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Final Report 528

Development of Wave and Surge Atlas for the Design and Protection of Coastal Bridges in South Louisiana

by

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16. Abstract

This report summarizes the work performed by Ocean Engineering Associates, Inc. (OEA), a division of INTERA Inc. (OEA/INTERA), for Louisiana Department of Transportation and Development (DOTD) on (1) the development of a Wave and Surge Atlas for coastal Louisiana and (2) the determination of the vulnerability of selected DOTD coastal bridges to design storm surge and wave loads. In this study, the bridge is considered to be vulnerable if the surge/wave forces and moments (with the appropriate load factors) exceed the resistive forces and moments created by the dead weight of the superstructure for any of the spans. A Level III storm surge/wave analysis was performed to provide the design water level and wave parameters needed to compute the loads. This analysis entailed (1) the hindcasting of 50 of the most severe tropical storms and hurricanes that have affected Louisiana coastal waters over the past 160 years, and (2) performing extreme value analyses on water elevation and wave heights throughout the area covered by the model to obtain 100-year design met/ocean conditions. To increase the data set for the extreme value analyses, a select number of the hindcasted storm paths were shifted to the right and left of the actual path and the modified-path storms hindcasted. This resulted in 124 hindcasts to perform. The results from the extreme value analyses were used to create a Wave and Surge Atlas. The atlas is presented in a GIS database for ease of access and use. The information in the GIS database has many applications beyond that of providing the conditions needed for computation of surge/wave loads on the bridge superstructures.

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ABSTRACT

This report summarizes the work performed by Ocean Engineering Associates, Inc. (OEA), a division of INTERA Inc. (OEA/INTERA), for the Louisiana Department of Transportation and Development (DOTD) on (1) the development of a Wave and Surge Atlas for coastal Louisiana, and (2) the determination of the vulnerability of selected DOTD coastal bridges to design storm surge and wave loads. In this study, the bridge is considered vulnerable if the surge/wave forces and moments (with the appropriate load factors) exceed the resistive forces and moments created by the dead weight of the superstructure for any of the spans. A Level III storm surge/wave analysis was performed to provide the design water level and wave parameters needed to compute the loads. This analysis entailed (1) the hindcasting of 50 of the most severe tropical storms and hurricanes that have affected Louisiana coastal waters over the past 160 years, and (2) performing extreme value analyses on water elevation and wave heights throughout the area covered by the model to obtain 100-year design met/ocean conditions. To increase the data set for the extreme value analyses, a select number of the hindcasted storm paths were shifted to the right and left of the actual path and the modified-path storms hindcasted. This resulted in 124 hindcasts to perform. The results from the extreme value analyses were used to create a Wave and Surge Atlas. The atlas is presented in a Geographic Information System (GIS) database for ease of access and use. The information in the GIS database has many applications beyond that of providing the conditions needed for computation of surge/wave loads on the bridge superstructures.

Computation of the surge/wave loads on bridge superstructures requires knowledge of the superstructure type (slab, girder, etc.), dimensions, and span low chord elevation, as well as the design water elevation and wave parameters. DOTD engineers provided the structural information. The proprietary computer model, Physics Based Model (PBM), developed by OEA/INTERA produced the data for development of the parametric equations in the American Association of State Highway and Transportation Officials (AASHTO) code *Guide Specifications for Bridges Vulnerable to Coastal Storms*. The PBM computed the surge/wave loads on the bridges examined in this study.

Selection of the bridges to be analyzed was a multi-step process. The original list of 3177 coastal bridges provided by DOTD engineers was reduced to 471 by the initial screening process. From these 471 bridges, DOTD District Offices with coastal parishes selected 100 bridges of concern. That said, bridge (recall number) 003450 was erroneously selected for 003480, so both bridges are included in the analysis — increasing the number to 101. These were screened based on aerial photographs, site photographs, topographic data, vegetation

canopy, fetch length, and the bridge approach elevations — reducing the number of bridges from 101 to 65. Of those 65, the Level III analysis identified 18 as vulnerable.

ACKNOWLEDGMENTS

This study was made possible by funding from the Louisiana Transportation Research Center (LTRC). In-kind services were provided by DOTD Bridge Design Section.

IMPLEMENTATION STATEMENT

The hurricane wave and storm surge induced damage experienced to a number of large and expensive bridges in the Gulf Coast states during the past decade led to the creation of the AASHTO document *Guide Specifications for Bridges Vulnerable to Coastal Storms*. This document provides guide specifications for calculating hurricane generated wave and storm surge loads on bridge superstructures for both design of new bridges and evaluation of existing bridges. This study was conducted to apply the AASHTO specification to evaluate DOTD's existing coastal bridges to discern their current vulnerability to this type of loading. The study identified 18 bridges as potentially vulnerable. Implementation of countermeasures or retrofits are at the discretion of DOTD and beyond the scope of this study. In addition to the vulnerability assessment, this study produced a Wave and Surge Atlas, transmitted to the Department, which contains 100-year wave and storm surge conditions at many of Louisiana's coastal bridges. The atlas provides a GIS interface to present and access the data. This tool will allow DOTD to rapidly identify 100-year wave and storm surge conditions along most of Louisiana's coastal waterways enabling acquisition of design wave and surge parameters for evaluation of existing bridges or design of new bridges.

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INTRODUCTION

The infrastructure in low-lying coastal areas subject to tropical storms and hurricanes is potentially vulnerable to the elevated water levels, high velocity flows, and wave conditions that accompany these types of storms. It is imperative that those responsible for the design and maintenance of this infrastructure have as much and as accurate information as practical about these conditions. In this document, environmental parameters are referred to as meteorological/oceanographic (met/ocean) conditions. In particular, coastal roadways and bridges are potentially vulnerable to this type of loading. A number of large and expensive bridges in the Gulf Coast states were destroyed by storms during the past decade. Most of this destruction was attributed to hurricane storm surge and wave forces.

In order for the met/ocean information to be useful, the frequency of occurrence must also be known. That is, estimates of its probability of occurrence each year must be known. With this information, the desired structure life, and the acceptable level of risk, design conditions can be established. Common design frequencies for coastal bridges are 1 and 2 percent chances of occurrence each year (referred to as 100-year and 50-year return intervals, respectively).

The Louisiana Transportation Research Center (LTRC) funded this project to develop the met/ocean data (1 percent chance) for South Louisiana and present the data in a GIS platform. This report details the development of the data and the GIS platform for accessing the information.

OBJECTIVE

This study intended to (1) establish 100-year design met/ocean conditions for Louisiana coastal waters and to present the results in a Surge/Wave GIS Database (Wave and Surge Atlas) and (2) identify DOTD bridges vulnerable to this type of loading from the Surge/Wave data and bridge information.

SCOPE

To achieve the study's objectives, the major tropical storms and hurricanes that have impacted the Louisiana coastal waters during the past 165 years were simulated (hindcasted) with calibrated computer models and the results analyzed via extreme value statistics to obtain design frequency met/ocean values for these locations. Surge/wave forces and moments on the superstructures of the coastal bridges identified by DOTD were computed and analyzed for vulnerability. In this study, a vulnerable bridge is one where the surge/wave forces or moments exceed the resistive forces and moments (based solely on the span dead weight) on one or more spans.

Selection of the bridges to be analyzed was a multi-step process. The original list of 3177 coastal bridges provided by DOTD engineers was reduced to 471 by the initial screening process. From these 471 bridges, DOTD District Offices with coastal parishes selected 101 bridges of concern. That said, bridge (recall number) 003450 was erroneously selected for 003480, so both bridges are included in the analysis — increasing the number to 101. These were screened based on aerial photographs, site photographs, topographic data, vegetation canopy, fetch length, and the bridge approach elevations — reducing the number of bridges from 101 to 65.

METHODOLOGY

Wind, Storm Surge, and Wave Models

Development of the Wave and Surge Atlas and the design conditions at each of the project bridges required development and application of hurricane storm surge and wave models. This chapter presents the development, calibration, and hindcast simulations of these models.

Wind and Atmospheric Pressure Fields

Both the storm surge and waves are generated by the wind and atmospheric pressure during the storm. For this study, Oceanweather, Inc. provided the wind and pressure fields for the hindcasted tropical storms and hurricanes. The wind speed and direction and the atmospheric pressure is computed at the nodes of two rectangular grids — WNAT28km basin scale and the LA3Min fine scale grid— at each time step for approximately five days during the approach and landfall of the storm. The WNAT28km basin scale grid spacing is 15 minute (Min) (0.25 degree, ~28 kilometers [km]) covering the domain 5-47.5N, 98-57.5W (Figure 1), the LA3Min fine scale grid spacing is 3 Min (0.05 degree, ~5 km) covering a domain 28.5- 31N 95-87.7W (Figure 2).

The wind and pressure fields are interpolated to the storm surge and wave mesh and provide the input to simulate surge, current and wave generation. The following sections discuss the storm surge and wave computer models.

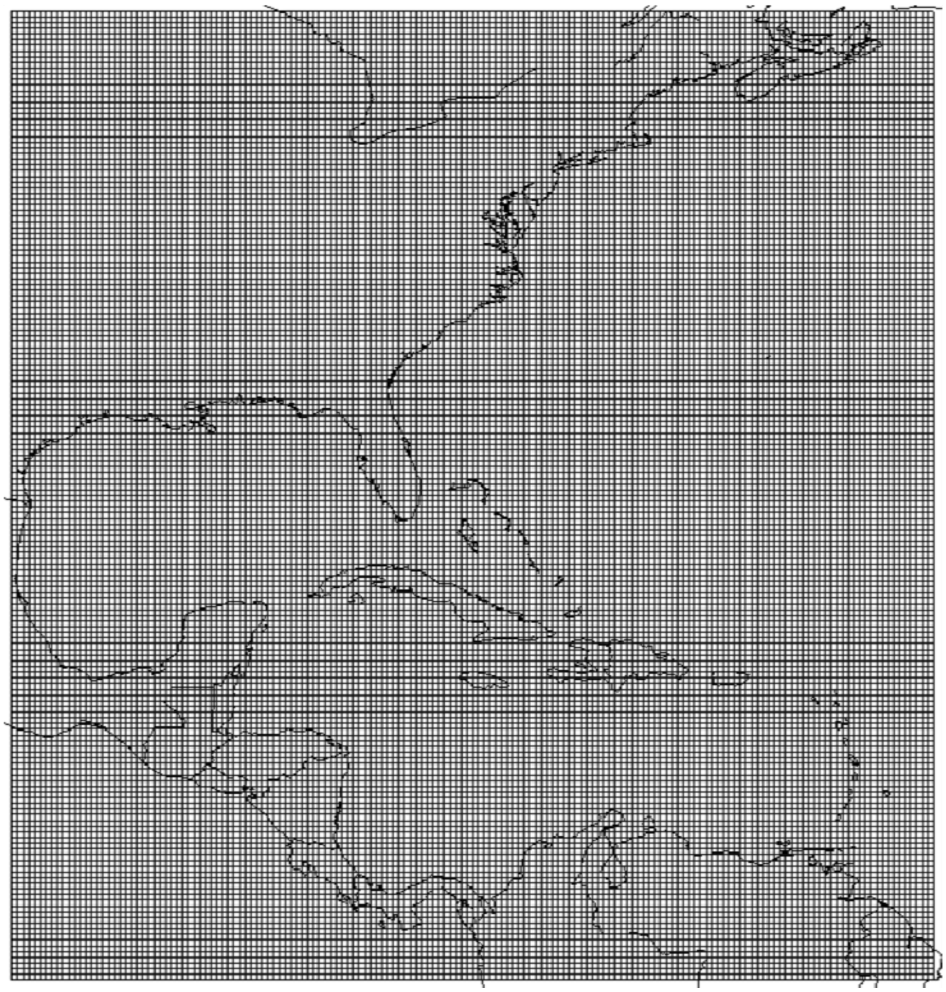

Figure 1
Coarse scale wind and pressure grid (WNAT28km)

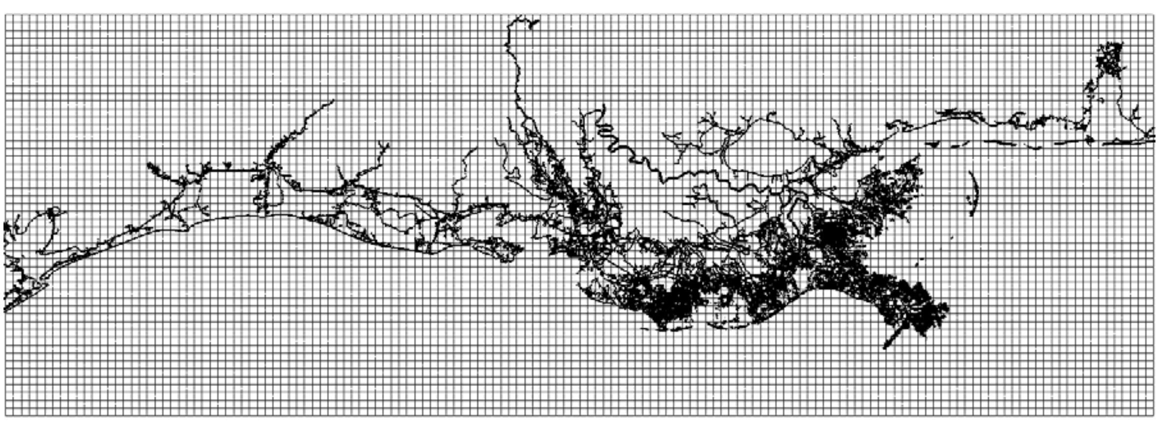

Figure 2
Fine scale wind and pressure grid (LA3Min)

Storm Surge and Wave Model Selection

This study employed the latest hindcast technology — the tightly coupled ADCIRC+SWAN model and hindcasted tropical storm and hurricane wind and pressure fields provided by Oceanweather, Inc.

Selected Models. The program ADCIRC (ADvanced CIRCulation Model for Coastal Ocean Hydrodynamics) simulated both the tidal circulation and the hurricane storm surges in the project area. ADCIRC is a numerical model developed specifically for generating long duration hydrodynamic circulation along shelves, coasts, and within estuaries.

The program SWAN (Simulating WAves Nearshore) simulated wave heights and periods. SWAN, developed at the Delft University of Technology in the Netherlands, is a one- and two-dimensional numerical model for estimating wave parameters in coastal areas, lakes and estuaries from given wind, bathymetric, and current conditions.

Both models have been applied extensively by OEA/INTERA as well as numerous governmental agencies including the United States (US) Army, Navy, and FEMA. Appendix B provides detailed information on both ADCIRC and SWAN.

Both models employ an unstructured model grid or finite element mesh (mesh) to describe the area of interest. The spatially varying mesh defines the topography and bathymetry of the project area. The density of the nodes in the mesh in an area is dependent on the size of the topographic/bathymetric feature of that area. That said, model runtime is proportional to the number of nodes in the mesh. The number of nodes is governed by the required accuracy, the geometric features to be resolved, and practical limits on model development and run times. The mesh configuration is generated through the application of an algorithm that relates mesh element size to both local bed elevation and local bed gradient. The mesh was then modified to increase the resolution in the regions within and surrounding the coast of Louisiana. Once generated, mesh nodes are assigned elevations using topography and bathymetry interpolated from National Oceanic and Atmospheric Administration (NOAA) datasets (Coastal Relief and ETOPO2 data sets and US Army Corps of Engineers [USACE] surveys —Appendix (A) for both the nearshore and the open ocean.

The mesh covers the western North Atlantic Ocean, the Gulf of Mexico, and the Caribbean Sea. Figure 3 through Figure 8 display the model mesh. Figure 3 presents the entire mesh with an inset showing the coastal Louisiana region of the mesh. Figure 4 through Figure 8 display the details of the model mesh along the coastline of Louisiana. Figure 4 provides a key to the bounds for the detailed images of the mesh presented in Figure 5 through Figure 8. Figure 5 presents the mesh in the western coastal region, which includes; Sabine Lake, Calcasieu Lake, Grand Lake, and White Lake Areas. Figure 6 presents the mesh in the central coastal region, which includes Vermilion Bay, West Cote Blanche Bay, and Timbalier Bay Areas. Figure 7 presents the mesh in the southeastern coastal region, which includes the Mississippi Delta areas. Figure 8 presents the northeastern coastal region of the model mesh illustrating the model detail in the Lake Pontchartrain, Lake Borgne, and Chandeleur Sound Areas. The final mesh contains more than 600,000 nodes.

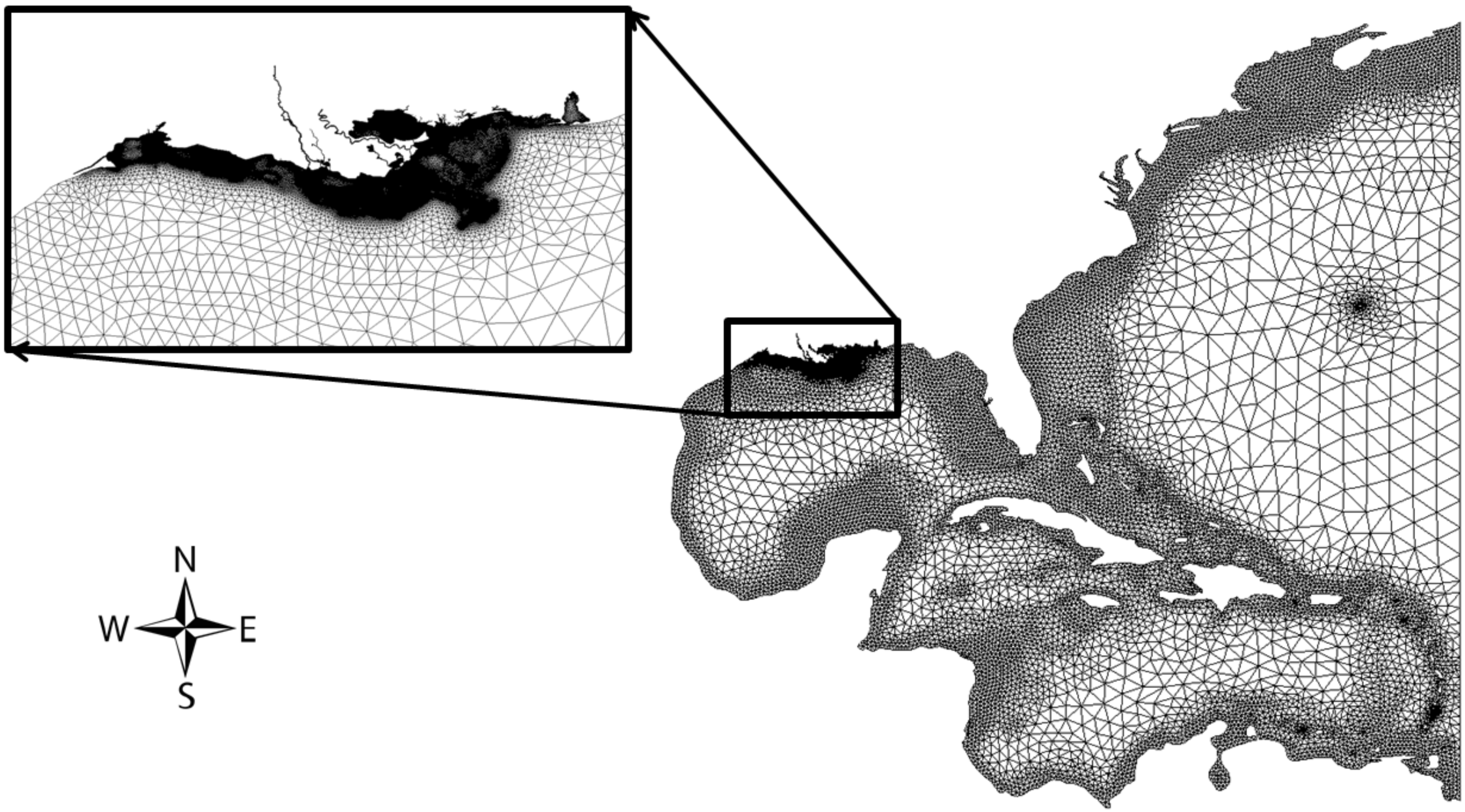

Figure 3
ADCIRC/SWAN mesh model domain with inset showing detail of coastal Louisiana

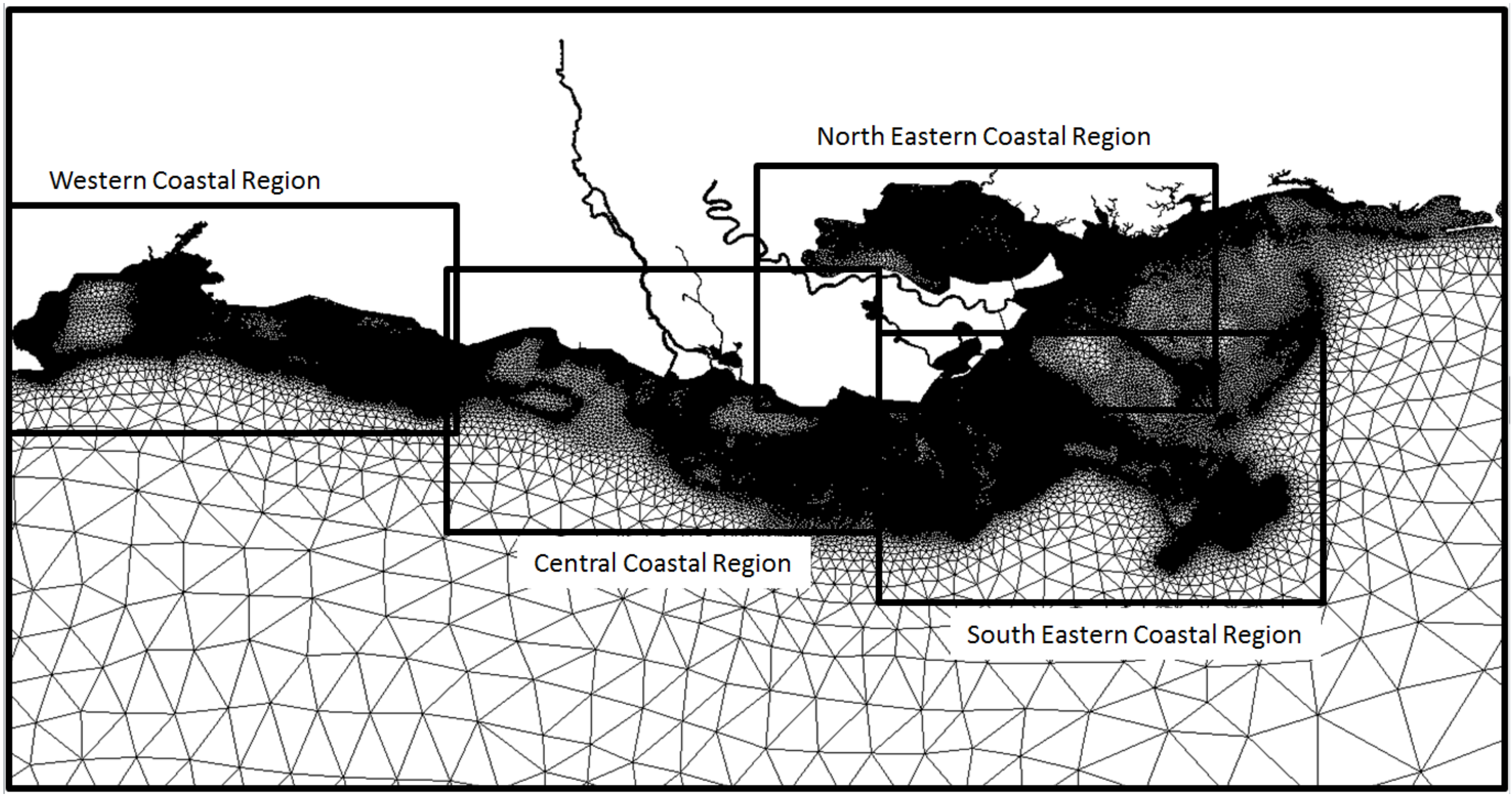

Figure 4
Location of the detailed regions of the mesh

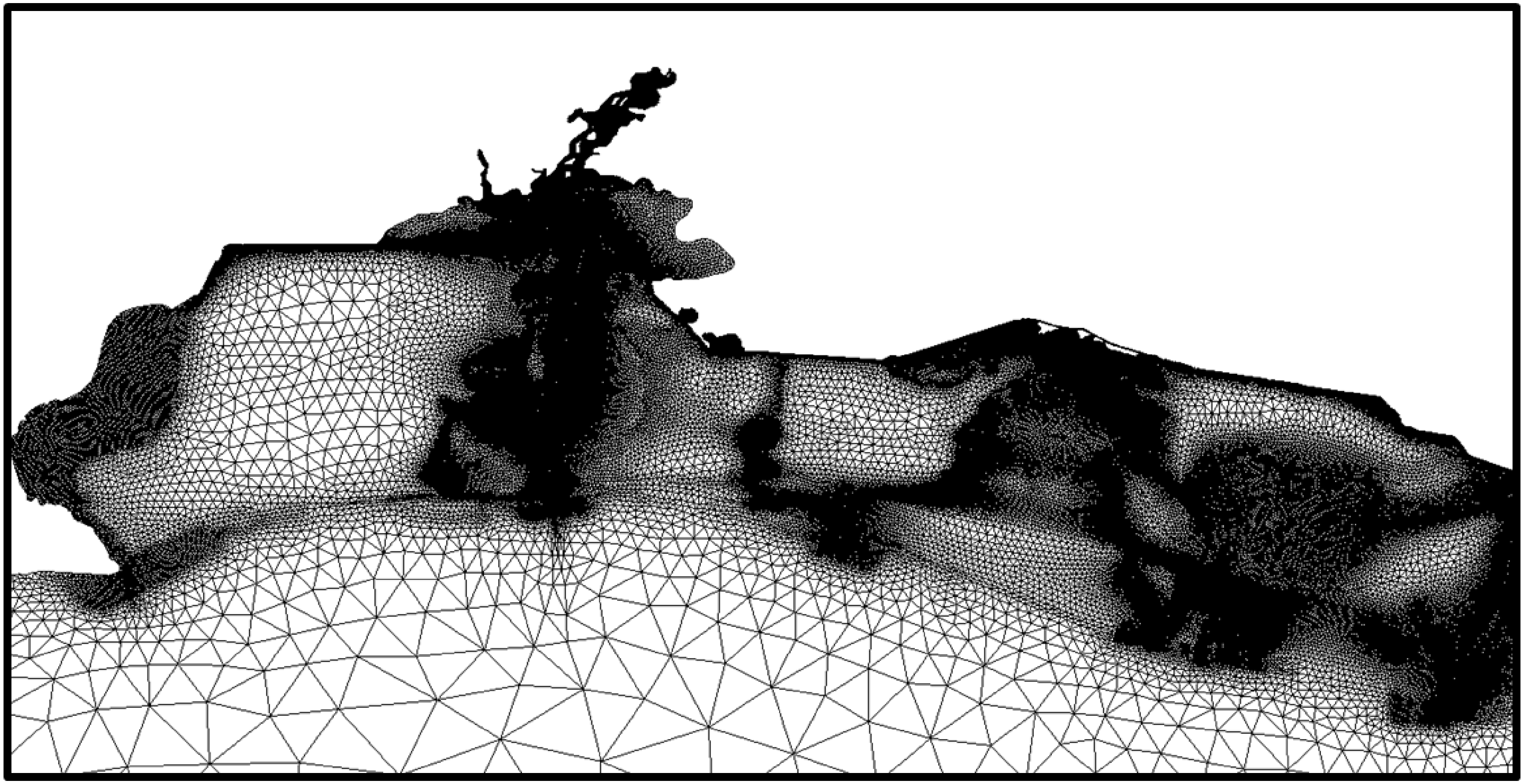

Figure 5
Western coastal region of the model mesh illustrating the model detail in the Sabine Lake, Calcasieu Lake, Grand Lake, and White Lake areas

