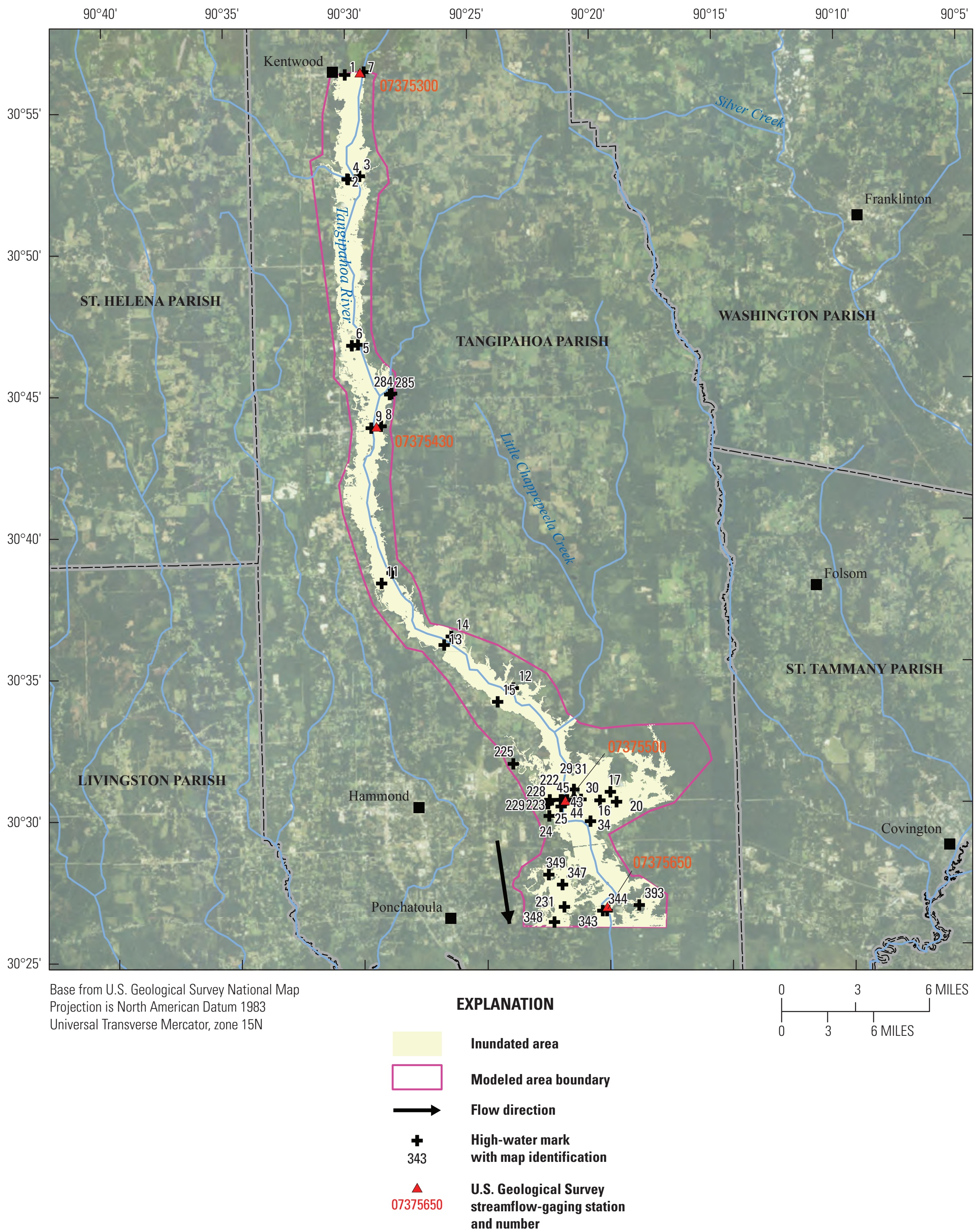


Figure 20. Flood inundation of an area of the Tangipahoa River, Louisiana, March 2016. See figure 2 for location.

Tchefuncte River

The Tchefuncte River flows south through the community of Covington and forms the southern section of the boundary of Washington Parish and Tangipahoa Parish on its upstream end and the northern section of the boundary between St. Tammany Parish and Tangipahoa Parish. Precipitation ranged from about 3 to 17 in. within the Tchefuncte River Basin over the duration of the storm. Twenty-four HWMs were identified and surveyed along a 32.4-mi reach through Covington and were used in the creation of the inundation map (fig. 21). The depths of water at the HWMs ranged from 0.3 to 6.9 ft, and the elevations ranged from 6.49 to 181.5 ft above NAVD 88. One streamflow-gaging station and one stage-gaging station operated by the USGS recorded peaks during the flooding: (1) Tchefuncte River near Folsom, La. (USGS 07375000), recorded a peak stage of 25.25 ft gage datum and a streamflow of 43,000 ft^3/s on March 11, 2016; and (2) Tchefuncte River near Covington, La. (USGS 07375050), recorded a peak stage of 31.20 ft gage datum on March 12, 2016. The mapped inundation area for the Tchefuncte River was modified for parts on the western boundary along Louisiana State Highway 1077 because HWMs were not defined on the western side of the highway.