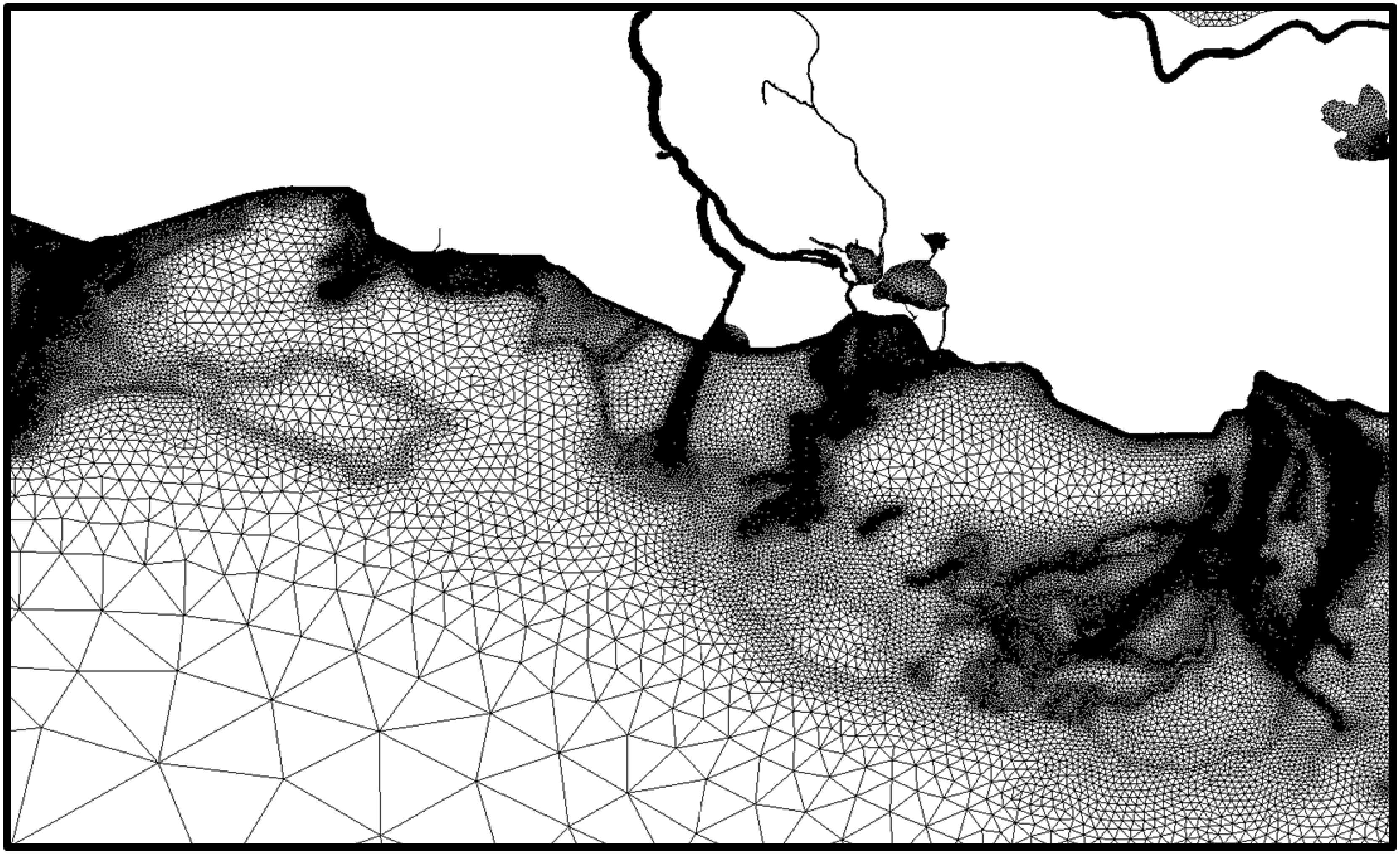

Figure 6
Central coastal region of the model mesh illustrating the model detail in Vermilion Bay, West Cote Blanche Bay, and Timbalier Bay areas

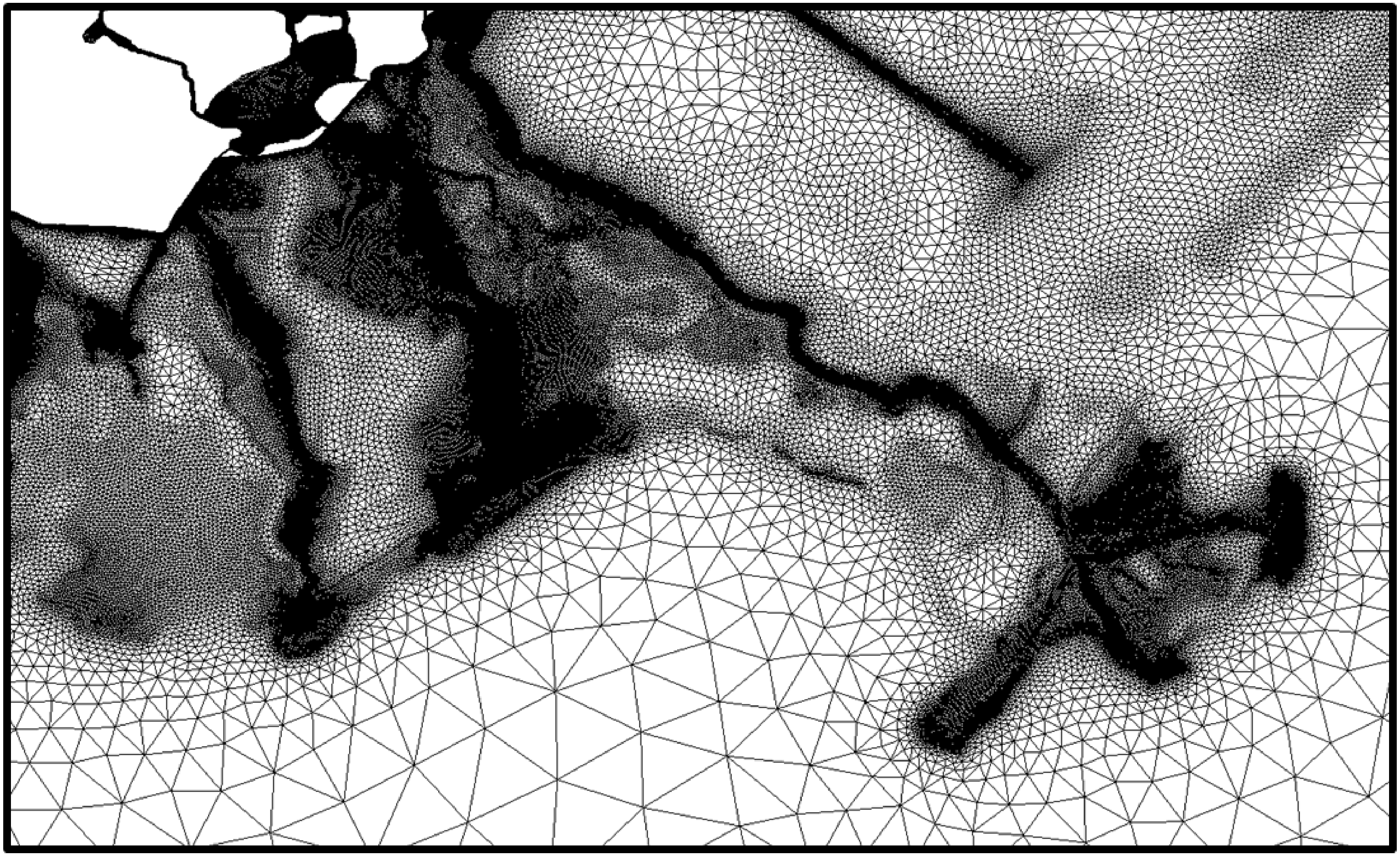

Figure 7
Southeastern coastal region of the model mesh illustrating the model detail in the Mississippi Delta areas

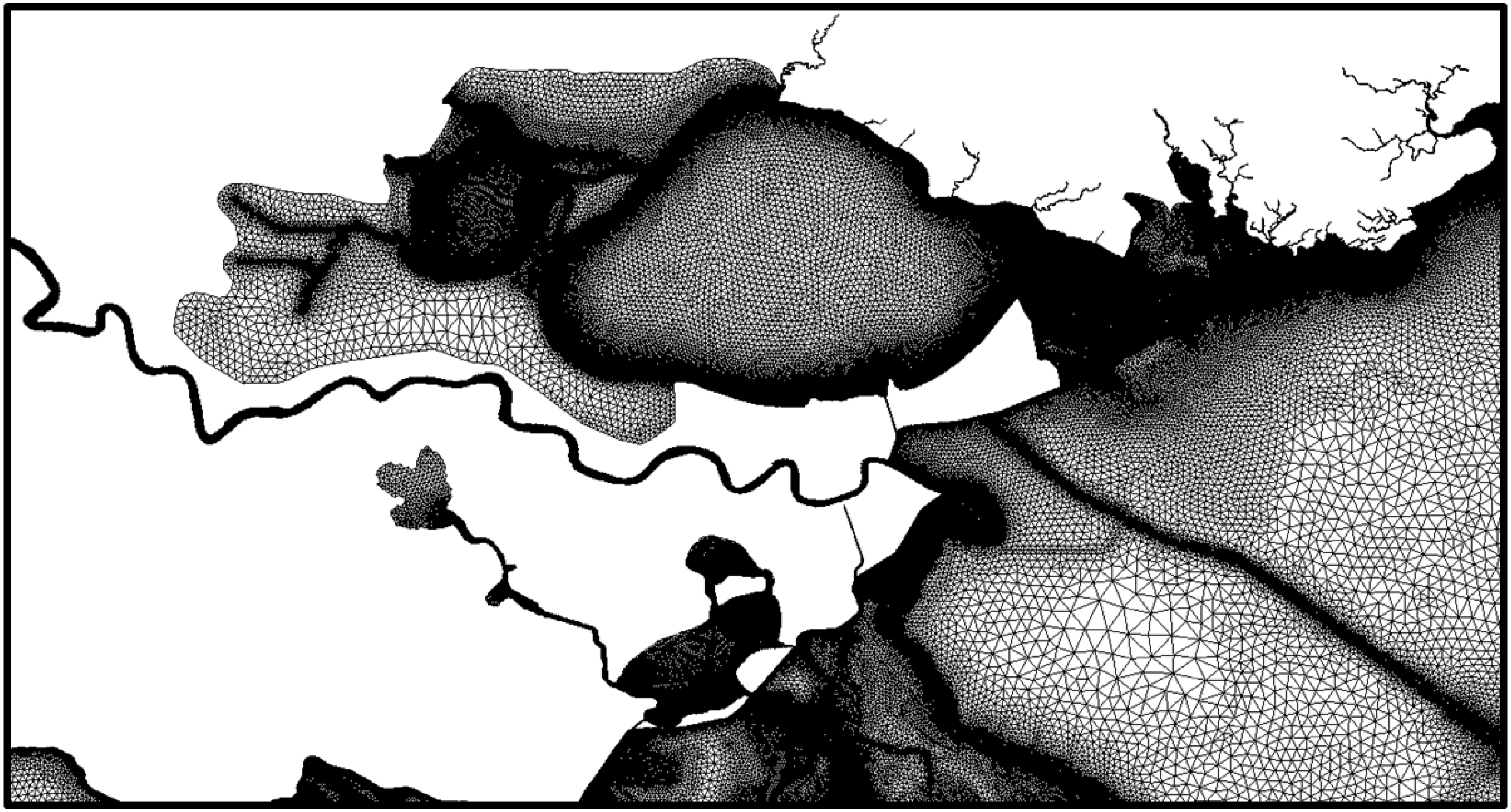

Figure 8
Northeastern coastal region of the model mesh illustrating the model detail in the Lake Pontchartrain, Lake Borgne, and Chandeleur Sound areas

Model Calibration. This section presents an overview of the ADCIRC and SWAN model calibration. Appendix C provides the details of the calibration.

Model calibration involves an iterative process of adjusting model parameters until the model results at set locations match measured values within acceptable limits. Once calibrated, the model is verified by comparing model results to measured data for additional events to verify they meet established criteria. Three types of measured data were collected for the calibration: water surface elevation (WSE) data, hurricane high water marks, and wave data. The following paragraphs provide an overview of the calibration.

The ADCIRC calibration includes the adjustment of model friction and lateral eddy viscosity until modeled water surface elevations match measured values within acceptable limits. FEMA defines this limit as 10 percent (Average Percent Error) or less for tidal calibrations *[1]*. For storm surge verifications, FEMA acknowledges the complexity associated with measurements during storms. Based on the complexity, FEMA notes that the acceptable error range exceeds that under normal tidal calibrations. NOAA and USGS provided measured data for the calibration and verification. Although NOAA gages are generally continuously deployed, they do occasionally fail during storm events or are decommissioned. For the tables presented in the following discussion, the entire set of gages are listed with "NA" (not available) signifying that the gage failed or was decommissioned during the times of interest. The USGS gages were temporary gages deployed for Hurricane Rita only. The locations of the gages are presented in Appendix C, Figure C.1 and Figure C.2. For discussion purposes, NOAA gages 8747437, 8761305, 8761927, 8762372, 8762482, 8760922, 8761724, and 8762075, are considered eastern gages and NOAA gages 8764044, 8764227, 8765251, 8766072,8767961, 8768094, and 8770570 are considered western gages.

The ADCIRC calibration employed two types of observed data at 11 NOAA gages distributed along the coast. The first, employed in the calibration, are time series of WSE recorded during a month of tides both with and without meteorological influences. The second, employed in the verification, are time series of WSE recorded during the passing of Hurricane Katrina and Hurricane Rita. Selection of these two storms was based on their landfall location — Hurricane Katrina in eastern Louisiana and Hurricane Rita in western Louisiana — and on the amount of available data collected during the storm. Appendix C provides details of the gage locations, the time series observations from the gages, and comparisons of the observed and simulated WSE.

Table 1 summarizes results from the ADCIRC model calibration, which involved the month-long NOAA predicted tidal record without meteorological influences. The table lists the Mean Error, the Root Mean Square Error (RMS), and the Average Percent Error. Positive values indicate over prediction and negative values under prediction. In the table, the average percent error for all gages is within the acceptable limits. Again, refer to Appendix C for the details of the calibration.

Table 1
ADCIRC calibration results

NOAA Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
8747437	-0.06	0.19	5%
8760922	-0.01	0.12	4%
8761305	-0.11	0.24	9%
8761724	-0.05	0.13	5%
8761927	-0.13	0.15	6%
8762075	-0.02	0.14	6%
8762372	NA	NA	NA
8762482	NA	NA	NA
8764044	NA	NA	NA
8764227	-0.1	0.22	9%
8765251	NA	NA	NA
8766072	-0.06	0.27	5%
8767961	-0.06	0.19	5%
8768094	-0.1	0.24	5%
8770570	0.01	0.17	4%

The next comparison demonstrates the ADCIRC model's ability to reproduce water surface elevation fluctuations caused by meteorological events (hurricanes and tropical storms). These comparisons evaluated the effect of two hurricanes on water surface elevation — Hurricane Katrina and Hurricane Rita. Hurricane Katrina made landfall along the southeastern coastline of Louisiana and finally near the Louisiana-Mississippi border on the morning of August 29, 2005. Given this landfall location, the storm's effects were limited to the eastern half of Louisiana. Conversely, Hurricane Rita made landfall on September 24, 2005, near Sabine Pass in southwestern Louisiana. Given the location of the storm's landfall, the storm's effects were greater in southwestern Louisiana. As a result of their landfall locations, Hurricane Katrina provides calibration data for the eastern portion of the model and Hurricane Rita provides calibration data for the western portion. Table 2 and Table 3 summarize the results from the ADCIRC model verifications. The table lists the Mean Error, the RMS Error, and the Average Percent Error. Positive values indicate overprediction and negative values underprediction. Both tables list the gages from east to west. As such, agreement between the model and the measured data for Hurricane Katrina should focus on the eastern gages (8747437 — 8762482) and the western gages for Hurricane Rita. As the average percent errors demonstrate, the eastern portion of the model performs well during Hurricane Katrina and the western portion of the model performs well during Hurricane Rita. Appendix C further details the verification.

Table 2
ADCIRC verification results for Hurricane Katrina

NOAA Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
8747437	NA	NA	NA
8760922	0.05	0.45	6%
8761305	NA	NA	NA
8761724	-0.19	0.44	8%
8761927	NA	NA	NA
8762075	NA	NA	NA
8762372	0.23	0.7	13%
8762482	0.12	0.25	17%
8764044	0.59	0.96	40%
8764227	NA	NA	NA
8765251	-0.40	0.68	24%
8766072	-0.38	0.6	19%
8767961	NA	NA	NA
8768094	0.45	0.63	23%
8770570	NA	NA	NA

Table 3
ADCIRC verification results for Hurricane Rita

NOAA Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
8747437	NA	NA	NA
8760922	-0.21	0.47	13%
8761305	NA	NA	NA
8761724	-0.44	0.73	17%
8761927	NA	NA	NA
8762075	-0.29	0.61	13%
8762372	0.21	0.64	16%
8762482	NA	NA	NA
8764044	-0.21	0.72	12%
8764227	NA	NA	NA
8765251	NA	NA	NA
8766072	NA	NA	NA
8767961	NA	NA	NA
8768094	NA	NA	NA
8770570	NA	NA	NA

USGS Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
B15b	-1	1.2	13%
LA9	0.7	1.1	17%
LA9b	-0.3	0.7	6%
LA10	0.3	2.8	32%
LA11	0.9	1.1	8%
LA12	1.2	1.3	10%
LC2a	0.3	0.6	7%
LC5	-0.4	1	15%
LC8a	0.1	0.7	6%
LC9	0.1	0.7	10%

Calibration of the SWAN model involved the four National Data Buoy Center (NDBC) wave stations presented in Appendix C. Table 4 through Table 6 presents a summary of the results. Positive values indicate overprediction of wave height and negative values underprediction. The average percent error ranged from a low of 7 percent to a high of 23 percent and an average of the average errors of 13.9 percent. Notably, for the calibration (Hurricane Katrina Table 4) the two gages nearest the Louisiana Coast (42039 and 42040) have average percent errors of 7 percent. Given the low errors and the slight tendency to overpredict, the calibration was deemed within acceptable bounds and, as such, the wave model was considered calibrated. Appendix C provides additional details of the SWAN calibration.

Table 4
Hurricane Katrina SWAN calibration summary NOAA gages

Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
42001	3.04	5.26	23%
42003	1.23	2.82	8%
42039	0.02	1.76	7%
42040	1.85	3.96	7%

Table 5
Hurricane Katrina SWAN verification summary USACE gages

Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
22	0.47	1.09	12%
23	0.43	0.92	9%

Table 6
Hurricane Rita SWAN verification summary NOAA gages

Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
42001	4.68	7.00	19%
42003	NA	NA	NA
42039	2.35	4.03	23%
42040	2.36	3.95	17%

Storm Surge and Wave Hindcast Procedure

As previously noted, the hindcast procedure employs the tightly coupled ADCIRC+SWAN model. As the name implies, the model is composed of the circulation model ADCIRC and the wave model SWAN. Since the models share an identical mesh, they pass wind speeds water levels, currents and radiation stresses efficiently allowing them to run sequentially in time. The procedure begins with the application of the storm surge/circulation model (ADCIRC). Inputs to this model include tidal potential boundary conditions and the pressure and wind fields. ADCIRC simulates the conditions for a set time then passes the WSE and currents to SWAN. SWAN then simulates wave generation, transformation and breaking for a set amount of time. Inputs to this model include WSE and currents from ADCIRC and wind fields. SWAN then passes radiation stresses to ADCIRC. ADCIRC then calculates WSE and currents with the radiation stresses as additional input. This process continues for the duration of the hindcast simulation. Figure 9 shows a diagram of the hindcast procedure including inputs, outputs, and interaction between the model applications.

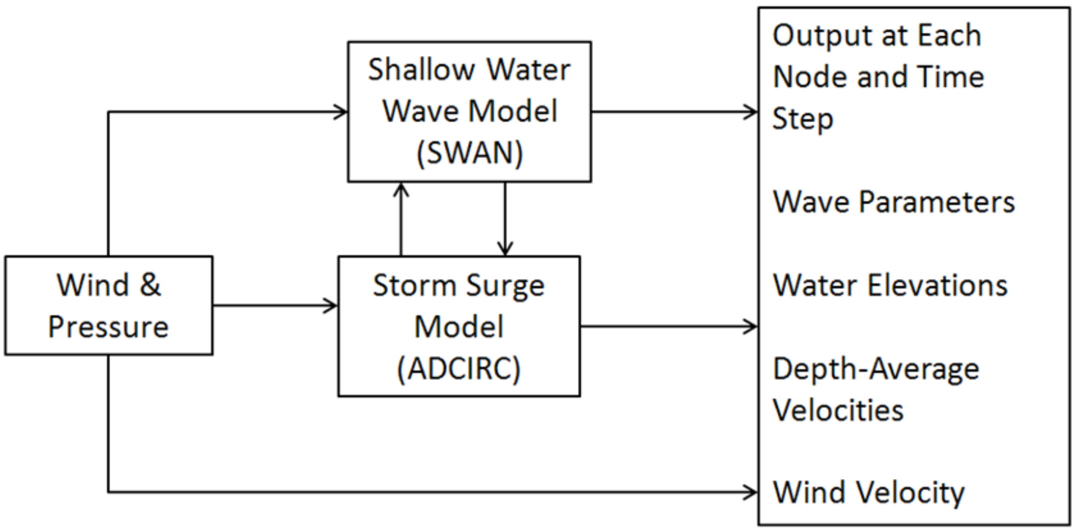

Figure 9
Model application procedure diagram

Selection of Hindcast Storms

The storm selection process involved the application of a simplistic hurricane wind model that examines all historical tropical storms and hurricanes whose paths came within 100 miles of the Louisiana Coastline. The computed wind fields aided in identifying hurricanes that had the potential for creating significant storm surge and wave heights in the areas of interest. Additionally, wave, wind, and water elevation measurements from numerous sources also aided in identifying additional hurricanes and storms that affected Louisiana coastal waters. This process produced the tropical storms and hurricanes listed in Table 7. Their paths are shown in

Figure 10 and

Figure 11. As the Table 7 illustrates, these storms occurred between 1852 and 2008. The steering currents for hurricanes could easily alter a hurricane path resulting in a point of landfall either to the right or left of the actual landfall location. For this reason, the path of a

select number of hindcasted storm was shifted ½ degree (approximately 30 nautical miles) in either direction from the original path. This increases the number of storms and the amount of data for the extreme value analyses. Notably, the probability of taking those different paths is not necessarily equal. The difference in probabilities was accounted for in the extreme value analyses. Appendix D details the procedure for shifting the hurricanes and the methodology for calculating the associated probabilities.

Table 7
Storms identified for hindcasting

Storm	Date
Not Named	19-Aug-1852
Not Named	15-Sep-1855
Not Named	09-Aug-1856
Not Named	08-Aug-1860
Not Named	11-Sep-1860
Not Named	30-Sep-1860
Not Named	06-Sep-1865
Not Named	02-Oct-1867
Not Named	19-Aug-1879
Not Named	29-Aug-1879
Not Named	14-Sep-1882
Not Named	13-Jun-1886
Not Named	08-Oct-1886
Not Named	14-Aug-1888
Not Named	04-Sep-1893
Not Named	27-Sep-1893
Not Named	10-Sep-1897
Not Named	27-Aug-1900
Not Named	19-Sep-1906
Not Named	13-Sep-1909
Not Named	05-Aug-1915
Not Named	21-Sep-1915
Not Named	28-Jun-1916
Not Named	20-Sep-1917
Not Named	01-Aug-1918

Storm	Date
Not Named	22-Aug-1926
Not Named	12-Aug-1932
Not Named	02-Aug-1940
Not Named	25-Jul-1943
Not Named	04-Sep-1947
Not Named	27-Sep-1949
AUDREY	25-Jun-1957
ETHEL	14-Sep-1960
HILDA	28-Sep-1964
BETSY	27-Aug-1965
CAMILLE	14-Aug-1969
EDITH	05-Sep-1971
CARMEN	29-Aug-1974
FREDERIC	29-Aug-1979
DANNY	12-Aug-1985
ELENA	28-Aug-1985
JUAN	26-Oct-1985
ANDREW	16-Aug-1992
GEORGES	15-Sep-1998
LILI	21-Sep-2002
KATRINA	23-Aug-2005
RITA	18-Sep-2005
HUMBERTO	12-Sep-2007
GUSTAV	25-Aug-2008
IKE	01-Sep-2008

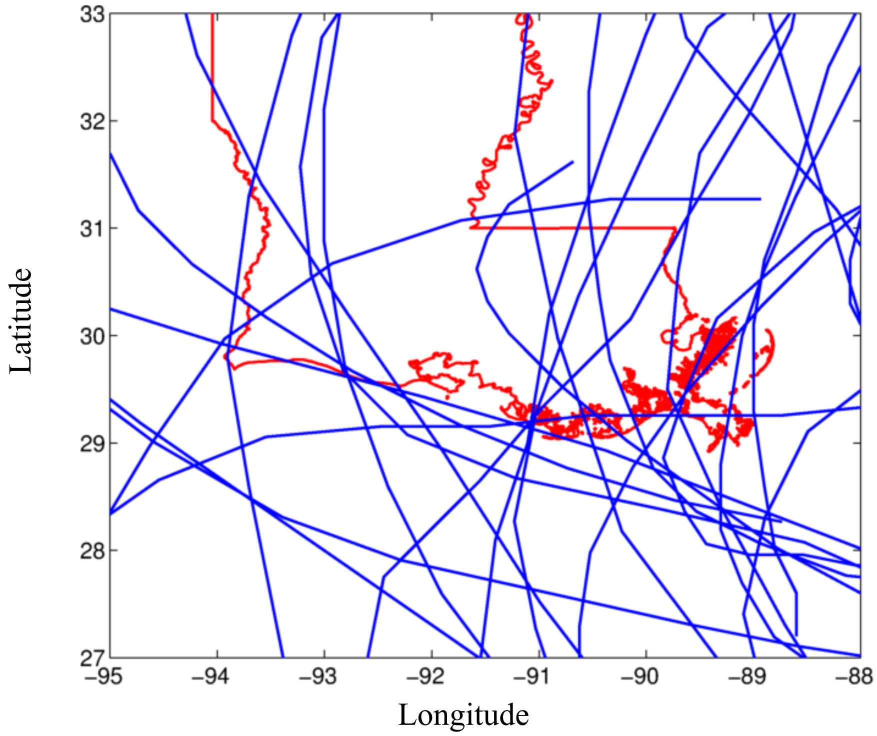

Figure 10
Paths of storms that occurred before 1920

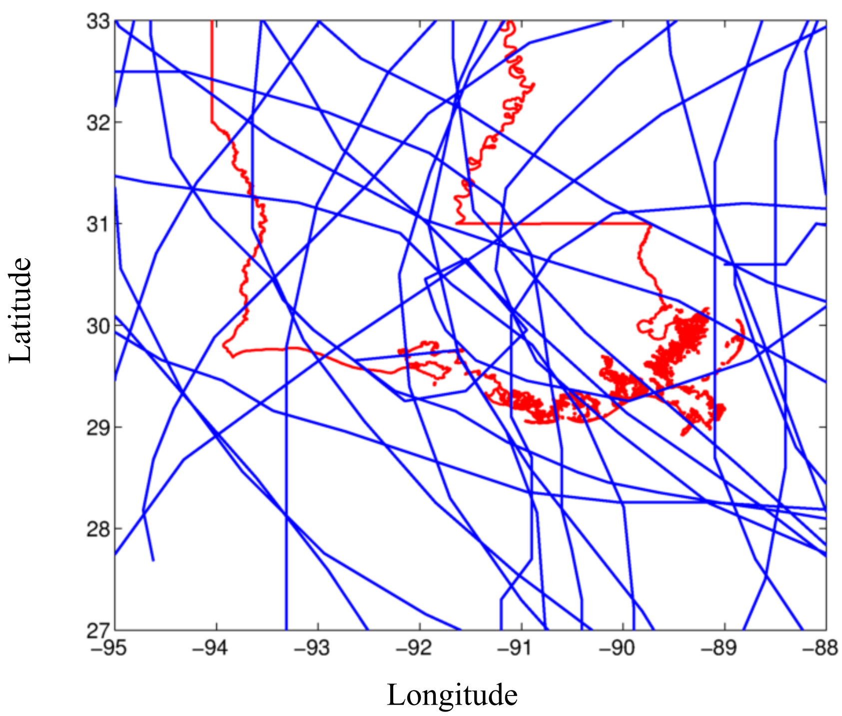

Figure 11
Paths of storms that occurred after 1920

Model Runs/Example Results

Once developed and calibrated, the model hindcasts the hurricanes and tropical storms. Fifty simulations (hindcasts) were performed with the wind and pressure fields provided by Oceanweather, Inc. for the storms listed in Table 7. This was followed by an additional 74 simulations of a select number of storms from the original set but with paths shifted to the right and left as described in Appendix D. This resulted in 124 data sets for the extreme value analyses.

The hindcasts produce wind speed and direction, water elevation, depth average current speed, significant wave height, and wave peak period at each grid node for each time step throughout the storm. The significant wave height is the average height of the one-third highest waves in a wave spectrum. The peak period is the period of the waves with the greatest energy.

Figure 12 through Figure 15 present model results from the Hurricane Katrina (2005) hindcast. Hurricane Katrina approached the coast of Louisiana as a Category 5 hurricane. Weakening as it reached the coast, Hurricane Katrina made landfall near Buras-Triumph, Louisiana, as a Category 3 hurricane on August 29, 2005. Figure 12 presents contours of the peak WSE (ft-MSL) that occurred during the storm. This figure illustrates the importance of the role of local wind setup/set down on WSE in Lake Pontchartrain. For example, at this point in the simulation, wind direction is predominately from the north, which lowers the water surface (-2 ft-MSL) in the northern portion of the lake and super-elevates the water surface (+6.5 ft-MSL) in the southern portions of the lake. Figure 13 presents contours of the peak significant wave height (ft.) that occurred during the storm. As the figure illustrates, waves within the interior waters peaked at approximately 15 ft. Figure 14 combines the WSE and the wave heights to present the maximum wave crest elevation (ft-MSL). As the figure demonstrates, during this particular storm wave crest elevations along the southern shoreline of Lake Pontchartrain exceeded +20 ft-MSL. As such, any bridge crossing these waterways with low chord elevations below +20 ft-MSL would have experienced wave forces during Hurricane Katrina. Figure 15 presents contours of depth-averaged current speeds (ft./sec.) during Hurricane Katrina. As the figure illustrates, the highest current speeds occurred in the Rigolets that connect Lake Pontchartrain to the Gulf of Mexico.

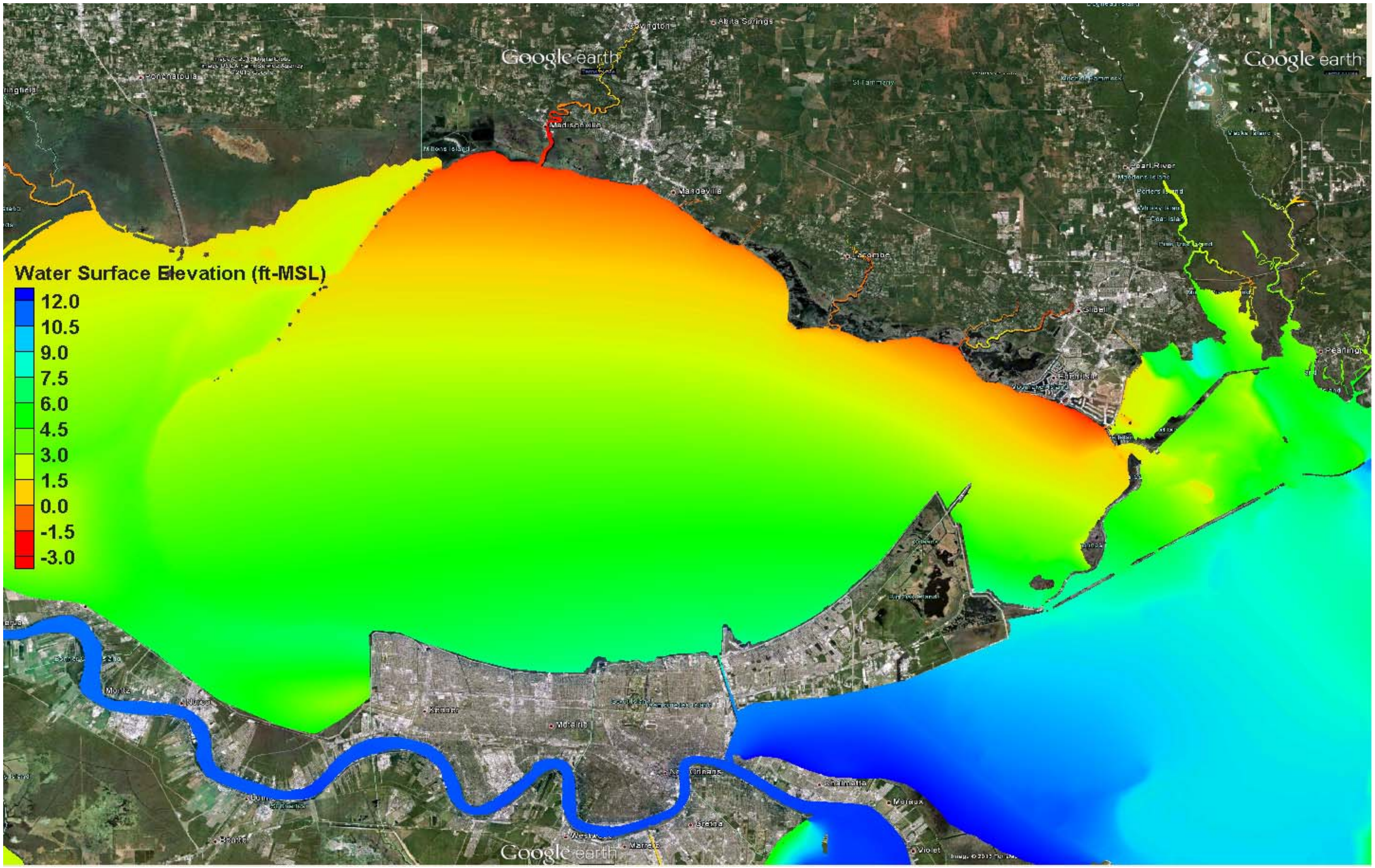

Figure 12
Contours of water surface elevation (ft-MSL) during Hurricane Katrina (8/29/2005 7:30 am)

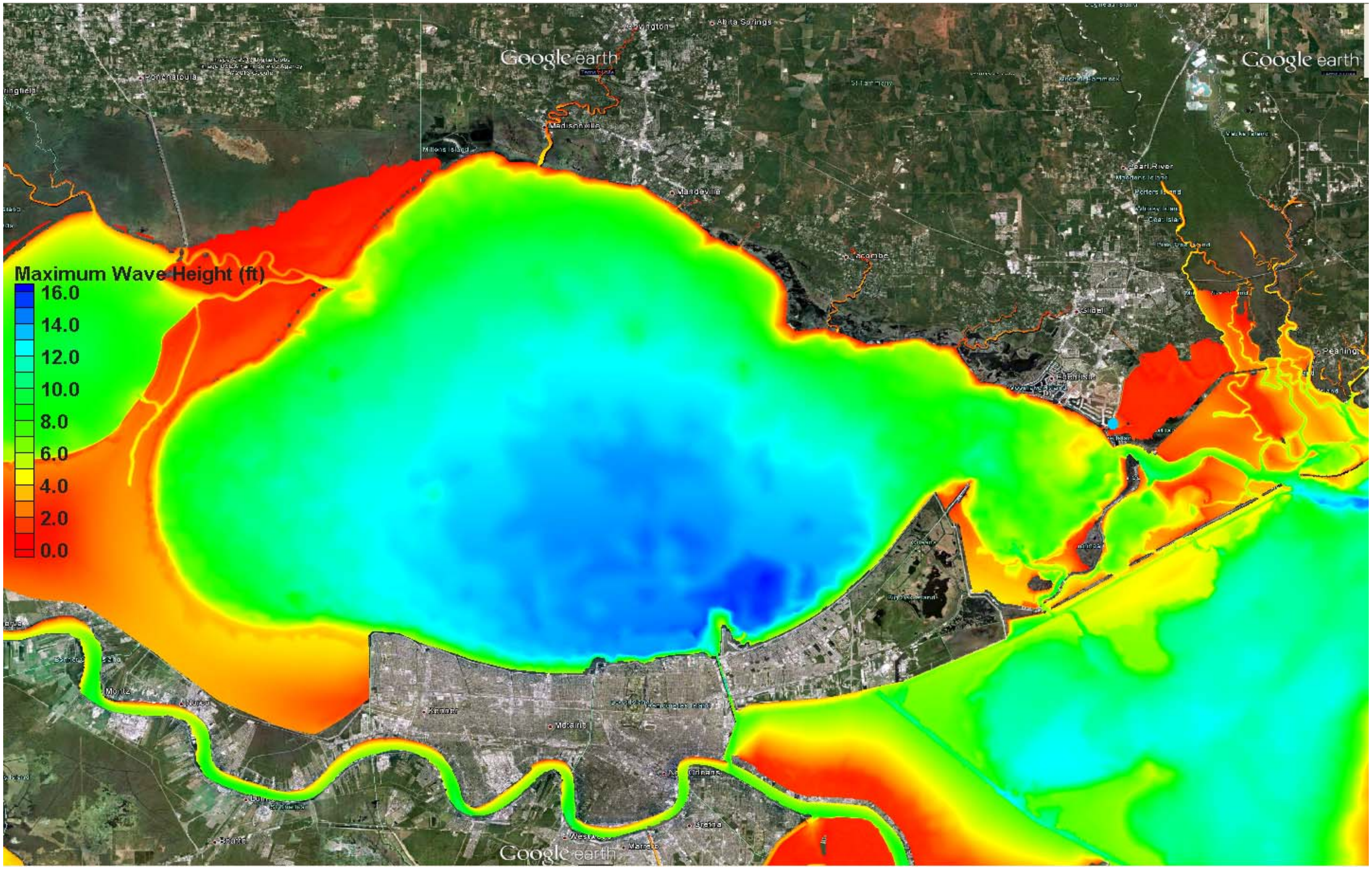

Figure 13
Contours of maximum probable wave height (ft.) during Hurricane Katrina (8/29/2005 7:30 am)

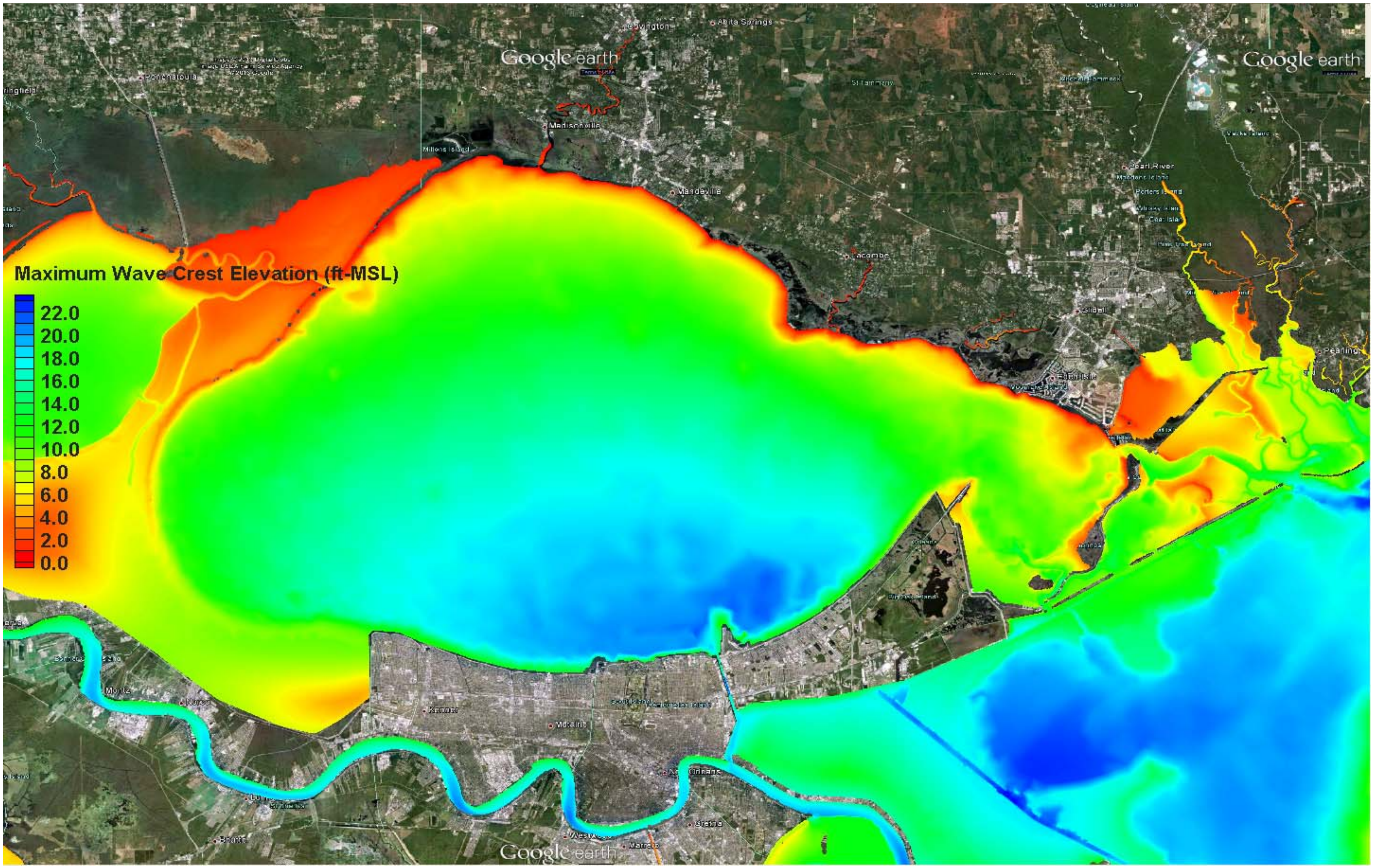

Figure 14
Maximum probable wave crest elevation contours (ft-MSL) during Hurricane Katrina (8/29/2005 7:30 am)

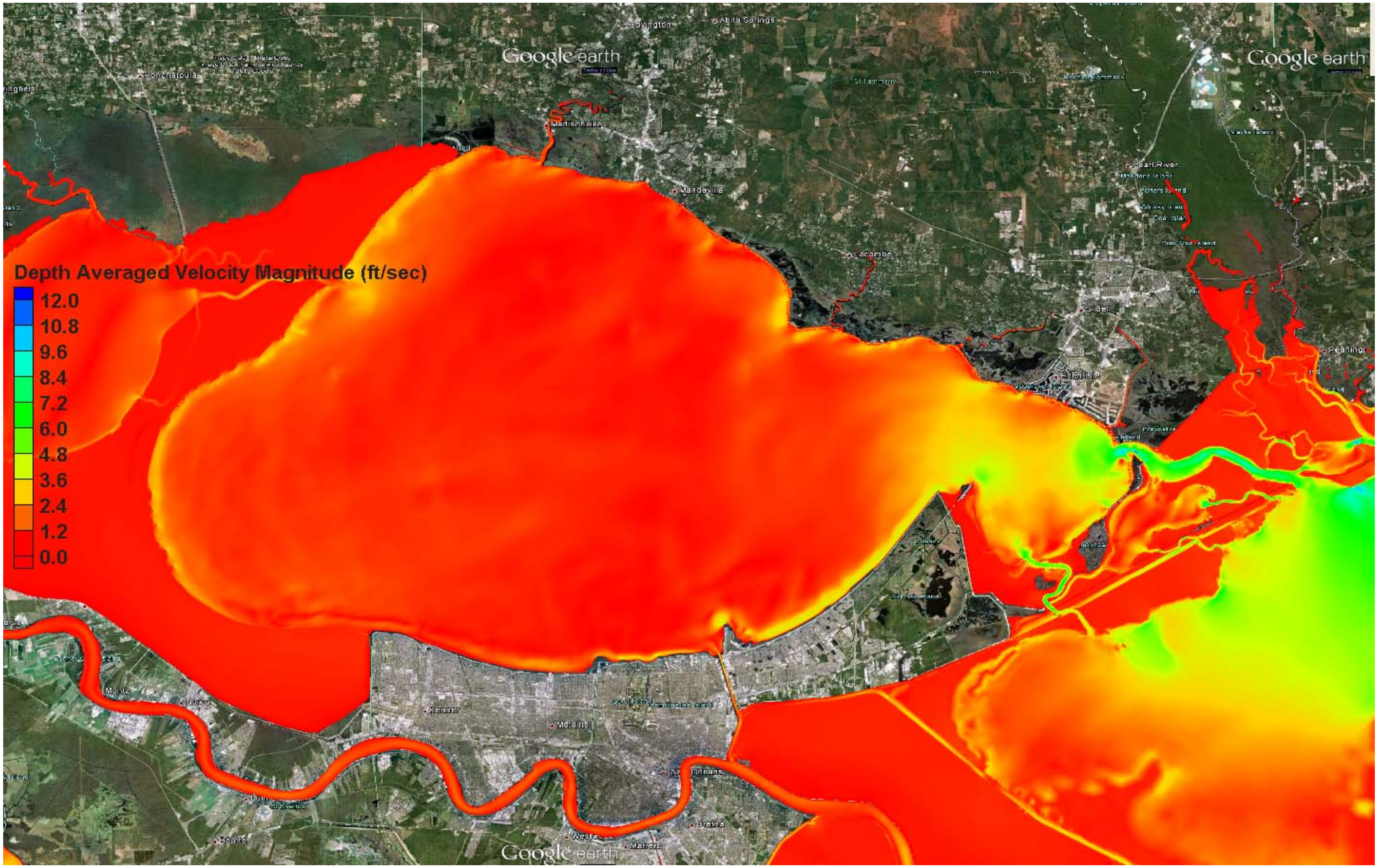

Figure 15
Contours of depth-averaged current speed (ft./sec.) during Hurricane Katrina (8/29/2005 6:30 am)

Extreme Value Analyses

Design loads for structures are typically based on their probability of exceedance and are dependent on the owner's level of acceptable risk. In the case of storm surge and wave loads on bridge superstructures, the AASHTO codes recommend met/ocean conditions with a 1 percent chance of being exceeded each year, commonly referred to as the 100-year return interval conditions *[2]*. Assuming sufficient data/information is available, extreme value statistics provide the probability of exceedance.