Summary

During the period of March 8–13, 2016, the interaction between a large, slow-moving, southward dipping jetstream and a low-pressure system over Mexico funneled deep tropical moisture into parts of the Gulf Coast States and the Mississippi River Valley, resulting in rainfall amounts near 27 inches that caused historic flooding in numerous stream basins in Louisiana, Texas, Arkansas, and Mississippi. At least four fatalities were reported, and damages from the flood were estimated at $1.3 billion. In the immediate aftermath of the flood, the U.S. Geological Survey and the Federal Emergency Management Agency initiated a cooperative study to evaluate the magnitude and extent of the flood and the probability of occurrence. U.S. Geological Survey hydrographers identified and documented 451 high-water marks that were used to create 19 flood-inundation maps that document the extent and depth of flooding. Peak gage-heights, peak streamflows, and estimated annual exceedance probabilities are provided for 36 streamflow-gaging stations operated by the U.S. Geological Survey in Louisiana, southern Arkansas, and western Mississippi. Of the 36 streamflow-gaging stations analyzed, 14 experienced a peak of record streamflow and 29 experienced peak streamflows that ranked in the top five for the period of record. Annual exceedance probability estimates for the analyzed streamflow-gaging stations ranged from less than 0.2 to 10 percent. Analyses of the probability of the peak streamflow that occurred, the depth of flood waters, and the areal extent of flood waters are important for the purposes of infrastructure design, community planning, and for the protection of life and property.

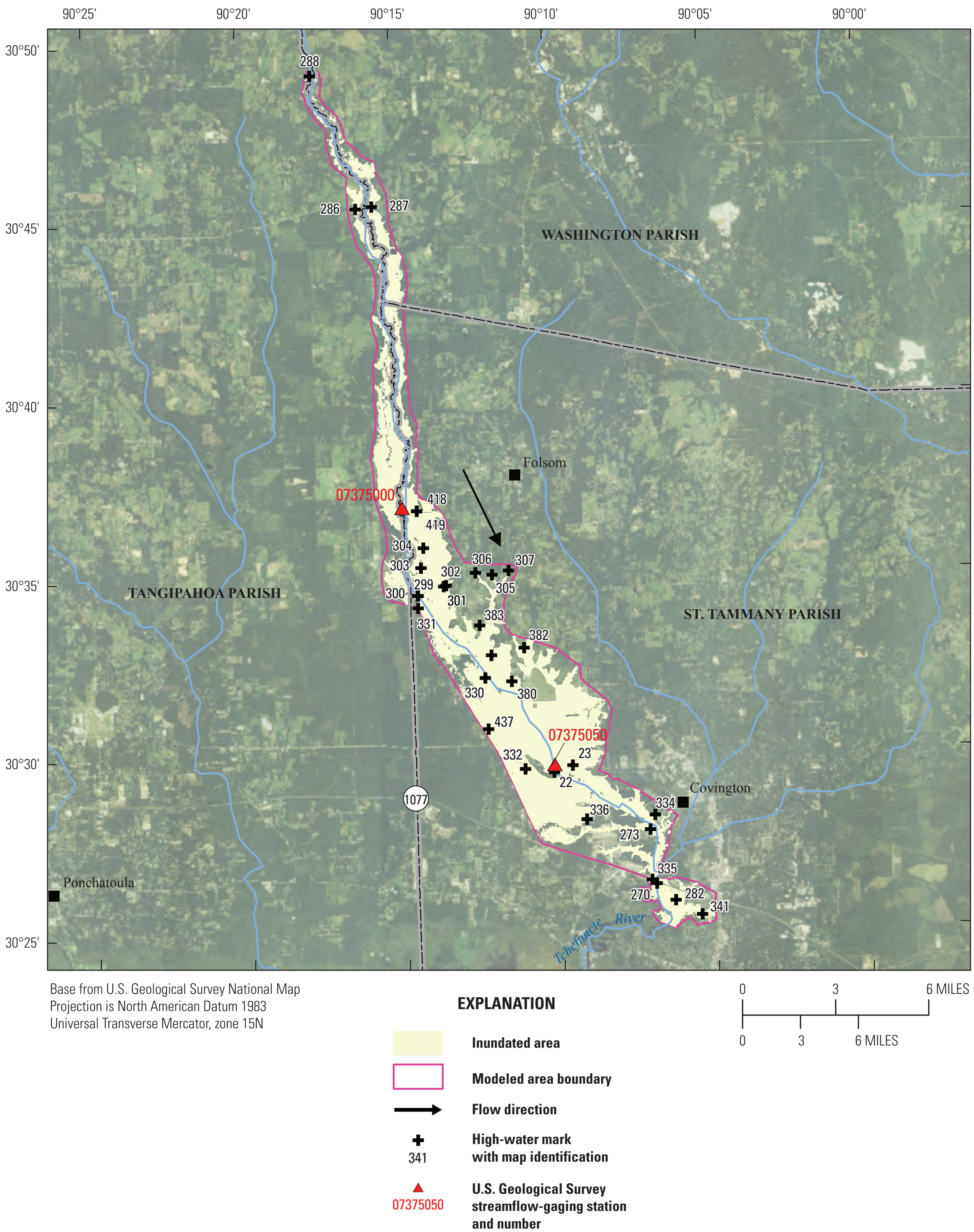


Figure 21. Flood inundation of an area of the Tchefuncte River, Louisiana, March 8-13, 2016. See figure 2 for location.