Extreme value analysis provides a method to estimate different return interval values for the quantities produced by tropical storm and hurricane hindcasts. For example, the 100-year return interval value WSE at a particular bridge location can be estimated from the results of simulations of past hurricane that have impacted that location. In this study, 50 of the most severe tropical storms and hurricanes that have impacted Louisiana coastal waters between 1850 and 2010 were hindcasted. Note, however, that even though this is a large number of storms, not all of the storms impacted the entire region of interest. In order to capture more of the natural variability of the storms and to improve the robustness of the extreme value analyses, additional hindcasts were performed on select number of the historical hurricanes, based on hurricane strength, landfall location, and path. For those storms, the paths were shifted a ½ degree in both directions from their actual path at landfall and the modified path storms hindcasted. A relative probability of occurrence was calculated for each storm path as detailed in Appendix D. This increased the total number of simulations to 124 and the effective record length to 480 years. Notably, this procedure is not the same as having an actual historical record of 480 years, because the shift process is capturing only some of the natural variation. For example, there is always the possibility of having a hurricane with wind speeds higher than any previously observed value, but this is not possible with the path-shifted hindcasts. As such, the accuracy of predictions extrapolated for periods significantly greater than 160 years remain uncertain. However, this methodology greatly improves the 100-year return interval predictions.

As discussed in Appendix E, the empirical cumulative distribution functions or CDF method for estimating 100-year return interval was the most appropriate methodology for this application. A bootstrapping method provides the means to examine the impact of astronomical tide phase. Appendix E describes both methods in detail.

Design Conditions for Wave Loading

One of the objectives of this study was to determine the vulnerability of DOTD coastal bridges to storm surge and wave loading. Since these forces and moments depend on the combination of water elevation and wave parameters (height and length), two sets of conditions required examination at each bridge: (1) the maximum 100-year water elevation and associated wave height and (2) the maximum wave height and associated water elevation. This is necessary since the maximum wave height does not necessarily occur at the same time as the maximum water elevation during the storm.

The hindcast simulations provided values of water elevation and wave parameters at each of the 65 bridge locations during the passage of each of the 124 storms. The maximum values of water surface elevation (and the wave heights at that point in time) and the maximum wave heights (and the water surface elevation at that point in time) at each bridge location were extracted from the hindcast results for each simulation. These simulation results are treated as “observations” and identified as such to distinguish them from probability model results.

Extreme Value Analysis Results

The extreme value analyses produced two sets of data: (1) the maximum storm water level associated significant wave height and associated peak wave period and (2) the maximum significant wave height, associated storm water level, and associated peak wave period for 100-year return interval met/ocean conditions. Table 8 and Table 9 present the met/ocean results for the 100-year design conditions at each of the bridges. For wave conditions, the tables provide a range of wave periods. The associated wave period is the peak wave period associated with the provided wave height. An additional set of design wave periods are provided that cover the statistical range of wave periods associated with the wave height. Appendix F details the methodology employed to generate the range of design wave periods. These data provide the met/ocean input information needed to compute design wave forces and moments for the subject bridges. Notably, as stated in the introduction, these results do not include the effects of predicted sea level rise.

Table 8
100-year extreme value analyses results for maximum storm water level and associated significant wave height and peak wave period

No.	Bridge Recall Number	Maximum Storm Water Level (ft-MSL)	Associated Significant Wave Height (ft.)	Associated Peak Wave Period (sec.)	Design Wave Period Long (sec.)	Design Wave Period Short (sec.)
1	000810	5.4	1.4	2.2	2.4	2.7
2	001552	6.0	5.4	4.3	4.7	5.2
3	002631	8.5	2.9	4.1	3.5	3.9
4	002632	8.5	2.9	4.1	3.5	3.9
5	002650	8.0	2.9	4.0	3.5	3.8
6	002892	9.9	5.1	6.0	4.6	5.1
7	002894	9.9	5.1	6.0	4.6	5.1
8	003390	6.5	1.0	4.0	2.0	2.3
9	003432	9.5	6.6	4.7	5.2	5.8
10	003440	8.3	5.4	4.5	4.7	5.3
11	003450	9.3	3.8	3.7	4.0	4.4
12	003480	8.1	1.4	1.1	2.4	2.7
13	003510	8.9	4.6	4.4	4.4	4.8
14	003520	9.2	4.3	4.4	4.2	4.7
15	003641	9.3	2.2	5.1	3.0	3.3
16	003690	9.5	6.5	4.7	5.2	5.8
17	009020	4.4	0.8	1.7	1.9	2.1
18	009030	6.6	1.6	4.4	2.6	2.9
19	009060	7.5	1.2	1.7	2.3	2.5
20	009198	5.7	3.2	3.9	3.7	4.1
21	009570	3.5	0.9	5.6	1.9	2.1
22	009580	2.9	1.6	2.3	2.6	2.8
23	009590	2.4	0.8	1.5	1.8	2.0
24	009600	4.2	1.0	15.0	2.0	2.2
25	009610	4.5	1.1	4.5	2.1	2.4
26	009620	5.2	1.2	3.7	2.2	2.5
27	009630	4.6	1.0	3.4	2.0	2.2
28	009700	2.9	1.0	2.0	2.0	2.2
29	009710	3.1	0.7	1.6	1.7	1.9
30	020185	9.5	5.2	6.1	4.7	5.2
31	020186	6.5	2.5	3.8	3.2	3.6

No.	Bridge Recall Number	Maximum Storm Water Level (ft-MSL)	Associated Significant Wave Height (ft.)	Associated Peak Wave Period (sec.)	Design Wave Period Long (sec.)	Design Wave Period Short (sec.)
32	020266	5.4	1.0	2.8	2.0	2.2
33	020319	9.9	3.4	4.2	3.8	4.2
34	030242	5.7	3.3	3.9	3.7	4.1
35	031755	5.8	1.8	9.5	2.8	3.0
36	032266	6.5	4.9	6.2	4.5	5.0
37	032780	7.3	3.5	6.1	3.8	4.2
38	033210	7.1	3.3	3.4	3.7	4.1
39	033590	3.9	1.4	5.7	2.4	2.7
40	033602	4.4	1.2	7.0	2.2	2.4
41	033650	4.0	1.2	2.0	2.2	2.5
42	033660	3.8	1.0	2.6	2.1	2.3
43	033672	0.0	0.0	0.0	0.0	0.0
44	033681	3.5	1.3	2.4	2.3	2.5
45	033698	8.2	2.1	3.8	2.9	3.3
46	033700	9.7	4.1	3.8	4.1	4.6
47	033730	2.6	1.1	1.9	2.2	2.4
48	033750	4.9	2.1	4.9	3.0	3.3
49	058910	5.4	0.2	0.0	0.9	1.0
50	058920	5.0	0.1	0.0	0.7	0.8
51	058930	5.0	0.1	0.0	0.6	0.7
52	058940	5.5	0.2	0.1	0.9	1.0
53	059482	6.7	1.3	2.3	2.4	2.6
54	060360	6.6	2.2	4.7	3.1	3.4
55	060412	3.4	0.1	0.5	0.8	0.8
56	062100	4.5	1.3	2.1	2.3	2.6
57	070096	5.1	2.9	6.6	3.5	3.9
58	070097	6.6	1.0	1.7	2.1	2.3
59	070119	6.7	1.1	2.2	2.1	2.3
60	070137	5.5	2.9	4.7	3.5	3.9
61	070141	2.6	1.5	3.8	2.5	2.8
62	070142	5.4	1.3	4.0	2.3	2.5
63	070143	3.7	1.3	2.4	2.3	2.5
64	070144	3.9	1.5	5.5	2.5	2.7
65	070166	5.6	2.4	2.5	3.2	3.5

Table 9
100-year extreme value analyses results for maximum significant wave height and associated peak wave period storm water level

No.	Bridge Recall Number	Associated Storm Water Level (ft-MSL)	Maximum Significant Wave Height (ft.)	Associated Peak Wave Period (sec.)	Design Wave Period Long (sec.)	Design Wave Period Short (sec.)
1	000810	3.3	2.2	2.5	3.0	3.4
2	001552	5.0	6.3	4.9	5.1	5.7
3	002631	8.0	2.9	3.9	3.5	3.9
4	002632	8.0	2.9	3.9	3.5	3.9
5	002650	7.8	3.1	3.6	3.6	4.0
6	002892	9.9	5.3	6	4.7	5.2
7	002894	9.9	5.3	6	4.7	5.2
8	003390	3.0	1.7	2.9	2.7	3.0
9	003432	9.4	7.0	4.9	5.4	6.0
10	003440	8.3	5.8	4.5	4.9	5.5
11	003450	7.8	4.8	4.8	4.5	5.0
12	003480	1.4	1.7	1.9	2.7	3.0
13	003510	8.9	4.7	4.4	4.4	4.9
14	003520	9.2	4.4	4.3	4.3	4.8
15	003641	6.7	2.4	3.5	3.1	3.5
16	003690	9.3	6.9	4.9	5.4	6.0
17	009020	2.0	1.4	1.9	2.4	2.6
18	009030	2.4	2.4	4.1	3.2	3.5
19	009060	-3.7	4.1	3.6	4.1	4.6
20	009198	1.9	4.6	4.1	4.4	4.8
21	009570	1.6	1.8	1.9	2.7	3.0
22	009580	1.2	1.7	2.1	2.7	3.0
23	009590	2.3	0.9	1.5	1.9	2.1
24	009600	2.8	1.0	11.1	2.0	2.2
25	009610	3.4	1.4	4.4	2.4	2.7
26	009620	3.6	1.6	2.6	2.6	2.9
27	009630	1.9	1.2	1.8	2.3	2.5
28	009700	2.7	1.1	1.9	2.1	2.3
29	009710	2.9	0.9	1.8	1.9	2.2
30	020185	9.5	5.2	6.1	4.7	5.2
31	020186	6.5	3.0	3.5	3.5	3.9

No.	Bridge Recall Number	Associated Storm Water Level (ft-MSL)	Maximum Significant Wave Height (ft.)	Associated Peak Wave Period (sec.)	Design Wave Period Long (sec.)	Design Wave Period Short (sec.)
32	020266	5.4	1.0	2.4	2.0	2.3
33	020319	9.1	4.1	3.7	4.1	4.6
34	030242	2.1	4.7	4.1	4.4	4.9
35	031755	3.7	2.1	2.4	3.0	3.3
36	032266	5.0	6.1	6.4	5.0	5.6
37	032780	4.7	4.2	3.3	4.2	4.6
38	033210	6.1	3.6	3.6	3.9	4.3
39	033590	2.8	1.8	5.3	2.8	3.1
40	033602	1.2	1.5	2.0	2.5	2.7
41	033650	1.8	2.0	2.1	2.9	3.2
42	033660	1.8	1.6	2.9	2.6	2.8
43	033672	0.0	0.0	0.0	0.0	0.0
44	033681	1.8	1.8	2.3	2.8	3.1
45	033698	7.1	2.7	3.3	3.4	3.7
46	033700	9.2	4.1	3.8	4.1	4.6
47	033730	1.4	1.8	2.4	2.7	3.0
48	033750	3.8	2.5	2.7	3.3	3.6
49	058910	-3.1	0.6	0.4	1.6	1.8
50	058920	-1.3	0.8	1.5	1.8	2.0
51	058930	0.9	0.9	1.5	2.0	2.2
52	058940	1.0	0.5	0.3	1.4	1.6
53	059482	3.9	1.7	2.4	2.7	3.0
54	060360	6.1	2.4	5.2	3.2	3.5
55	060412	-0.5	1.2	1.8	2.3	2.5
56	062100	4.1	1.7	2.8	2.7	3.0
57	070096	4.4	3.3	7.2	3.7	4.1
58	070097	4.4	1.4	1.9	2.4	2.7
59	070119	4.4	1.4	2.7	2.4	2.7
60	070137	4.6	3.3	3.7	3.7	4.1
61	070141	-0.8	1.9	2.0	2.8	3.1
62	070142	2.8	1.7	1.8	2.7	3.0
63	070143	1.4	1.9	2.5	2.8	3.1
64	070144	2.5	2.1	6.1	2.9	3.2
65	070166	4.8	2.6	2.5	3.3	3.6

Table 8 and Table 9 give one set of met/ocean data for each bridge. For bridges crossing large water bodies, the 100-year storm water level and wave heights can vary along the bridge. For these cases, the extreme values analysis was performed at multiple locations and the results from the location with the highest wave crest elevation are presented in Table 8 and Table 9. This section details the process for determining which set of met/ocean data to apply in the force calculations, using Bridge Recall Number 001552 (US 11 over Lake Pontchartrain) as an example. Statistics were calculated at nine different locations (Figure 16). Table 10 provides the coordinates of these locations, along with the 100-year maximum storm water level and associated wave parameters. From the table, the wave crest elevation at location number 5 has the highest elevation even though it does not have the highest storm water level. Since location number 5 has the highest wave crest elevation, the 100-year maximum storm water level and associated wave parameters from location number 5 are presented in Table 8 and provide the input to the surge and wave force calculations. Similarly, Table 11 presents the maximum significant wave height and associated storm water level at the same nine locations. For the maximum wave height and associated storm water level, location 8 has the highest wave crest elevation and the values at this location are presented in Table 9 and used as input to calculate surge and wave forces on the bridge superstructure.

Table 10
Example statistics for Bridge 001552 for maximum storm water level

Location Number	Latitude	Longitude	Maximum Storm Water Level (ft-MSL)	Associated Significant Wave Height (ft.)	Associated Peak Wave Period (sec.)	Associated Wave Crest Elevation (ft-MSL)
1	30.1555	-89.8561	5.6	3.5	4.9	9.3
2	30.1618	-89.8534	5.8	4.8	4.4	11.8
3	30.1665	-89.8514	5.8	5.3	4.5	12.5
4	30.1735	-89.8486	5.9	5.4	4.4	12.7
5*	30.1874	-89.8427	6.0	5.4	4.3	12.8
6	30.1972	-89.8387	6.1	5.2	4.2	12.6
7	30.2040	-89.8348	6.1	5.0	4.1	12.4
8	30.2102	-89.8298	6.1	4.6	4.1	11.9
9	30.2174	-89.8240	6.2	3.1	4.6	9.6

Table 11
Example statistics for Bridge 001552 for maximum significant wave height

Location Number	Latitude	Longitude	Associated Storm Water Level (ft-MSL)	Maximum Significant Wave Height (ft.)	Associated Peak Wave Period (sec.)	Associated Wave Crest Elevation (ft-MSL)
1	30.1555	-89.8561	5.7	3.9	4.7	9.5
2	30.1618	-89.8534	1.9	6.6	5.0	8.4
3	30.1665	-89.8514	2.2	6.8	5.0	9.1
4	30.1735	-89.8486	1.8	7.1	4.9	9.0
5	30.1874	-89.8427	3.1	6.6	4.7	10.6
6	30.1972	-89.8387	3.3	6.3	4.7	10.8
7	30.2040	-89.8348	4.1	6.4	4.9	12.1
8*	30.2102	-89.8298	5.0	6.3	4.9	12.7
9	30.2174	-89.8240	5.9	3.5	4.8	9.2

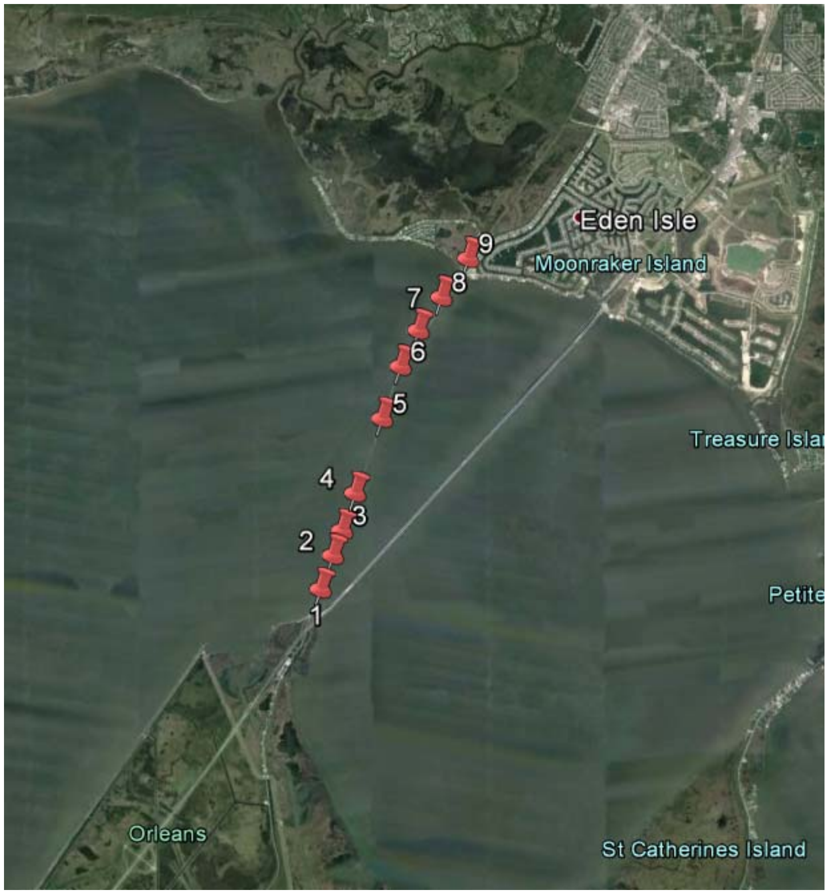

Figure 16
Locations statistical analysis was performed for Bridge 001552

Wave and Surge Atlas

The magnitude of the met/ocean information produced by this study is extremely large; therefore, its presentation does not lend itself to the usual tables and graphs. For this reason, this information, which has applications far beyond the computation of wave loads on bridge superstructures, is presented in a GIS database. The database, constructed with ESRI ArcInfo and ArcReader GIS mapping software, provides greater flexibility in graphical representation of large datasets with seamless flow between various types of information.

The Wave and Surge GIS Database presents the user with an interactive map that contains 100-year hydraulic design data for Louisiana's coastal waters. Hydraulic data contained within the database include the following: 100-year maximum storm surge level (and associated significant wave height and peak wave period) and the 100-year maximum significant wave height (and associated peak wave period and storm water level). Thematic groups include roadways, county boundaries, and city and town locations. Base maps in the database include land boundaries, aerial imagery, and topographic maps.

Accessibility of the hydraulic information is by mouse click at the desired point on the map. This information can also be obtained by typing in the x-y coordinates (lat-long, state-plane, etc.) or bridge recall number. The search results are presented in tabular format with the coordinates and hydraulic values displayed in a window on the map.

The information in the Storm Surge and Wave GIS Database will have numerous applications for both existing and future water related projects. Figure 17 displays a screen shot of the Storm Surge and Wave GIS base map. In the figure, the locations of the 65 bridges evaluated in the study are represented by the yellow dots. A detailed description of the database and its application is presented in Appendix G.

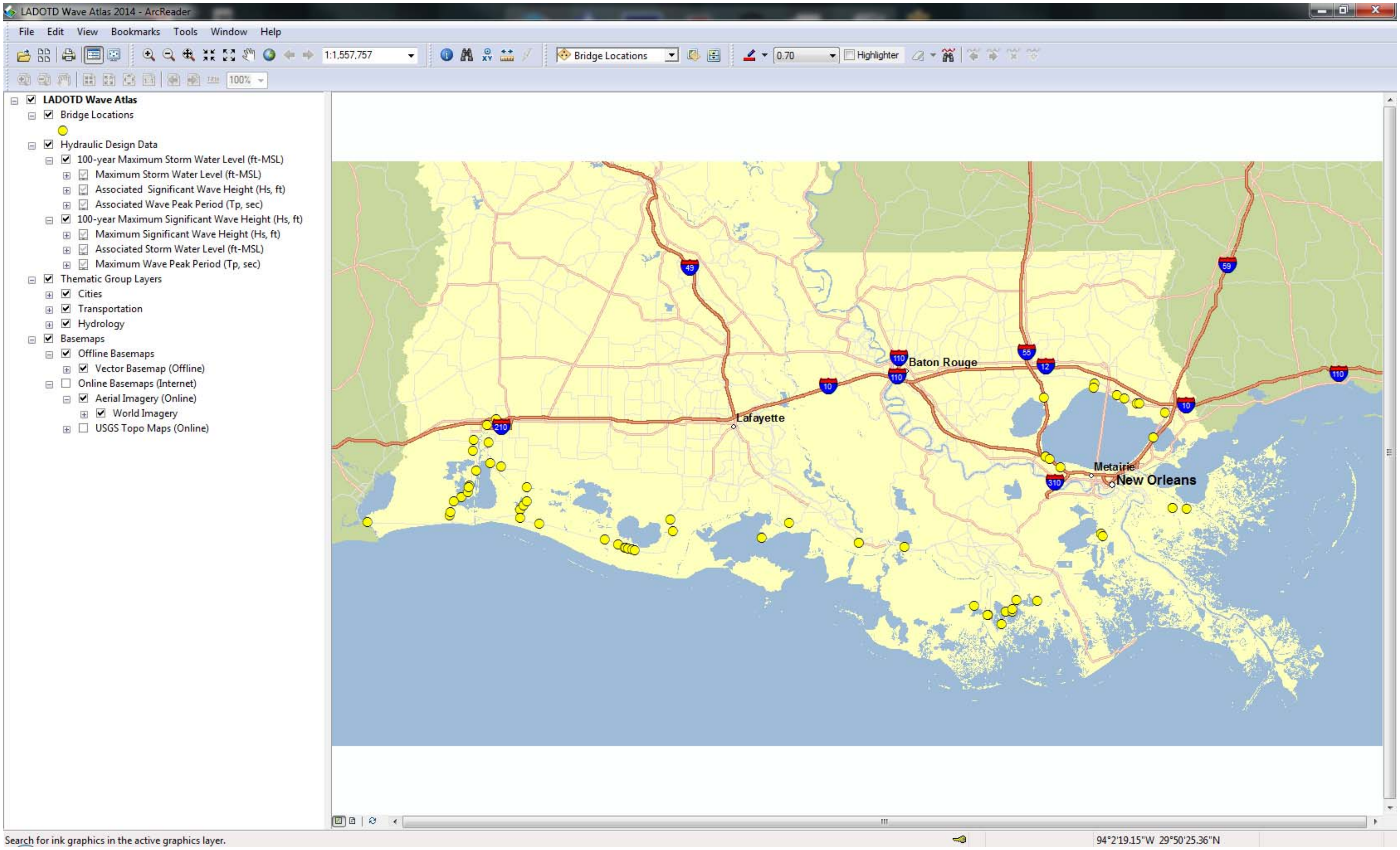

Figure 17
Screenshot of storm wave and surge atlas GIS geodatabase

Coastal Bridge Vulnerability to Surge/Wave Forces

Selection of Bridges for Evaluation

DOTD supplied OEA/INTERA with a list of 1920 on system and 1257 off-system bridges that were in coastal parishes of Louisiana (Calcasieu, Cameron, Iberia, Jefferson, Lafourche, Orleans, Plaquemines, St. Bernard, St. Charles, St. John the Baptist, St. Mary, St. Tammany, Tangipahoa, Terrebonne, and Vermillion). The list of these 3177 bridges is provided in Appendix J. OEA/INTERA, working closely with DOTD, reduced the number of bridges for further investigation. The criteria used for excluding bridges include: structure types that were not bridges (CONBOX, CONPIP, METRCH, PLARCH, TUNNEL, FERRYF, FERRYT, and PONTON) and bridges protected by a levee system. After these initial eliminations, accurate bridge location information was required for spatial analysis. The coordinates in the DOTD provided database were not accurate for most of the bridges. OEA/INTERA, with assistance from DOTD, corrected the coordinates for those bridges based on aerial imagery and bridge descriptions. At this point in the screening, off-system bridges were removed from the list by DOTD. Using bridge location information, maps and aerial imagery, bridges located at high elevations, away from large water bodies and FEMA V zones were eliminated along with bridges that could be identified as having high, low cord elevations. At the end of this stage, 471 bridges were selected and sent to districts for further screening. The districts eliminated bridges that will be replaced soon, were recently constructed and designed for wave forces, and minor structures that will not be retrofitted even if found vulnerable. Bridges on evacuation routes and those deemed important to a community were kept in the list. The final list from the districts contained 100 bridges. That said, bridge (recall number) 003450 was erroneously selected for 003480, so both bridges are included in the analysis — increasing the number to 101.

A final screening involved a more thorough and detailed review of aerial photographs and topography of the bridge locations to evaluate wave fetch lengths, vegetation canopy, and approach elevations. Figure 18 and Figure 19 present examples of short fetches and vegetation canopy. This final screening removed 36 bridges from the list. As a result, the analysis Appendix J provides a table that details the reasons for the removal of each of the bridges eliminated by this screening. In addition, Appendix J provides tables at various levels of screening (3177 bridges, 471 bridges, 101 bridges, 36 removed bridges) along with correspondence with the Districts. Figure 20 provides a flowchart summarizing the screening process.

Finally, Table 12 lists the 65 bridges evaluated along with the waterway, roadway, and the bridge's Criticality Index assigned by DOTD. Table 13 provides the criteria for the

Criticality Index values. A value of 1 to 4 was assigned to all bridges considered in this study by DOTD engineers.

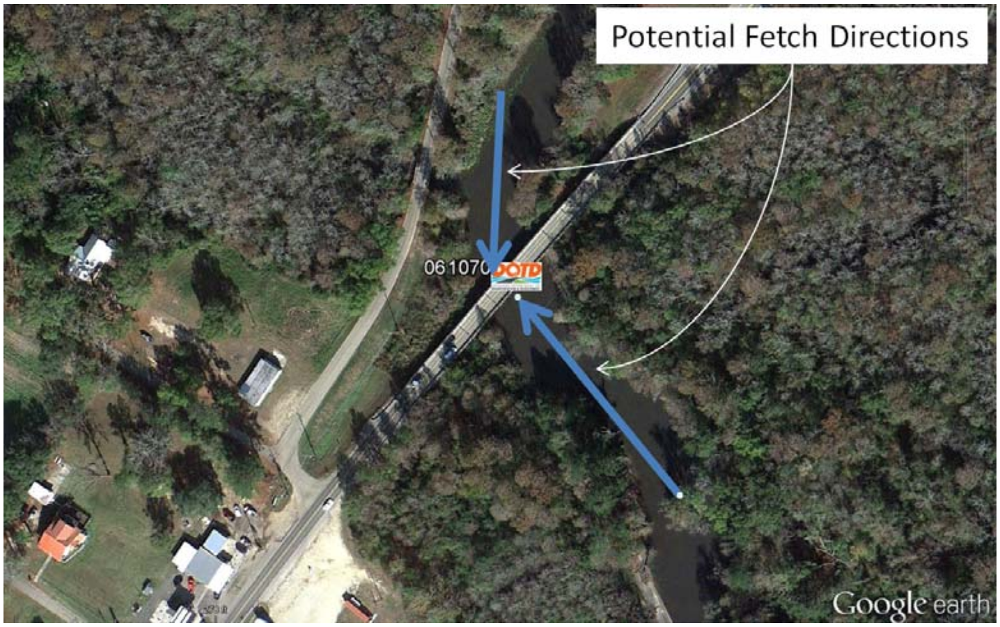

Figure 18
Aerial photograph of bridge removed from consideration because of limited fetch

Figure 19
Photograph of upstream view of bridge removed from consideration because of vegetation canopy

Table 12
Bridges evaluated

No.	Recall Number	Description	Criticality
1	000810	LA-302 over BAYOU BARATARIA	3
2	001552	US-11 over LAKE PONTCHARTRAIN	3
3	002631	LA-46 over BAYOU LALOUTRE	3
4	002632	LA-46 over BAYOU LALOUTRE	3
5	002650	LA-46 over BAYOU LA LOUTRE	3
6	002892	I-10 over BONNET CARRE SPILLWAY	4
7	002894	I-10 over BONNET CARRE SPILLWAY	4
8	003390	LA-315 over FALGOUT CANAL	3
9	003432	LA-57 over BAYOU DULAC	3
10	003440	LA-56 over ROBINSON CANAL	3
11	003450	LA-56 over BOUDREAUX CANAL	3
12	003480	LA-56 over BAYOU PETIT	3
13	003510	LA-55 over MADISON CANAL	3
14	003520	LA-55 over LAPEYROUSE CANAL	3
15	003641	LA-655 over ISLE JEAN CHARLES CANAL	3
16	003690	LA-3011 over DRAINAGE CANAL	3
17	009020	US-90 over RAMOS BAYOU	2
18	009030	LA-319 over CYPREMORT POINT	3
19	009060	LA-83 over IVANHOE CANAL	2
20	009198	US-90 over WAX LAKE OUTLET	4
21	009570	LA-82 over LONG DITCH	3
22	009580	LA-82 over TURF BAYOU	3
23	009590	LA-82 over WEST RELIEF	3
24	009600	LA-82 over MARSH DITCH	3
25	009610	LA-82 over MIDDLE CANAL	3
26	009620	LA-82 over MILLER CANAL	3
27	009630	LA-82 over EAST RELIEF	3
28	009700	LA-82 over DRAINAGE CANAL	3
29	009710	LA-82 over WARREN CANAL	3
30	020185	I-10 over LAKE PONTCHARTRAIN X-OVER	1
31	020186	I-10 over SWAMP (EMERGENCY X-OVER)	1
32	020266	LA-3257 over PAILET CANAL	3
33	020319	LA-55 over HUMBLE CANAL	3
34	030242	US-90 over WAX LAKE OUTLET	4
35	031755	LA-27 over CHOUPIQUE BAYOU	3
36	032266	LA-82 over SABINE LAKE CAUSEWAY	4
37	032780	I-10 over CALCASIEU RIVER, RR, STS.	4

No.	Recall Number	Description	Criticality
38	033210	I-210 over PRIEN LAKE	4
39	033590	LA-27 over KAYOU BAYOU	3
40	033602	LA-27 over KELSO BAYOU/HACKBERRY	3
41	033650	LA-27 over CANAL	3
42	033660	LA-27 over CANAL	3
43	033672	LA-27 over CANAL	3
44	033681	LA-27 over ICWW GIBBSTOWN	4
45	033698	LA-82 over BAYOU	3
46	033700	LA-82 over MERMENTAU R./G.CHENIER	4
47	033730	LA-82 over SUPERIOR CANAL	4
48	033750	LA-385 over S FORK BLACK BAYOU	2
49	058910	US-190 over BAYOU CASTINE	3
50	058920	US-190 over CANE BAYOU	3
51	058930	US-190 over BAYOU LACOMBE	3
52	058940	US-190 over BIG BRANCH	3
53	059482	LA-22 over TCHEFUNCTE R/MADISONVILLE	3
54	060360	LA-1077 over BLACK BAYOU	1
55	060412	LA-433 over BAYOU BONFOUCA	3
56	062100	US-51 over OWL BAYOU	1
57	070096	LA-27 over BAYOU	3
58	070097	LA-384 over GUY BAYOU	2
59	070119	LA-1133 over CANAL	1
60	070137	LA-27 over BAYOU	3
61	070141	LA-27 over LITTLE CROSS CREEK	3
62	070142	LA-27 over BIG CROSS CREEK BRIDGE	3
63	070143	LA-27 over HOG ISLAND GULLY	3
64	070144	LA-27 over LONG POINT BAYOU	3
65	070166	LA-384 over DRAIN	2

Table 13
Criticality index definition table

Criticality Index	Description
1	Minor impact to economy or emergency needs if closed (alternative routes exist)
2	Medium impact if closed - may lead to a barrier island but an alternative route exists
3	Major impact if closed – only road to a barrier island, evacuation route with no reasonable alternatives
4	Extreme impact if closed – Interstate or major economic connector (detour very long)

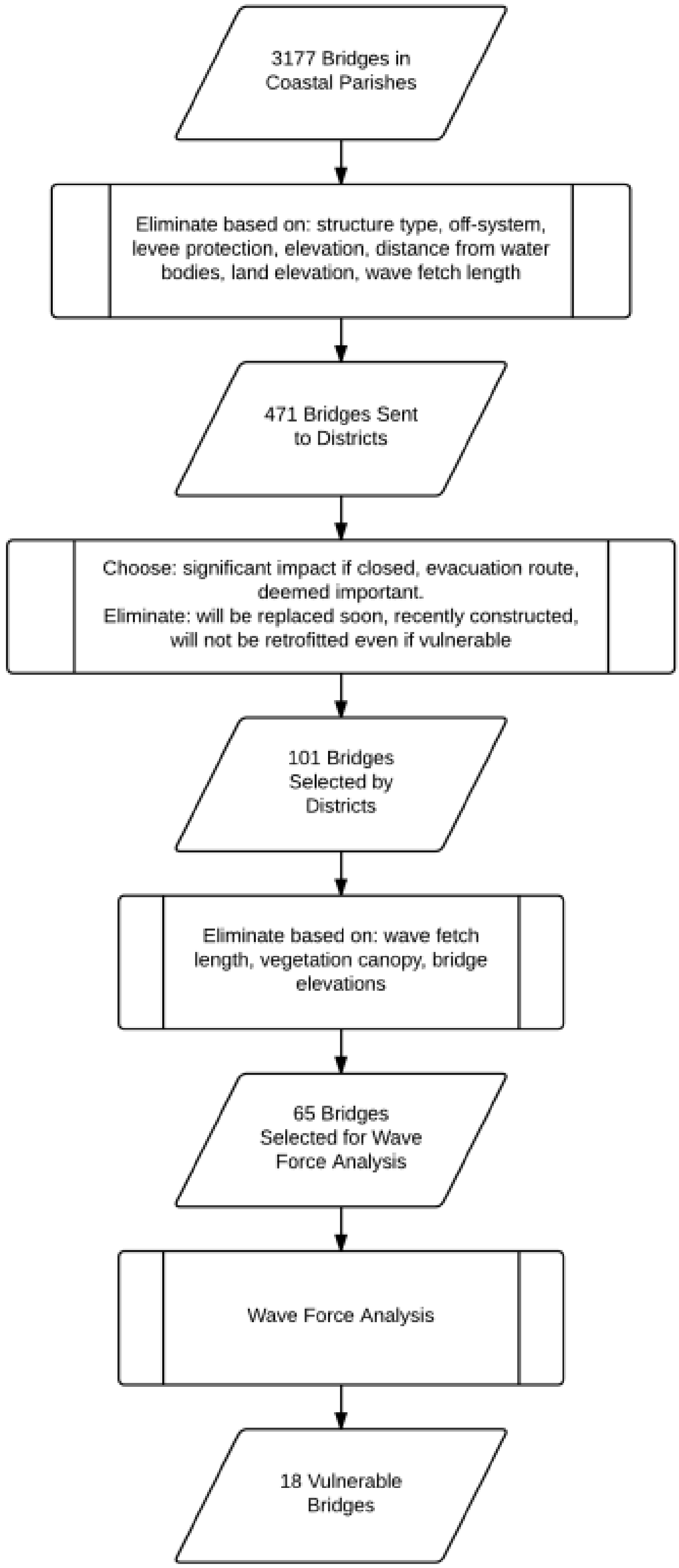

Figure 20
Flowchart for bridge screening and evaluation process

Method of Analysis

The procedure for identifying the vulnerability of the selected bridges begins with identifying the most critical span on each bridge. The structural parameters (span type, dimensions, low chord elevation, superstructure dead weight, etc.) for that span were provided by DOTD. Next, the design forces and moments were computed along with a conservative estimate (i.e., a lower estimate) of the resistive forces and moments. As discussed in detail below, the design forces include a load factor, the magnitude of which depends on the criticality of the bridge. The resistive forces are conservative in that only the dead weight of the superstructure is considered. If there are tie-downs or other means of increasing the resistance, then the actual resistive forces and moments will be greater. The vulnerability index is the ratio of the design force or moment divided by the maximum resistive force or moment. If the vulnerability index is greater than or equal to 1 for either force or moment, the bridge is considered to be vulnerable. The computer model used to compute the forces and moments is discussed briefly below with more detail given in Appendix H.

Physics Based Model. Until recently, the methods for predicting wave forces on horizontal structures such as bridge spans were not well developed. Kaplan and Kaplan et al. published an analytical approach for computing forces on the decks of offshore platforms using an approach similar to that used in the development of Morison's Equation for horizontal wave forces on vertical piles *[3], [4], [5]*. There are, however, differences between offshore platform decks and bridge spans as well as differences in the range of wave frequencies (and thus wave lengths) encountered by most coastal bridges. Starting with Kaplan's Equations, Dr. Sheppard and his graduate students at the University of Florida developed predictive equations for wave-induced horizontal and vertical forces and the resulting moments on bridge superstructures *[6]*. OEA/INTERA developed a proprietary computer program (Physics Based Model or PBM) that evaluates these equations for a wide variety of bridge superstructure designs and met/ocean conditions. The PBM generated the data that formed the basis of the parametric force and moment equations in the AASHTO code *Guide Specifications for Bridges Vulnerable to Coastal Storms*. This involved calculating wave forces and moments using the PBM for a large number of met/ocean conditions for many of the more common beam types. Curve fitting that data provided the equations in the AASHTO code. These equations envelope the majority of the data, which, in general, results in conservative predictions. Additionally, the equations in the code are limited by the conditions used in their development. Specifically, waves were limited to wave periods between 3 and 10 seconds with steepness limited to values between 0.035 and 0.15 and heights were limited to no greater than 65 percent of the water depth.

The PBM computed the surge/wave loads in this study. Appendix H presents information on the surge/wave force and moment equations in the PBM.

Surge/Wave Forces and Moments. The forces and moments were computed for two sets of conditions; the 100-year storm water level and the associated wave height and the 100-year wave height and the associated storm water level and a range of wave periods. For bridges crossing large water bodies, where the 100-year storm water level and wave heights vary along the bridge, the largest combination of wave heights and storm water levels were used in the calculations. Once calculated, the larger of the forces and moments provided the inputs to compute the bridge vulnerability. The computed forces and moments (using the PBM) are given in Table 14. In the table, three sets of forces/moments are presented: (1) the maximum vertical force and associated horizontal force and moment, (2) the maximum horizontal force and associated vertical force and moment, and (3) the maximum moment and associated vertical and horizontal forces. As can be seen in the table, many of the bridges display no (zero) calculated forces and moments. For these bridges, the low chords exceeded the calculated maximum wave crest envelopes. Figure 21 illustrates these forces. The vertical force is positive upwards, horizontal force is positive in the direction of wave propagation, and a clockwise overturning moment is positive. These forces, along with the resistance provided by the span dead weight, provide the information needed to determine the vulnerability of each bridge span.

Appendix I provides an example of how to use data from the 100-year Wave and Surge Atlas to compute surge/wave induced forces and moments on bridge superstructures with both the PBM and the parametric equations in the AASHTO Guide Specifications. This appendix also presents an example for a long bridge over a large water body as discussed in the Extreme Value Analysis Results section.

Table 14
100-year surge/wave forces and moments calculated using the PBM

No.	Bridge Recall Number	Maximum Vertical Force			Maximum Horizontal Force			Maximum Overturning Moment about the Lower Trailing Edge		
		Maximum Vertical Force (kips)	Associated Horizontal Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Horizontal Force (kips)	Associated Vertical Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Moment about the Trailing Edge (ft-kips)	Associated Vertical Force (kips)	Associated Horizontal Force (kips)
1	000810	0	0	0	0	0	0	0	0	0
2	001552	44	19	322	26	13	-215	419	20	14
3	002631	64	0	1,883	5	37	38	1,883	63	0
4	002632	67	3	1,041	5	34	-406	1,979	65	0
5	002650	258	37	2,571	69	222	1,271	4,788	251	0
6	002892	426	259	5,752	289	154	2,864	6,731	181	40
7	002894	426	259	5,752	289	154	2,864	6,731	181	40
8	003390	0	0	0	0	0	0	0	0	0
9	003432	2,254	773	25,788	919	1,796	23,562	26,423	2,143	805
10	003440	246	8	2,124	10	90	194	2,846	108	8
11	003450	1,839	434	14,250	681	753	10,029	20,612	1,398	314
12	003480	204	2	2,795	17	124	986	3,073	189	2
13	003510	62	-1	1,233	20	31	-148	1,261	61	-1
14	003520	65	1	1,183	6	40	-674	1,288	61	0
15	003641	51	1	474	2	28	589	589	28	2
16	003690	68	6	1,005	15	45	242	1,082	64	2
17	009020	0	0	0	0	0	0	0	0	0

No.	Bridge Recall Number	Maximum Vertical Force			Maximum Horizontal Force			Maximum Overturning Moment about the Lower Trailing Edge		
		Maximum Vertical Force (kips)	Associated Horizontal Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Horizontal Force (kips)	Associated Vertical Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Moment about the Trailing Edge (ft-kips)	Associated Vertical Force (kips)	Associated Horizontal Force (kips)
18	009030	64	0	896	7	42	394	919	62	0
19	009060	0	0	0	0	0	0	0	0	0
20	009198	0	0	0	0	0	0	0	0	0
21	009570	0	0	0	0	0	0	0	0	0
22	009580	0	0	0	0	0	0	0	0	0
23	009590	0	0	0	0	0	0	0	0	0
24	009600	0	0	0	0	0	0	0	0	0
25	009610	0	0	0	0	0	0	0	0	0
26	009620	0	0	0	0	0	0	0	0	0
27	009630	0	0	0	0	0	0	0	0	0
28	009700	0	0	0	0	0	0	0	0	0
29	009710	0	0	0	0	0	0	0	0	0
30	020185	0	0	0	0	0	0	0	0	0
31	020186	0	0	0	0	0	0	0	0	0
32	020266	30	0	631	1	16	411	631	29	0
33	020319	0	0	0	0	0	0	0	0	0
34	030242	0	0	0	0	0	0	0	0	0
35	031755	297	1	5,933	19	261	6,075	6,075	261	19
36	032266	0	0	0	0	0	0	0	0	0
37	032780	0	0	0	0	0	0	0	0	0

No.	Bridge Recall Number	Maximum Vertical Force			Maximum Horizontal Force			Maximum Overturning Moment about the Lower Trailing Edge		
		Maximum Vertical Force (kips)	Associated Horizontal Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Horizontal Force (kips)	Associated Vertical Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Moment about the Trailing Edge (ft-kips)	Associated Vertical Force (kips)	Associated Horizontal Force (kips)
38	033210	0	0	0	0	0	0	0	0	0
39	033590	0	0	0	0	0	0	0	0	0
40	033602	0	0	0	0	0	0	0	0	0
41	033650	44	0	939	1	43	1,203	1,326	44	0
42	033660	52	1	1,143	1	50	1,226	1,308	51	0
43	033672	0	0	0	0	0	0	0	0	0
44	033681	0	0	0	0	0	0	0	0	0
45	033698	48	2	827	4	39	90	1,071	42	0
46	033700	124	12	1,515	14	94	523	1,811	102	7
47	033730	0	0	0	0	0	0	0	0	0
48	033750	0	0	0	0	0	0	0	0	0
49	058910	0	0	0	0	0	0	0	0	0
50	058920	0	0	0	0	0	0	0	0	0
51	058930	0	0	0	0	0	0	0	0	0
52	058940	0	0	0	0	0	0	0	0	0
53	059482	949	21	23,565	40	724	18,721	24,442	840	-5
54	060360	81	0	971	7	52	400	1,088	76	-4
55	060412	0	0	0	0	0	0	0	0	0
56	062100	22	1	433	1	12	350	528	15	1
57	070096	83	3	714	3	50	936	1,047	46	2

No.	Bridge Recall Number	Maximum Vertical Force			Maximum Horizontal Force			Maximum Overturning Moment about the Lower Trailing Edge		
		Maximum Vertical Force (kips)	Associated Horizontal Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Horizontal Force (kips)	Associated Vertical Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Moment about the Trailing Edge (ft-kips)	Associated Vertical Force (kips)	Associated Horizontal Force (kips)
58	070097	41	0	651	1	22	73	797	41	0
59	070119	0	0	0	0	0	0	0	0	0
60	070137	60	3	729	3	20	585	729	35	3
61	070141	0	0	0	0	0	0	0	0	0
62	070142	4	0	-36	0	-1	-122	6	1	0
63	070143	0	0	0	0	0	0	0	0	0
64	070144	0	0	0	0	0	0	0	0	0
65	070166	35	0	908	3	14	-293	908	35	0

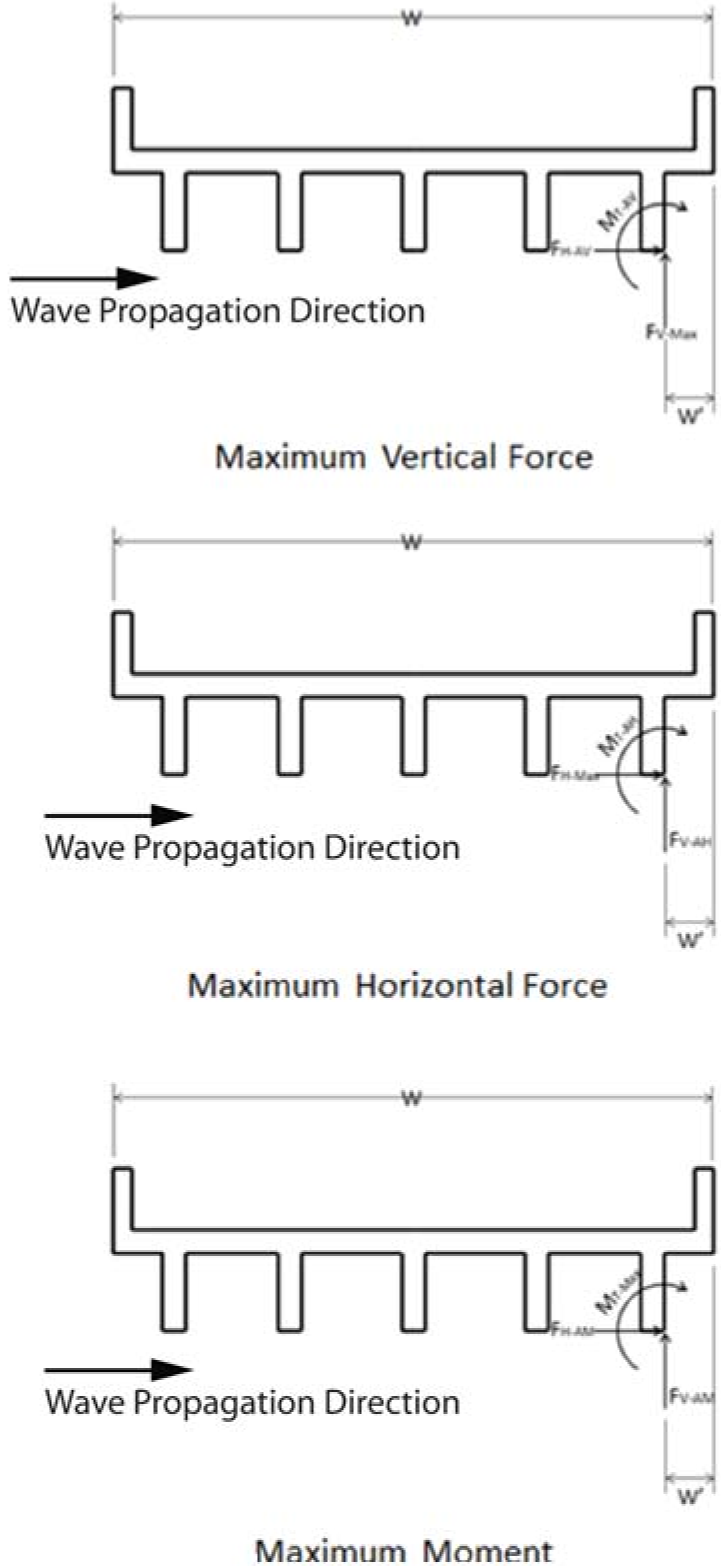

Figure 21
Force and moment definition sketch

Bridge Vulnerability. In this study, bridges with spans where the design surge/wave forces and/or moments (with the proper load factors) exceed the maximum resistive forces and/or moments are classified as vulnerable. The AASHTO code recommends a strength limit state wave force load factor of 1.75 for bridges classified by the owner as "critical/essential." For bridges designated as "typical," the extreme event limit state wave force load factor is specified as 1.00. DOTD provided the criticality classification for the bridges examined in this study. Bridges classified with a criticality of 3 or greater are considered "critical/essential" and are evaluated with a load factor of 1.75. Conversely, bridges classified with a criticality of 2 or less are considered "typical" and are evaluated with a load factor of 1.00.

The resistive forces consist of superstructure dead weight, tie-downs or other constraints (if present) and frictional forces between the super- and substructure. Due to the effort required to obtain information on the existence and condition of tie-downs and estimating frictional forces, only superstructure dead weight is considered in this analysis. Bridges found to be vulnerable, from this conservative approach, should be further examined to discern accurate tie-down information prior to making decisions regarding corrective action. The vulnerability index for both vertical force and moment were computed. These indices along with the resistive forces and moments are presented in Table 15. From the table, this analysis identified 18 bridges as vulnerable to the 100-year surge/wave loading.