Selected References

Benson, M.A., and Dalrymple, Tate, 1967, General field and office procedures for indirect measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. Al, 30 p. [Also available at http://pubs.er.usgs.gov/publication/twri03A1.]

Cohn, T.A., Lane, W.L., and Baier, W.G., 1997, An algorithm for computing moments-based flood quantile estimates when historical flood information is available: Water Resources Research, v. 33, no. 9, p. 2089–2096.

Cohn, T.A., Lane, W.L., and Stedinger, J.R., 2001, Confidence intervals for Expected Moments Algorithm flood quantile estimates: Water Resources Research, v. 37, no. 6, p. 1695–1706.

Di Liberto, Tom, 2016, “Maya Express” behind Gulf Coast soaking, accessed August 5, 2016, at https://www.climate.gov/news-features/event-tracker/maya-express-behind-gulf-coast-soaking.

Durre, Imke, Squires, M.F., Vose, RS., Arguez, A., Applequist, S. and Yin, X., 2012, Computational procedures for the 1981–2010 normals—Precipitation, snowfall, and snow depth: National Climatic Data Center Report, 10 p.

Fenneman, N.M., 1946, Physical divisions of the United States: U.S. Geological Survey map, scale 1:7,000,000, 1 sheet.

Heal, E.N., and Breaker, B.K., 2016, Flood inundation extent and depth in selected areas of Louisiana, Texas, and Mississippi in March 2016: U.S. Geological Survey data release, https://doi.org/10.5066/F7T43R6C.

Koenig, T.A., Bruce, J.L., O’Connor, J.E., McGee, B.D., Holmes, R.R., Jr., Hollins, Ryan, Forbes, B.T., Kohn, M.S., Schellekens, M.F., Martin, Z.W., and Peppler, M.C., 2016, Identifying and preserving high-water mark data: U.S. Geological Survey Techniques and Methods, book 3, chap. A24, 47 p. [Also available at http://dx.doi.org/10.3133/tm3A24.]

Musser, J.W., Watson, K.M., Painter, J.A., and Gotvald, A.J., 2016, Flood-inundation maps of selected areas affected by the flood of October 2015 in central and coastal South Carolina: U.S. Geological Survey Open-File Report 2016–1019, 81 p. [Also available at http://dx.doi.org/10.3133/ofr20161019.]

National Centers for Environmental Information (NCEI), 2016a, accessed August 2, 2016, at http://www.ncdc.noaa.gov/billions/events.

National Centers for Environmental Information (NCEI), 2016b, accessed on August 2, 2016, at http://www.ncdc.noaa.gov/sotc/national/201603.

R Core Team, 2016, R: A language and environment for statistical computing: R Foundation for Statistical Computing, Vienna, Austria.

Rantz, S.E., and others, 1982a, Measurement and computation of streamflow: U.S. Geological Survey Water-Supply Paper 2175, v. 1, 284 p. [Also available at http://pubs.usgs.gov/wsp/wsp2175/pdf/WSP2175_vol1a.pdf.]

Rantz, S.E., and others, 1982b, Measurement and computation of streamflow: U.S. Geological Survey Water-Supply Paper 2175, v. 2, 631 p. [Also available at http://pubs.usgs.gov/wsp/wsp2175/pdf/WSP2175_vol2a.pdf.]

Turnipseed, D.P., and Sauer, V.B., 2010, Discharge measurements at gaging stations: U.S. Geological Survey Techniques and Methods book 3, chap. A8, 87 p. [Also available at http://pubs.usgs.gov/tm/tm3-a8/.]

Veilleux, A.G., Cohn, T.A., Flynn, K.M., Mason, R.R., Jr., and Hummel, P.R., 2014, Estimating magnitude and frequency of floods using the PeakFQ 7.0 program: U.S. Geological Survey Fact Sheet 2013–3108, 2 p. [Also available at http://pubs.usgs.gov/fs/2013/3108/.]

Wagner, D.M., Krieger, J.D., and Veilleux, A.G., 2016, Methods for estimating annual exceedance probability discharges for streams in Arkansas, based on data through water year 2013: U.S. Geological Survey Scientific Investigations Report 2016–5081, 136 p. [Also available at http://dx.doi.org/10.3133/sir20165081.]

Weather Channel, 2016, accessed August 5, 2016, at https://weather.com/storms/severe/news/historic-south-flooding-march-2016.

Wood, S.N., 2004, Stable and efficient multiple smoothing parameter estimation for generalized additive models: Journal of the American Statistical Association, v. 99, p. 673–686.

Wood, S.N., 2011, Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models: Journal of the Royal Statistical Society, v. 73, p. 3–36.

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