Table 15
Surge/wave forces, moments, and vulnerability indices

No.	Bridge Recall Number	Load Factor	Maximum Vertical Force (kips)	Dead Weight (kips)	Vertical Force Vulnerability Index	Maximum Moment (ft-kips)	Dead Weight Resistive Moment (ft-kips)	Moment Vulnerability Index	Conclusion
1	000810	1.75	0	386	0.0	0	4,245	0.0	Not Vulnerable
2	001552	1.75	44	218	0.4	419	3,274	0.2	Not Vulnerable
3	002631	1.75	64	132	0.8	1,883	2,640	1.2	**Vulnerable**
4	002632	1.75	67	132	0.9	1,979	2,640	1.3	**Vulnerable**
5	002650	1.75	258	131	3.5	4,788	1,634	5.1	**Vulnerable**
6	002892	1.75	426	493	1.5	6,731	10,715	1.1	**Vulnerable**
7	002894	1.75	426	493	1.5	6,731	10,715	1.1	**Vulnerable**
8	003390	1.75	0	443	0.0	0	6,753	0.0	Not Vulnerable
9	003432	1.75	2254	443	8.9	26,423	6,753	6.8	**Vulnerable**
10	003440	1.75	246	246	1.7	2,846	4,124	1.2	**Vulnerable**
11	003450	1.75	1839	383	8.4	20,612	5,260	6.9	**Vulnerable**
12	003480	1.75	204	138	2.6	3073	1170	4.6	**Vulnerable**
13	003510	1.75	62	81	1.3	1,261	1,094	2.0	**Vulnerable**
14	003520	1.75	65	81	1.4	1,288	1,094	2.1	**Vulnerable**
15	003641	1.75	51	122	0.7	589	2,259	0.5	Not Vulnerable
16	003690	1.75	68	29	4.1	1,082	363	5.2	**Vulnerable**
17	009020	1	0	138	0.0	0	2,769	0.0	Not Vulnerable
18	009030	1.75	64	85	1.3	919	978	1.6	**Vulnerable**
19	009060	1	0	65	0.0	4	875	0.0	Not Vulnerable
20	009198	1.75	0	863	0.0	0	17,817	0.0	Not Vulnerable

No.	Bridge Recall Number	Load Factor	Maximum Vertical Force (kips)	Dead Weight (kips)	Vertical Force Vulnerability Index	Maximum Moment (ft-kips)	Dead Weight Resistive Moment (ft-kips)	Moment Vulnerability Index	Conclusion
21	009570	1.75	0	110	0.0	0	1,209	0.0	Not Vulnerable
22	009580	1.75	0	62	0.0	0	850	0.0	Not Vulnerable
23	009590	1.75	0	62	0.0	0	850	0.0	Not Vulnerable
24	009600	1.75	0	62	0.0	0	850	0.0	Not Vulnerable
25	009610	1.75	0	62	0.0	0	850	0.0	Not Vulnerable
26	009620	1.75	0	62	0.0	0	850	0.0	Not Vulnerable
27	009630	1.75	0	62	0.0	0	850	0.0	Not Vulnerable
28	009700	1.75	0	96	0.0	0	1,388	0.0	Not Vulnerable
29	009710	1.75	0	96	0.0	0	1,388	0.0	Not Vulnerable
30	020185	1	0	334	0.0	0	8,349	0.0	Not Vulnerable
31	020186	1	0	251	0.0	0	6,283	0.0	Not Vulnerable
32	020266	1.75	30	73	0.7	631	1,167	0.9	Not Vulnerable
33	020319	1.75	0	473	0.0	0	7,808	0.0	Not Vulnerable
34	030242	1.75	0	858	0.0	0	17,512	0.0	Not Vulnerable
35	031755	1.75	297	340	1.5	6,075	7,021	1.5	**Vulnerable**
36	032266	1.75	0	1442	0.0	0	33,171	0.0	Not Vulnerable
37	032780	1.75	0	296	0.0	0	8,981	0.0	Not Vulnerable
38	033210	1.75	0	536	0.0	0	17,083	0.0	Not Vulnerable
39	033590	1.75	0	177	0.0	0	3,778	0.0	Not Vulnerable
40	033602	1.75	0	645	0.0	0	13,312	0.0	Not Vulnerable
41	033650	1.75	44	215	0.4	1,326	4,719	0.5	Not Vulnerable
42	033660	1.75	52	215	0.4	1,308	4,719	0.5	Not Vulnerable
43	033672	1.75	0	91	0.0	0	1,824	0.0	Not Vulnerable

No.	Bridge Recall Number	Load Factor	Maximum Vertical Force (kips)	Dead Weight (kips)	Vertical Force Vulnerability Index	Maximum Moment (ft-kips)	Dead Weight Resistive Moment (ft-kips)	Moment Vulnerability Index	Conclusion
44	033681	1.75	0	136	0.0	0	2,572	0.0	Not Vulnerable
45	033698	1.75	48	64	1.3	1,071	894	2.1	**Vulnerable**
46	033700	1.75	124	81	2.7	1,811	1,094	2.9	**Vulnerable**
47	033730	1.75	0	371	0.0	0	3,892	0.0	Not Vulnerable
48	033750	1	0	96	0.0	0	1,388	0.0	Not Vulnerable
49	058910	1.75	0	87	0.0	0	1,090	0.0	Not Vulnerable
50	058920	1.75	0	87	0.0	0	1,090	0.0	Not Vulnerable
51	058930	1.75	0	328	0.0	0	4,585	0.0	Not Vulnerable
52	058940	1.75	0	87	0.0	0	1,090	0.0	Not Vulnerable
53	059482	1.75	949	863	1.9	24,442	14,669	2.9	**Vulnerable**
54	060360	1	81	53	1.5	1,088	504	2.2	**Vulnerable**
55	060412	1.75	0	815	0.0	0	12,964	0.0	Not Vulnerable
56	062100	1	22	239	0.1	528	5,434	0.1	Not Vulnerable
57	070096	1.75	83	177	0.8	1,047	3,778	0.5	Not Vulnerable
58	070097	1	41	100	0.4	797	1,605	0.5	Not Vulnerable
59	070119	1	0	73	0.0	0	1,167	0.0	Not Vulnerable
60	070137	1.75	60	177	0.6	729	3,778	0.3	Not Vulnerable
61	070141	1.75	0	177	0.0	0	3,778	0.0	Not Vulnerable
62	070142	1.75	4	177	0.0	6	3,778	0.0	Not Vulnerable
63	070143	1.75	0	177	0.0	0	3,778	0.0	Not Vulnerable
64	070144	1.75	0	177	0.0	0	3,778	0.0	Not Vulnerable
65	070166	1	35	73	0.5	908	1,167	0.8	Not Vulnerable

DISCUSSION OF RESULTS

The objectives of this study included (1) creating a Wave and Surge Atlas for 100-year storm conditions for Louisiana coastal waters, (2) applying the met/ocean data to compute the storm surge and wave loads on selected DOTD coastal bridge superstructures, and (3) based on these computed loads, assessing the analyzed bridges' vulnerability. The database includes 100-year (1 percent chance of occurrence each year) maximum water elevations with associated wave heights, and maximum wave heights with associated water elevations throughout the modeled area. The results are presented in a GIS database with a public domain GIS reader. The met/ocean information has many potential uses beyond that for computing surge/wave loading on bridge superstructures.

Sixty-five coastal bridges were examined in this study. The 100-year surge/wave forces and moments were computed for the most critical span(s) on these bridges. The resistive forces and moments (based on the superstructure dead weight) were also computed. The vulnerability index, which is the calculated forces/moments with the appropriate load factors divided by the resistive forces/moments, provides the means for determining the bridge's vulnerability. Bridges with vulnerability indices equal to or greater than one were classified as vulnerable. Of the 65 bridges analyzed, 18 were determined vulnerable to these types of loads (see Table 15).

CONCLUSIONS AND RECOMMENDATIONS

Results of this study provide the DOTD with design surge/wave data throughout southern Louisiana. That data provided the input to identify DOTD's vulnerable coastal bridges and develop the Wave and Surge Atlas.

The vulnerability analysis identified 18 bridges as vulnerable. If any of the vulnerable bridges have constraints (e.g., tie-downs), then a more accurate assessment of the resistive forces and moments contributed by those constraints should be evaluated. For some bridges the amount the design surge/wave load exceeds the resistive forces (span dead weight) is minimal. In those cases, the additional dead weight resistance contributed by the railings, barriers, and parapets could offset the amount of resistance exceeded by the surge/wave load. For those bridges that remain vulnerable, retrofit options include adding constraints and providing venting to reduce the volume of trapped air between girders. In many cases, particularly for older bridges, the more appropriate plan of action is eventual replacement. Implementation of countermeasures or retrofit options are at the discretion of the DOTD and beyond the scope of this study.

For future bridges, the AASHTO *Guide Specifications for Bridges Vulnerable to Coastal Storms* recommends raising the low chord 1 ft. above the design (1 percent) wave crest elevation. The wave crest elevation is the sum of the surge elevation and 70 percent of the wave height, which are readily accessible using the Wave and Surge Atlas. For cases where raising the bridge above the design wave crest is impractical, AASHTO recommends that bridges designed for the strength limit state include a load factor of 1.75. For bridges designed for the extreme event limit state, AASHTO recommends the wave load factor of unity. Refer to the AASHTO *Guide Specifications for Bridges Vulnerable to Coastal Storms* for additional guidance when designing bridges within the wave crest.

The current Atlas contains surge and wave information with a 1% chance of occurrence each year (100-year return interval). This information is useful for computing wave loads on bridge superstructures. There are, however, many issues encountered by DOTD engineers that require other frequency meteorological/oceanographic information (e.g., 10-, 25-, 50-year return interval values). For instance, a temporary facility (a detour bridge) may be designed based on a 5-year return interval (20% chance of occurrence each year). Bridges whose service life is approaching their design life may be retrofitted based on a return interval different from 100-year return interval. Therefore, the research team recommends a Phase-II study where surge and wave information for different returned intervals, as well as corresponding forces on coastal bridges, be developed and provided in separate GIS databases

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
ADCIRC	Advanced Circulation Model for Coastal Ocean Hydrodynamics
CDF	cumulative distribution function
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
ft.	foot (feet)
ft./sec.	feet per second
GIS	Geographic Information System
km	kilometer(s)
DOTD	Louisiana Department of Transportation and Development
LTRC	Louisiana Transportation Research Center
Min	minute(s)
MSL	mean sea level
NDBC	National Data Buoy Center
NOAA	National Oceanic and Atmospheric Administration
OEA/INTERA	OEA, a division of INTERA Incorporated
%	percent
PBM	Physics Based Model
RMS	Root Mean Square
sec.	second
SWAN	Simulating Waves Nearshore
US	United States
USGS	United States Geological Survey
WSE	water surface elevation

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3. Kaplan, P. “Wave Impact Forces on Offshore Structures: Re-Examination and New Interpretations.” Proceedings of the 24th Annual Conference on Offshore Technology, OTC 6814, Houston, TX, 1992, pp. 79-86.

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APPENDICES

Appendix A: Data Sources
Appendix B: Model Descriptions
Appendix C: Model Calibration Details
Appendix D: Shifted Storm Paths
Appendix E: Extreme Value Analyses Details
Appendix F: Design Wave Period
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Appendix H: Physics Based Model
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APPENDIX A: DATA SOURCES

Bathymetry and Topography

The Level III evaluation of the Louisiana Bridges focuses on the development of complex wave and surge models to simulate the historical sea state. Development and application of the models requires aerial photography, bathymetry, and topography. This appendix describes the data collection effort.

Aerial Photography and Maps

Aerial photography and maps provide base map information from which to construct the model meshes. These data include a complete set of georeferenced, photographs for coastal Louisiana downloaded from Google Earth (Shape2Earth Ver1.0.0.1), georeferenced USGS quadrangle maps, and NOAA navigation charts. Additional information obtained includes shoreline files and GIS basemaps. Details for each are provided below:

DOTD Aerial Photography

Source:	Google Earth
Software:	Shape2Earth Ver1.0.0.1
Georeferenced:	Yes
Hor. Coords:	Geographic
Resolution	Varies
Date of Aerials:	Varies
Aerial Coverage:	Coast of Louisiana

Figure A. 1 displays the coverage of the obtained aerials.

Figure A. 1
Aerial photographs

NOAA Online Navigation Charts

Source: Chart Navigator (NOAA)

Web Address:
http://www.nauticalcharts.noaa.gov/mcd/catalogs/viewer.php?cat=Gulf&side=Chart

Figure A. 2 presents an example of the NOAA navigation charts employed in this study.

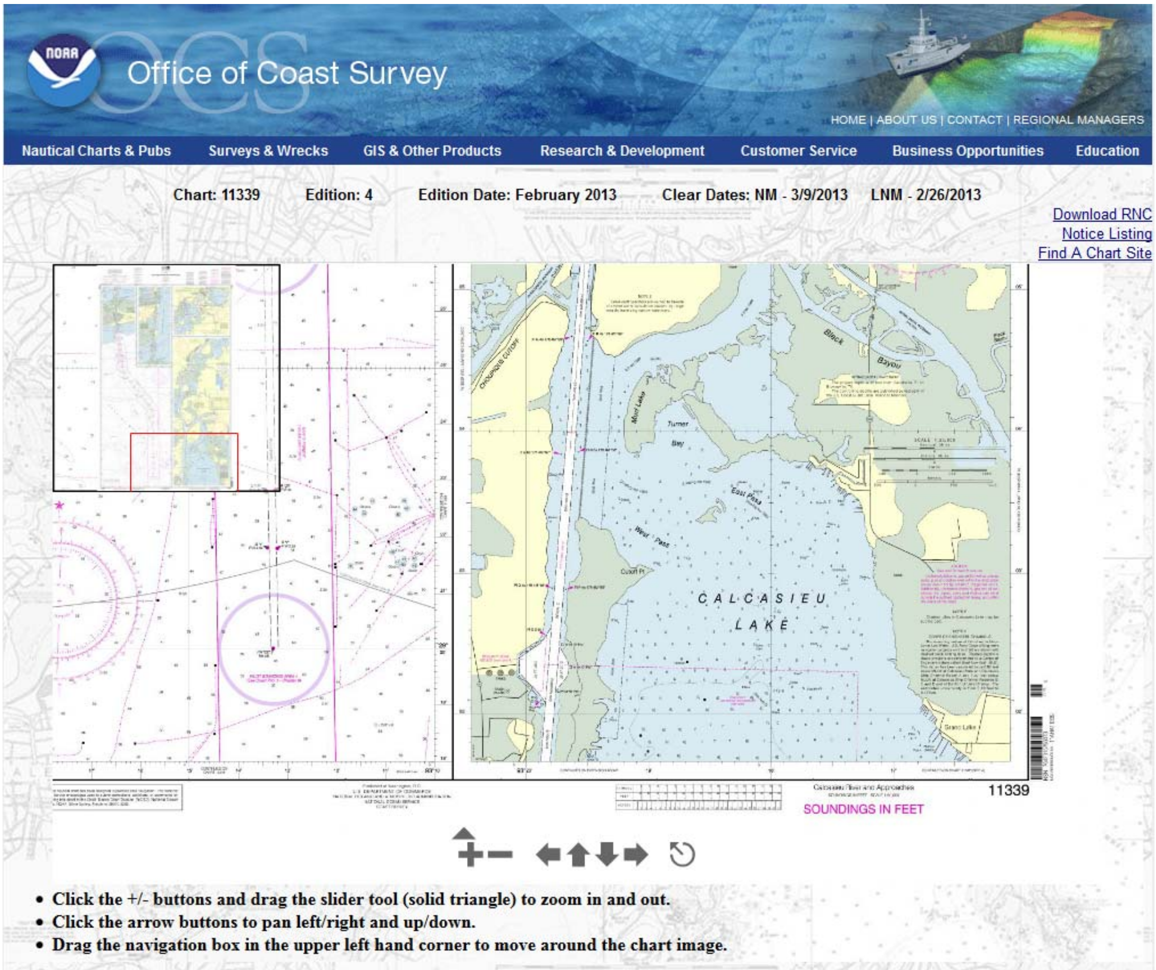


Figure A. 2
NOAA nautical chart viewer chart 11339 Calcasieu River and approaches

Global Self-consistent, Hierarchical, High-resolution Shoreline Shapefile

Agency: National Geographic Data Center (NGDC)
Horizontal Datum: World Geographic (Latitude-Longitude)
Vertical Datum: NA
Extents: Global

Survey Description: GSHHS - A Global Self-consistent, Hierarchical, High-resolution Shoreline Database. GSHHS is a high-resolution shoreline data set amalgamated from two databases in the public domain. The data have undergone extensive processing and are free of internal inconsistencies such as erratic points and crossing segments. The shorelines are constructed entirely from hierarchically arranged closed polygons. Shapefile created by David Divins (David.Divins@noaa.gov) at NGDC from GSHHS. Figure A. 3 and Figure A. 4 present this shoreline coverage.

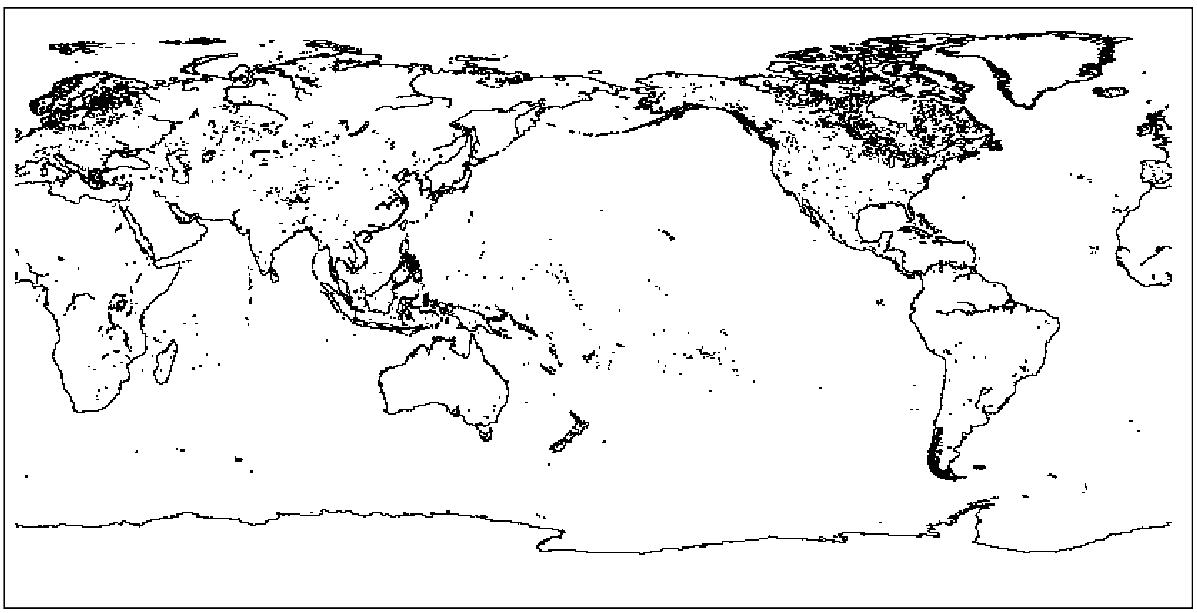


Figure A. 3
GSHHS shapefile complete coverage

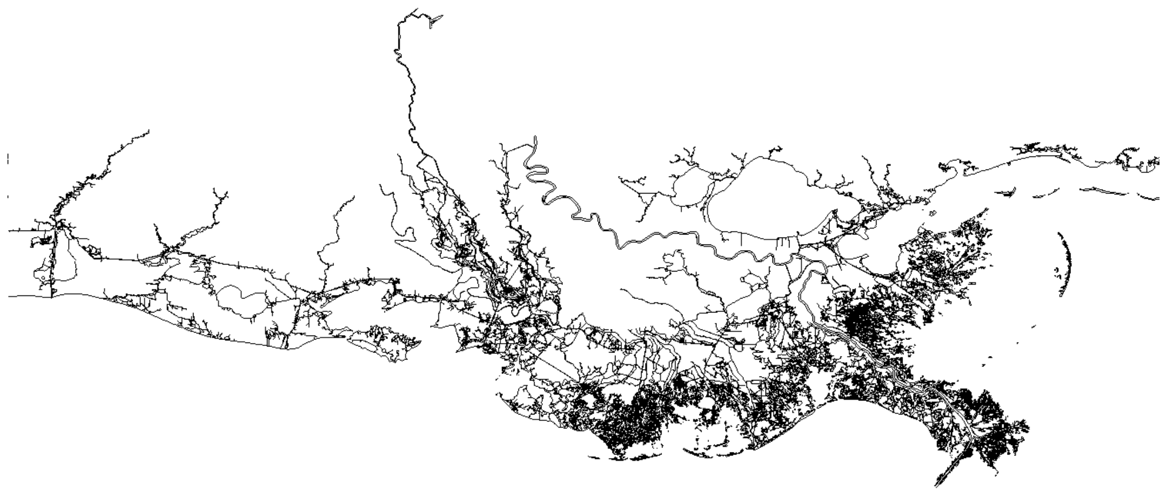


Figure A. 4
GSHHS shapefile Louisiana coastal coverage

Bathymetry and Topography

The bathymetric and topographic surveys of the study area provide data to populate the meshes for the numerical wave and storm surge models. As such, the coverage of the data should include not only the Louisiana, but also the northwest Atlantic Ocean as well as the Gulf of Mexico. Several sources of bathymetric and topographic data from numerous on-line sources were located.

The data for constructing the models came primarily from two sources: the ETOPO2 (5) and the Coastal Relief datasets maintained by the NGDC. These are described below.

Agency:	National Geographic Data Center (NGDC)	
Horizontal Datum:	World Geographic (Latitude-Longitude)	
Vertical Datum:	Mean Sea Level (meters)	
Survey Extents:	Latitude:	5° North to 46° North
	Longitude:	100° West to 60° West

Survey Description: ETOPO5 was generated from a digital database of land and sea-floor elevations on a 5-minute latitude/longitude grid. The resolution of the gridded data varies from true 5-minute for the ocean floors, the USA., Europe, Japan, and Australia to 1 degree in data-deficient parts of Asia, South America, northern Canada, and Africa. Data sources are as follows: Ocean Areas: US Naval Oceanographic Office; USA, W. Europe, Japan/Korea: US Defense Mapping Agency; Australia: Bureau of Mineral Resources, Australia; New Zealand: Department of Industrial and Scientific Research, New Zealand; balance of world land masses: US Navy Fleet Numerical Oceanographic Center. Various data bases were originally assembled in 1988 into the worldwide 5-minute grid by Margo Edwards, then at Washington University, St. Louis, MO. The ETOPO5 data may be credited in publications by reference to “Data Announcement 88-MGG-02, Digital relief of the Surface of the Earth. NOAA, National Geophysical Data Center, Boulder, Colorado, 1988.” The version of the data making up ETOPO5 is from May 1988, with the exception of a small area in Canada (120-130 W, 65-70 N), which was regridded in 1990. Figure A. 5 presents the ETOPO5 data for the North Atlantic Ocean.

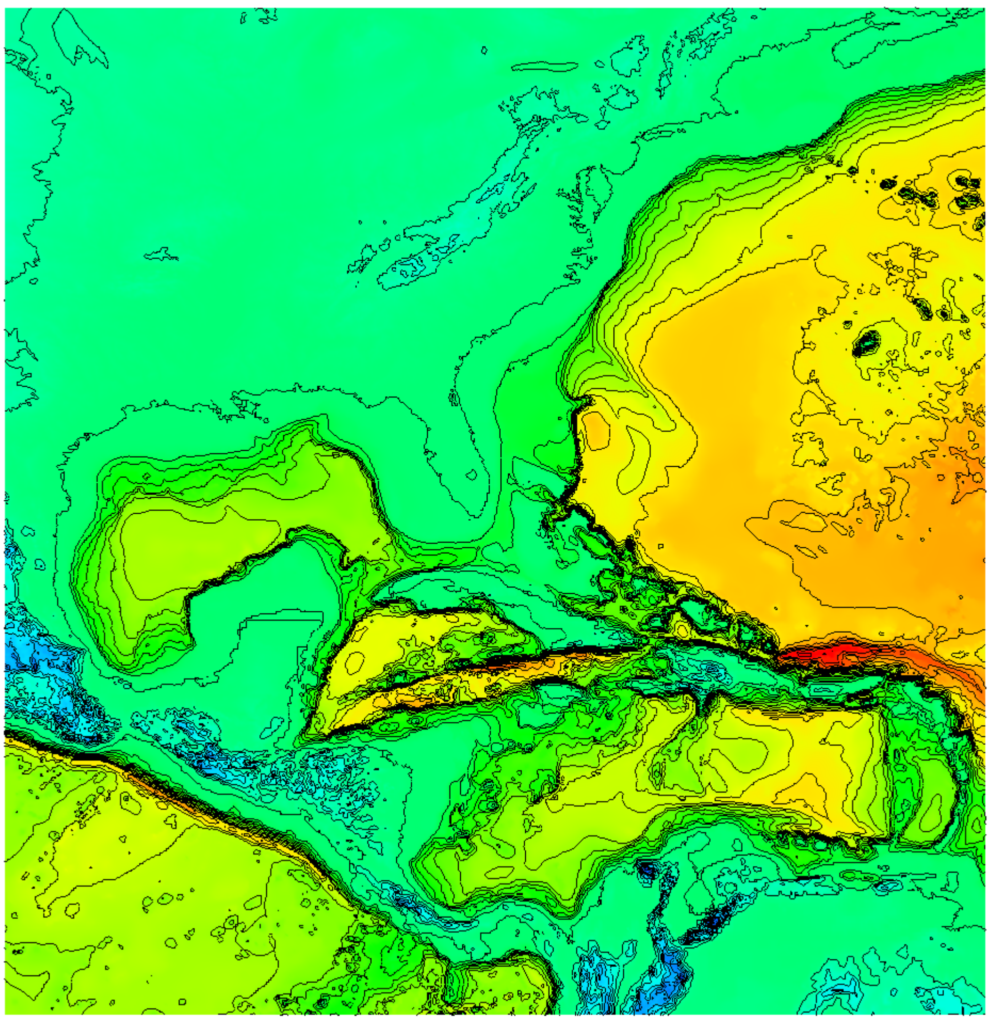


Figure A. 5
ETOPO5 survey data

ETOPO2 Survey Data

Agency:	National Geographic Data Center (NGDC)
Horizontal Datum:	World Geographic (Latitude-Longitude)
Vertical Datum:	Mean Sea Level (meters)
Survey Extents:	Latitude: 5° North to 46° North
	Longitude: 100° West to 60° West

Survey Description: World survey data spaced at 2-ft. increments. The seafloor data between latitudes 64° North and 72° South are from the work of Smith and Sandwell (1997). These data were derived from satellite altimetry observations combined with carefully, quality-assured shipboard echo-sounding measurements, by Dr. Walter H.F. Smith, of the NOAA Laboratory for Satellite Altimetry and Dr. David T. Sandwell, of the Institute of Geophysics and Planetary Physics at the University of California, San Diego. Seafloor data southward of 72° South are from the US Naval Oceanographic Office's (NAVOCEANO) Digital Bathymetric Data Base Variable Resolution (DBDBV), version 4.1, gridded at 5 minute spacing; some data in this region are from the older DBDB5 (these data were also used in ETOPO5). Seafloor data northward from 64° North are from the new International Bathymetric Chart of the Arctic Ocean (IBCAO) Version 1. Land topography is from the GLOBE Project, an internationally designed, developed, and independently peer-reviewed global digital elevation model (DEM), at a latitude-longitude grid spacing of 30 arc-seconds (30"). The GLOBE Task Team was established by the Committee on Earth Observation Satellites (CEOS). It is part of Focus I of the International Geosphere-Biosphere Programme - Data and Information System. The ETOPO2 data may be credited in publications by reference to "U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Geophysical Data Center, 2001. 2-minute Gridded Global Relief Data (ETOPO2) http://www.ngdc.noaa.gov/mgg/fliers/01mgg04.html." Figure A. 6 presents the ETOPO2 dataset for the North Atlantic Ocean.

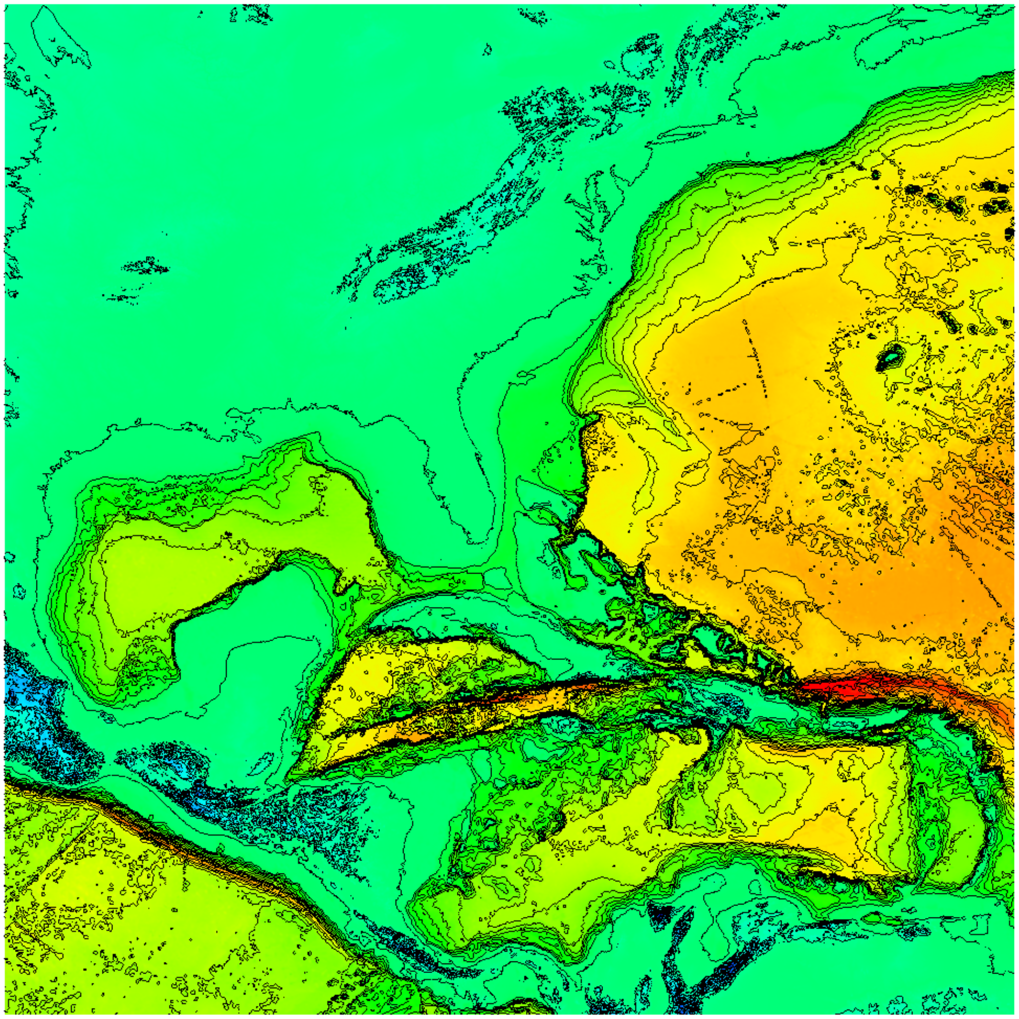
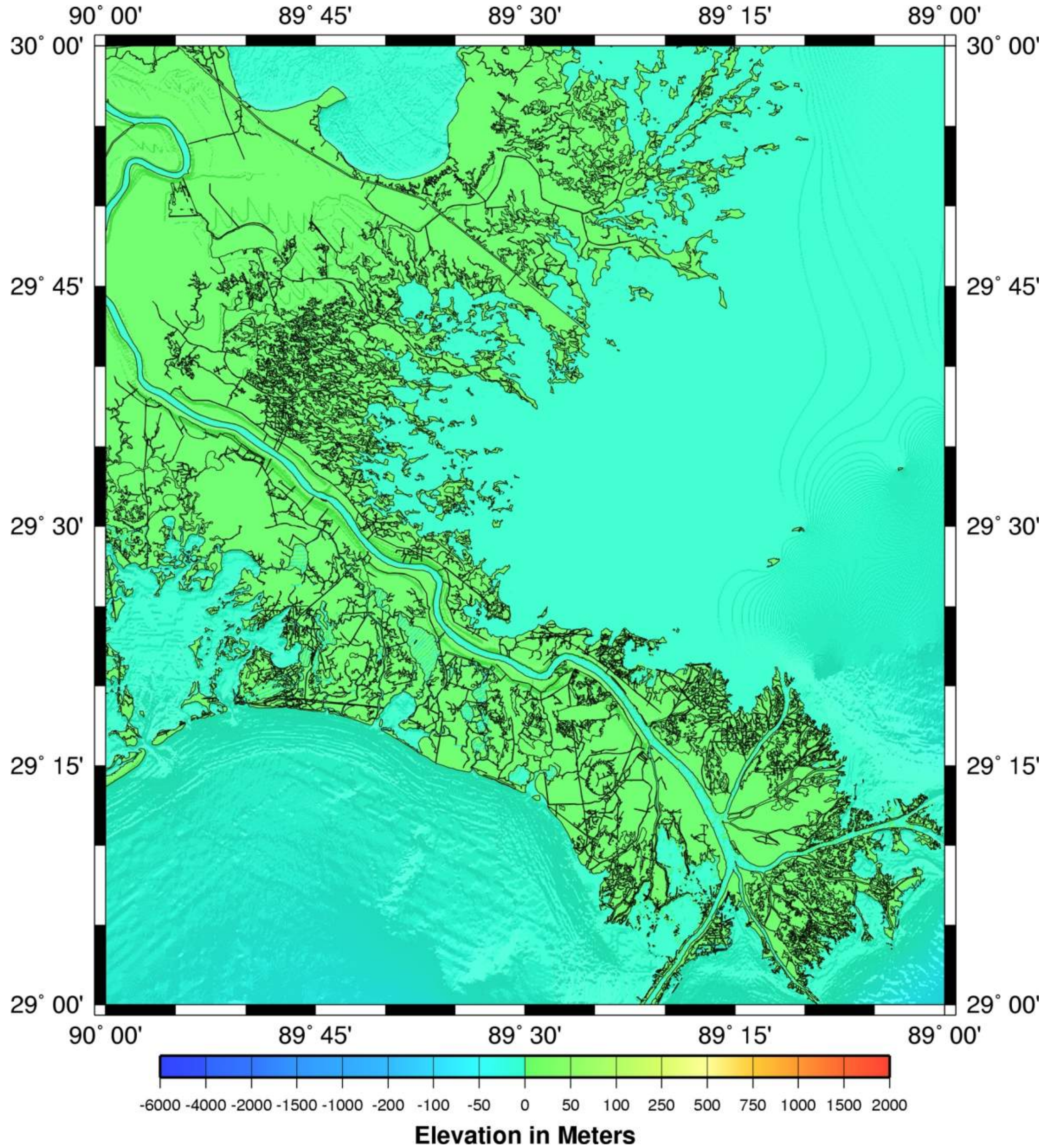


Figure A. 6
ETOPO2 survey data

Coastal Relief Survey Data

Agency:	National Geographic Data Center (NGDC)	
Horizontal Datum:	World Geographic (Latitude-Longitude)	
Vertical Datum:	Mean Sea Level (meters)	
Survey Extents:	Latitude:	33° North to 37° North
	Longitude:	79° West to 75° West

Survey Description: U.S. Coastal Margin data spaced on a 3-arc second grid. Land elevations within the gridded dataset come from the United States Geological Survey/ National Image Mapping Agency (USGS/NIMA) 1:250,000 or 1° DEMs of the states. Soundings for each volume of the Coastal Relief model series are compiled from hydrographic surveys conducted by the National Ocean Service (NOS) and from various academic institutions. The surveys were carried out using a variety of sounding methods including SeaBeam 16-beam, 12-kHz swath mapping system (19,685- >9842 ft.) operating water depths, General Instruments 17-beam, 36-kHz Hydrochart II swath mapping system (16.4 -492.1ft operating water depths), single-beam echosounder (e.g., 3.5 kHz narrow 2° beam), and lead-line sounding method. These latter surveys date as far back as the late 1800's. The vertical accuracy of the soundings is 0.98 ft. in 0 to 65.6 ft. of water, 3.28 ft. in 65.6 - 328 ft. of water, and 1 percent of the water depth in 328 m of water. The horizontal accuracy of the soundings is within a radius of 0.06 inches of the sounding location at the scale at which the soundings are recorded. NOS surveys are plotted at map scales that range from 1/10,000 for harbors and channels to 1/50,000 for open ocean surveys, with 1/20,000 being the most commonly used scale. The horizontal accuracy of the soundings is generally 98.4 ft., but it can vary from as fine as 49.2 ft. in ports and estuaries to as coarse as 246 ft. in the offshore areas.



(1 meter = 3.28 ft.)

Figure A. 7
Example coastal relief survey data Louisiana

APPENDIX B: MODEL DESCRIPTIONS

Introduction

As noted earlier in the report, this study employed the latest hindcast technology, which uses the tightly coupled ADCIRC+SWAN model and hindcasted tropical storm and hurricane wind and pressure fields provided by Oceanweather, Inc. This appendix provides a more detailed description of ADCIRC and SWAN.

ADCIRC

The program ADCIRC (ADvanced CIRCulation Model for Coastal Ocean Hydrodynamics) simulated both the tidal circulation and the hurricane storm surges in the project area. ADCIRC is a numerical model developed specifically for generating long duration hydrodynamic circulation along shelves, coasts, and within estuaries. The intent of the model is to produce numerical simulations for very large computational domains in a unified and systematic manner. The collaboration of many researchers have led to the development of the ADCIRC model including investigators at the University of Notre Dame (J.J. Westerink), the University of North Carolina at Chapel Hill (R.A. Luettich), the University of Texas at Austin (M.F. Wheeler and C. Dawson), the University of Oklahoma (R. Kolar), the State of Texas (Jurji), and the Waterways Experiment Station (N. Scheffner) (Luettich and Westerink, 2000).

Both the U.S. Army and Navy have applied ADCIRC extensively for a wide range of tidal and hurricane storm surge predictions in regions including the western North Atlantic, Gulf of Mexico and Caribbean Sea, the Eastern Pacific Ocean, the North Sea, the Mediterranean Sea, the Persian Gulf, and the South China Sea. ADCIRC employs computational models of flow and transport in continental margin waters to predict free surface elevation and currents for a wide range of applications including evaluating coastal inundation, defining navigable depths and currents in near shore regions, to assessing pollutant and/or sediment movement on the continental shelf. An extensive list of publications describing the development and application of ADCIRC are available through the ADCIRC web site (http://adcirc.org/Related_publications.html).

ADCIRC is a robust computer program for solving the equations of motion for a moving fluid on a rotating earth. The equation formulation includes applying the traditional hydrostatic pressure and Boussinesq approximations and discretizing the equations in space via the finite element (FE) method and in time via the finite difference (FD) method. The ADCIRC program includes both a two-dimensional depth integrated (2DDI) mode and a three-dimensional (3D) mode. For both, the model solves for elevation via the depth-integrated continuity equation in Generalized Wave-Continuity Equation (GWCE) form. The model solves for velocity via either the 2DDI or 3D momentum equations. These equations retain all the nonlinear terms. ADCIRC includes solution capabilities in either a Cartesian or a spherical coordinate system.

ADCIRC solves the GWCE via either a consistent or a lumped mass matrix and an implicit or explicit time stepping scheme. If a lumped, fully explicit formulation is specified, no matrix solver is necessary. In all other cases, the GWCE is solved using the Jacobi preconditioned iterative solver from the ITPACKV 2D package. The 2DDI momentum equations are lumped and therefore required no matrix solver.

Possible boundary conditions for the model include specified elevation (harmonic tidal constituents or time series), specified boundary normal flow (harmonic tidal constituents or time series), zero boundary normal flow, slip or no slip conditions for velocity, external barrier overflow out of the domain, internal barrier overflow between sections of the domain; surface stress (wind and/or wave radiation stress), atmospheric pressure, or outward radiation of waves (Sommerfield condition). ADCIRC can be forced with: elevation boundary conditions, normal flow boundary conditions, surface stress (wind) boundary conditions, tidal potential,- or an earth load/self-attraction tide.

For this application, the inputs to the ADCIRC model include a bathymetric/topographic unstructured mesh, hindcasted wind and pressure fields, tidal potentials, and wave radiation stresses from SWAN.

SWAN

The program SWAN (Simulating WAves Nearshore) was used to simulate wave heights and periods. SWAN, developed at the Delft University of Technology in the Netherlands, is a one- and two-dimensional numerical model for estimating wave parameters in coastal areas, lakes and estuaries from given wind, bathymetric, and current conditions. The model is based on the wave action balance equation with sources and sinks (Holthuijsen et al., 2003). The wave propagation processes represented in SWAN include propagation through geographic space, refraction due to spatial variations in bottom and current, shoaling due to spatial variations in bottom and current, blocking and reflections by opposing currents, and transmission through, blockage by or reflection from obstacles. Wave generation and dissipation processes represented in SWAN include generation by wind, dissipation by white-capping, dissipation by depth-induced wave breaking, dissipation by bottom friction, and wave-wave interactions (quadruplets and triads). The model contains both stationary and non-stationary operational modes formulated for Cartesian, curvilinear, or spherical coordinate systems.

The inputs to the SWAN model include a bathymetric/topographic unstructured mesh, hindcasted wind field, water surface elevation, and currents from ADCIRC.

APPENDIX C: MODEL CALIBRATION DETAILS

Introduction

Model calibration involves an iterative process of adjusting model parameters until the model results at set locations match measured data at those locations. Once calibrated, the model is verified by comparing model results to measured data for additional events to ensure they meet established criteria. Three types of measured data were collected for the calibration: water surface elevations (WSE), high water marks, and wave heights. The following paragraphs describe the data type, limitations of the data, and the spatial coverage.

Figure C. 1, Figure C. 2, and Figure C. 3 present the location of the tide and wave gage stations. National Oceanic and Atmospheric Administration (NOAA), U. S. Geological Survey (USGS), and the U.S. Corps of Engineers (USACE) all provided data for the calibration/verification. As the figures illustrate, the gages are distributed along the coast throughout the state

For the NOAA tide gages, two sets of data are provided: measured and predicted time series of water surface elevation. The measured data is the actual water surface elevation fluctuations at the gage location and includes effects of meteorological events. Conversely, the predicted data is created from tidal constituents and is based only on astronomical influences.

Figure C. 4 presents an example of the NOAA gage data during the passing of Hurricane Katrina. In the figure, the blue line presents the tide predicted by NOAA and the red line presents the measured water surface elevation. As the figure illustrates, the predicted and observed water surface elevations do not always agree. The differences between the two results from storm surge, wave setup, and local wind setup/set down, which are not included in NOAA's predictions. Some of the gages were either not online or failed for some events and are designated with an NA (Not Available) in the summary tables.

The USGS gages were part of an experimental monitoring network deployed as Hurricane Rita approached the Louisiana coast. Two types of sensors were deployed at 33 sites in southwestern Louisiana 23, of which produced worthwhile measurements. The gages recorded time histories of temperature and pressure (water and some with barometric) during the passing of Hurricane Rita. Sensors without barometric pressure capabilities were adjusted using the closest sensor with barometric pressure capabilities. Accuracy varied from 0.1 ft. to 0.03 ft. for the two types of sensors employed. Results from seven of the gages were compared to nearby high water marks. With the exception of two sensors, recorded maxima measured within a foot of the high water marks. Those two sensors were not included in the calibration/verification. Additionally, many of the gages were deployed in upland areas, such that the peak surge only reached the gage for a short period. Gages with short records were also not included in the calibration/verification. That said, the results from those gages did provide a check for the high water mark data. Of the 23, eight were in close enough proximity to tidal waterways affected by storm surge to provide a sufficient data set for calibration/verification purposes.

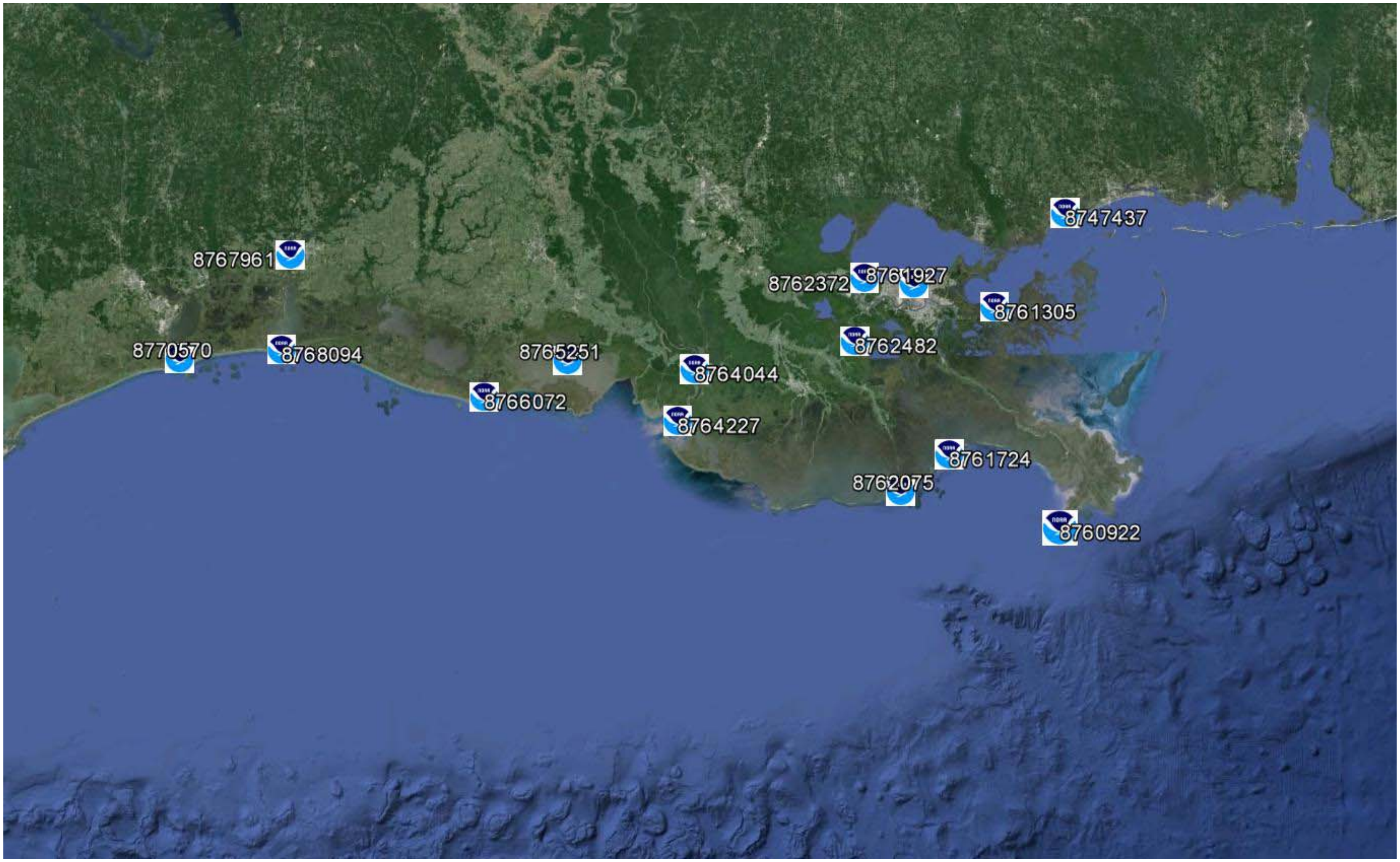


Figure C. 1
Location of NOAA tide stations for surge calibration

Figure C. 2
Location of USGS gage stations for surge calibration

Figure C. 3
Location of NOAA and USACE wave gage stations

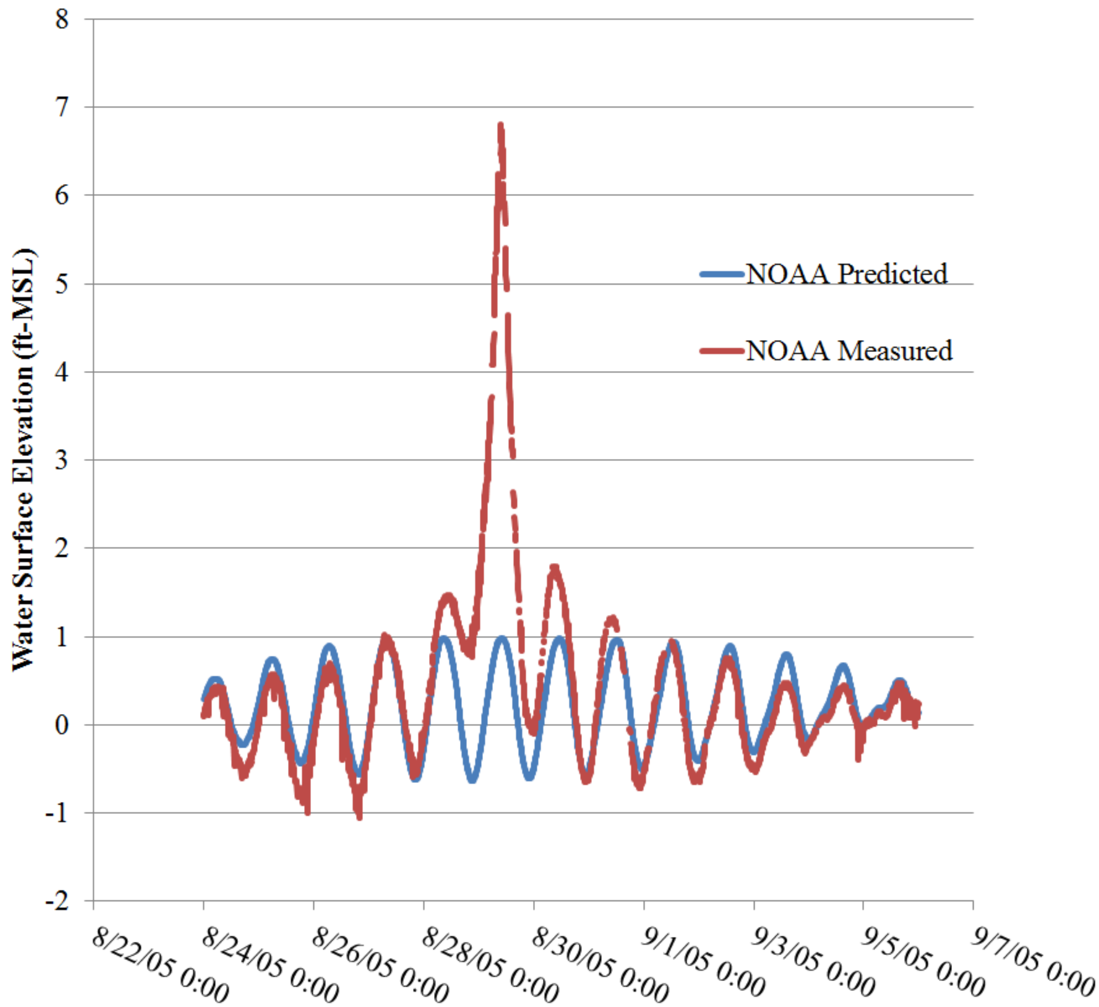


Figure C. 4
NOAA gage 8670922 historical water surface data recorded during Hurricane Katrina

Hurricane high water marks represent the elevations of debris lines left by the hurricane storm surge. Debris lines found inside buildings or protected areas generally represent the peak still water elevation at that location during the storm. Debris lines found in open areas are deposited by either the peak still water, waves riding on the still water, or wave run-up. Figure C. 5, and Figure C. 6 present the location of the hurricane high water marks for Hurricanes Katrina and Rita collected by FEMA (FEMA 2006 and FEMA 2006). Figure C. 5 presents the hurricane high water marks found in protected areas and generally represent the peak still water elevations. Figure C. 6 presents the hurricane high water marks found in open areas and may represent the elevation of the peak still water, the elevation of waves riding on the still water, or the peak elevation of the wave run-up. Since the source of high water marks produced in open areas is uncertain, the calibration focused on the still water high water mark data presented in Figure C. 5. Figure C. 7 presents a comparison between the still water high water marks and NOAA water surface elevations in Lake Pontchartrain during Hurricane Katrina. In the figure, there are eight high water mark elevations ranging from +3.9 ft-NAVD to +11.8 ft-NAVD and a time series plot of water surface elevation from NOAA gage 8762372 that peaks at +5.5 ft-MSL (+6.8 ft-NAVD). As this figure demonstrates, several high water mark elevations are much greater and likely include a wave component. As such, those values are not included in the model comparisons. This quality control method was applied to other areas to eliminate high water mark elevations that include a wave component. As Figure C. 5 illustrates, the spatial coverage provides calibration points throughout the state.

Calibration of the SWAN model focused on the four National Data Buoy Center (NDBC) wave stations, the locations of which are shown in Figure C. 8. NDBC wave stations provide time series of measured significant wave heights. Significant wave height is the average height of the one-third highest waves in a 20-minute wave record.

The following method quantifies the difference between model and measured values. The first equation provides an estimate of the mean error, E, the average of the deviation of the calculated from the measured values:

$$E = \frac{\sum_{i=1}^{N} (\chi_c - \chi_m)_i}{N} \qquad \text{(C-1)}$$

where χ_c is the calculated value, χ_m is the measured value, and N is the total number of data points. A positive mean error indicates that the model overestimates the value, while a negative mean error indicates the model underestimates the measured value.

The root-mean square error, E_{rms}, given by the following equation, is a measure of the absolute value of the error. The variables are the same as in the previous equation.

$$E_{rms} = \sqrt{\frac{\sum_{i=1}^{N} (\chi_c - \chi_m)_i^2}{N}} \qquad \text{(C-2)}$$

The final error estimator, E_{pct}, is the percent error. This parameter gives an indication of the degree to which the calculated values misrepresent the measured values. The percent error, in terms of rms error, is defined as:

$$E_{pct} = \frac{E_{rms}}{R} \qquad \text{(C-3)}$$

where R is a representative range of the variable χ. The R-value for the wave and period calculations equals the maximum value measured during the comparison period.

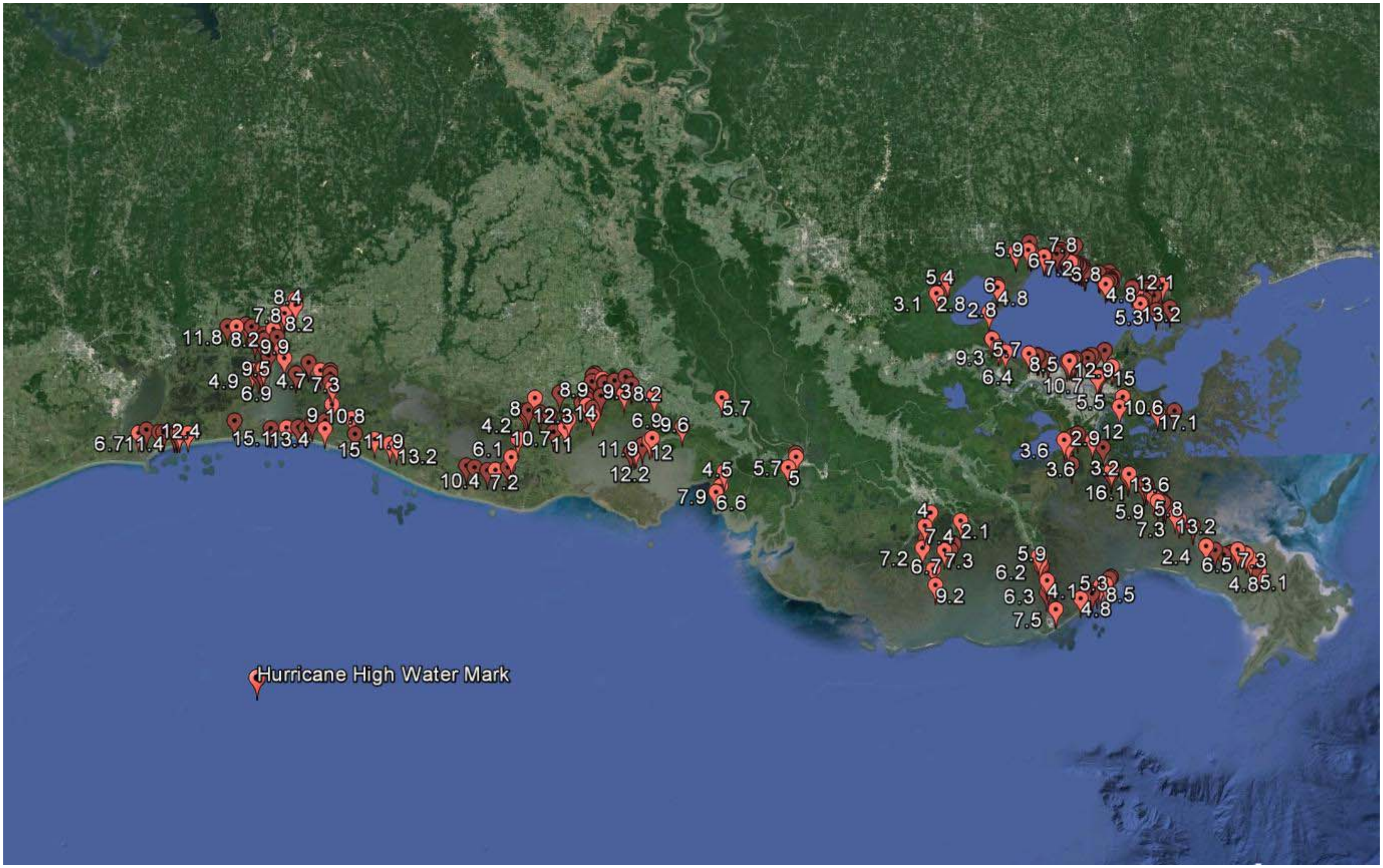


Figure C. 5
Hurricane Katrina and Hurricane Rita coastal hurricane high water marks

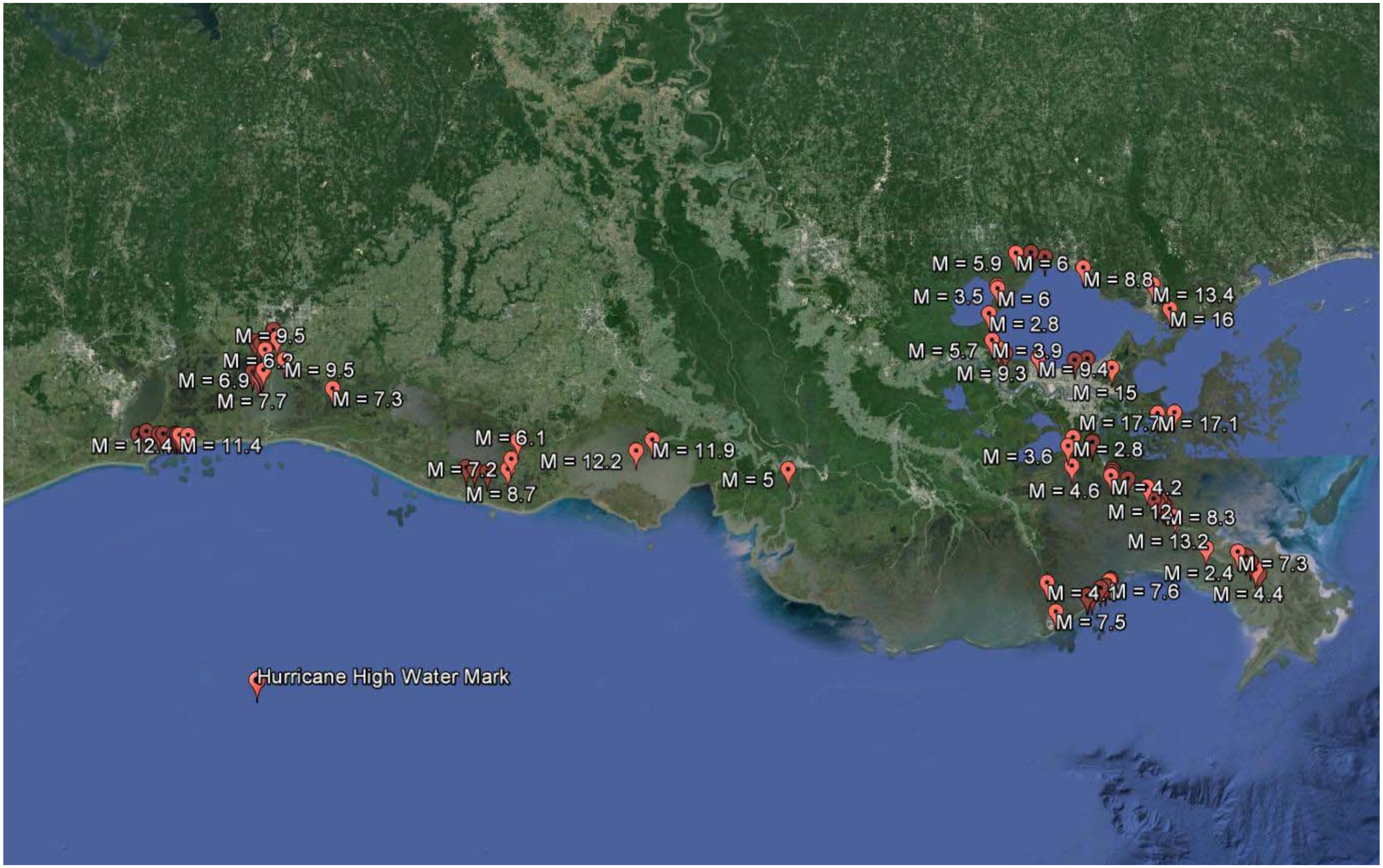


Figure C. 6
Hurricane Rita coastal hurricane high water marks

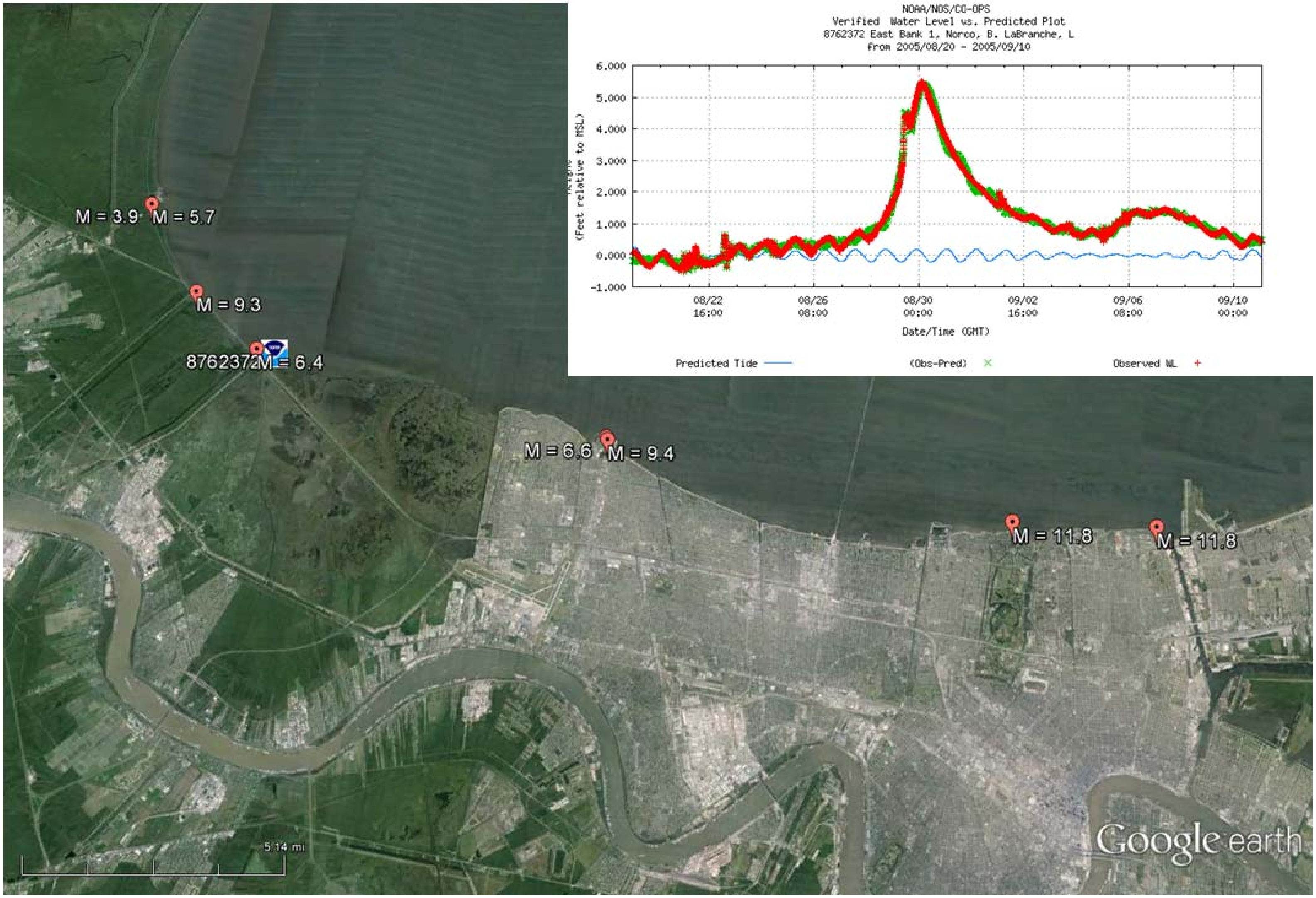


Figure C. 7
Example of hurricane high water marks filtering for Hurricane Katrina

Figure C. 8
NOAA NDBC wave station locations

ADCIRC Model Calibration

The ADCIRC calibration includes the adjustment of model friction and lateral eddy viscosity until modeled water surface elevations match measured values within acceptable limits. FEMA *[C.1]* defines this limit as 10 percent (average percent error) or less for tidal calibrations. For storm surge verifications, FEMA acknowledges the complexity associated with measurements during storms. Based on the complexity, FEMA notes that the acceptable error range exceeds that under normal tidal calibrations. For this study, calibration error ranged from 4 percent to 9 percent and from 6 percent to 40 percent for the verification.

Three events were employed in the calibration/verification of the storm surge/tidal circulation model (ADCIRC). The first event is a month of tides from January 1 to January 30, 2012. The remaining events verify the calibrated model by comparing modeled and measured water surface elevations and modeled and measured high water elevations during Hurricanes Katrina and Rita.

The astronomical tide calibration focuses on the NOAA tide gages distributed evenly along the Louisiana Coast, the locations of which were shown in Figure C. 1. Figure C. 9 presents a comparison of the measured (NOAA) and simulated (ADCIRC) water surface elevations at NOAA Gage 8760922 during the entire length of the tide simulation. In the figure, the green line represents the water surface elevation at the gage location simulated by ADCIRC and the red line represents the measured water surface elevation at the gage. There are many instances where the two lines coincide, indicating good agreement between the modeled and measured data. Conversely, there are instances where the model either over predicts or under predicts the measured data. The instances where the model and measurement differ are primarily due to wind set up and set down. Although the observations from the gage include effects of wind, budget and time-constraints preclude the inclusion of wind in the model for the calibration procedure. That said, NOAA provides the predicted tides, which are derived from a network of tide gages, measuring stations and automated buoys up and down the U.S. coastline. The predicted tides only include the astronomical components. They do not include meteorological effects such as wind, rain, freshwater runoff and other short-term meteorological events. Figure C. 10 presents a comparison of the NOAA predicted (blue line) and measured (red line) water surface elevations along with a short portion (January 7, 2012 to January 14, 2012) of the simulated (green line) water surface elevations. In the figure, the ADCIRC and NOAA predicted agree well while the NOAA measured only agrees for a small portion of time. The disagreement between ADCIRC/NOAA predicted and NOAA measured is due to wind set up beginning on January 10th when wind speeds fluctuated between 20 and 35 knots until January 13th. Figure C. 11 through Figure C. 21 present comparisons between the ADCIRC simulated (green line), NOAA measured (red line), and NOAA predicted (blue line) tides for the month of January 2012. As these figures illustrate, the simulated and predicted lines correspond well throughout the month, while the measured shows the effects of meteorological influences for portions of the month.

Table C. 1 and Table C. 2 present a summary of the statistics from the calibration for the measured and predicted data for each gage. These tables further demonstrate the effect of wind on the comparison between the measured WSE and the predicted WSE. For example, the average error for the comparison between ADCIRC simulated and NOAA predicted at NOAA station 8760922 (4 percent) is significantly less than the difference between ADCIRC predicted and NOAA measured (14 percent). As Table C. 2 illustrates, for astronomical tides the model reproduced the NOAA predicted water surface elevations within FEMA's acceptable error range. This demonstrates the models ability to reproduce water surface elevations during astronomical tides. The meteorological effects (atmospheric pressure and wind speed and direction) are, of course, included in all of the hindcasts.

Figure C. 9
30-day calibration comparison simulated versus measured at NOAA gage 8760922

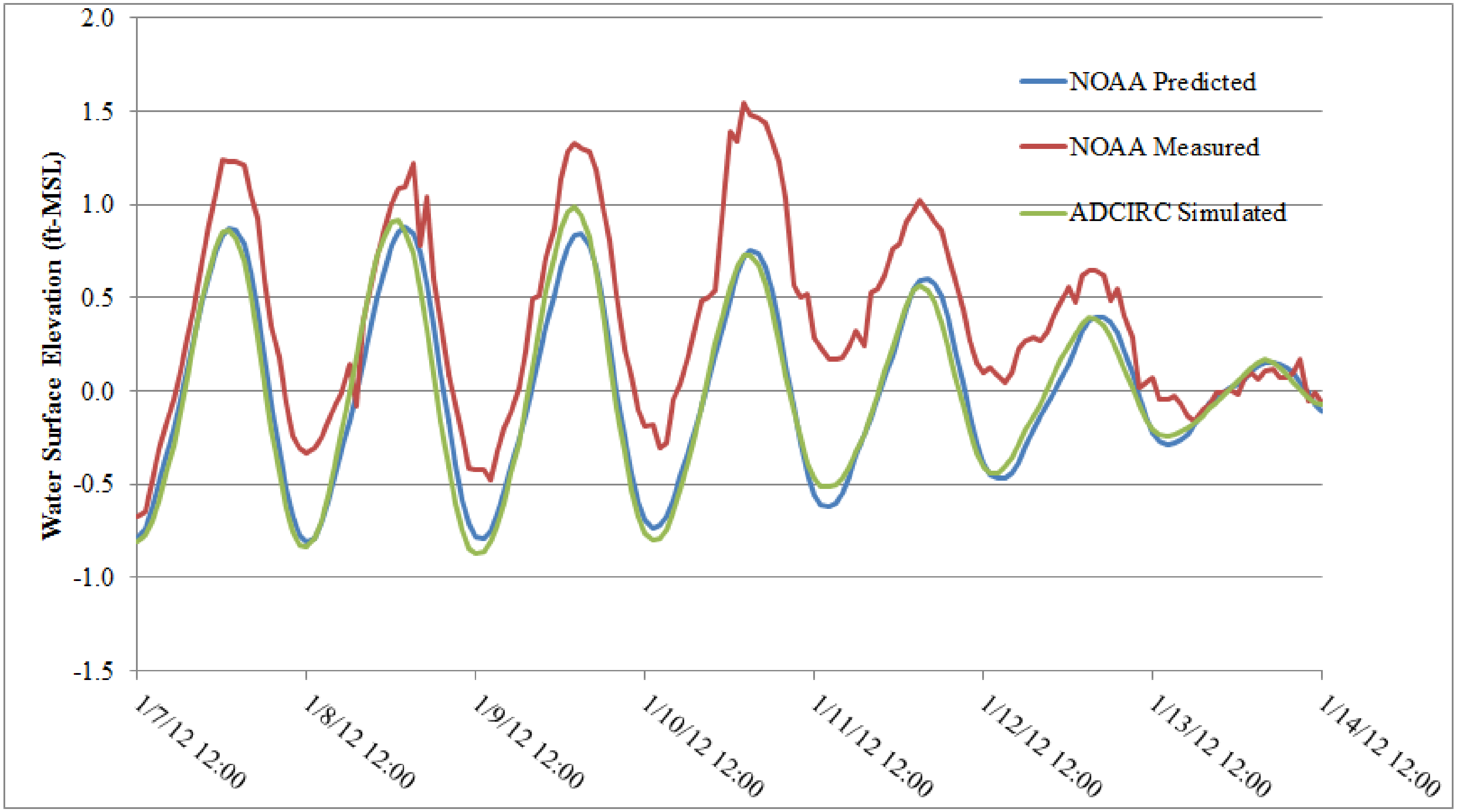
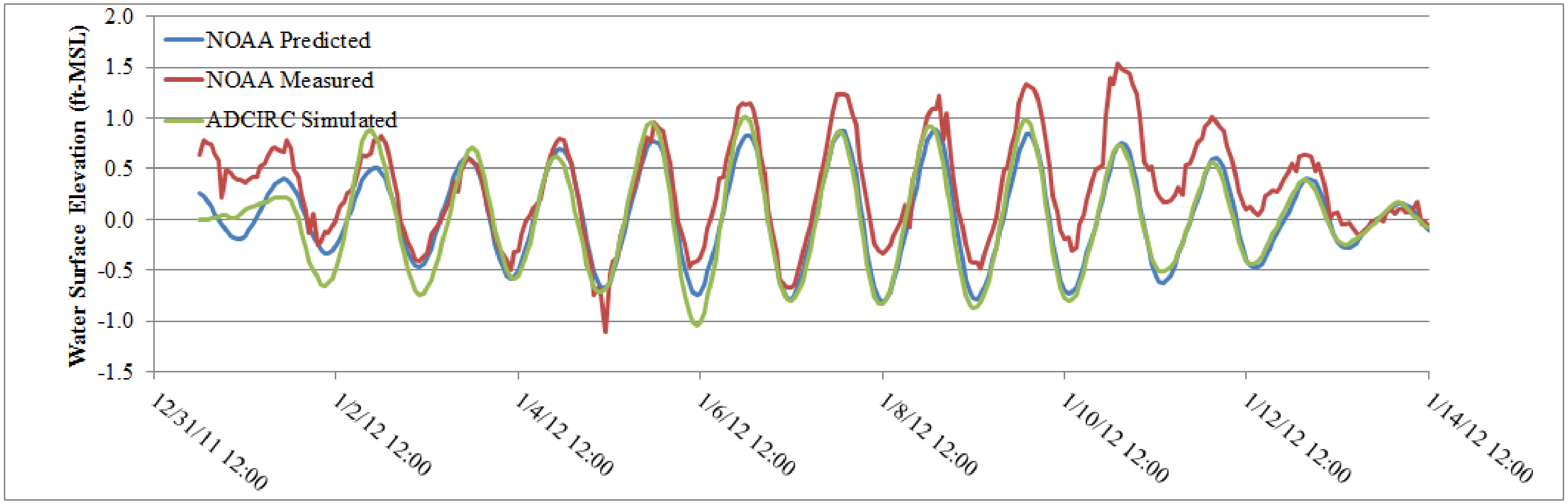


Figure C. 10
ADCIRC, NOAA measured, and NOAA predicted comparisons at NOAA gage 8760922



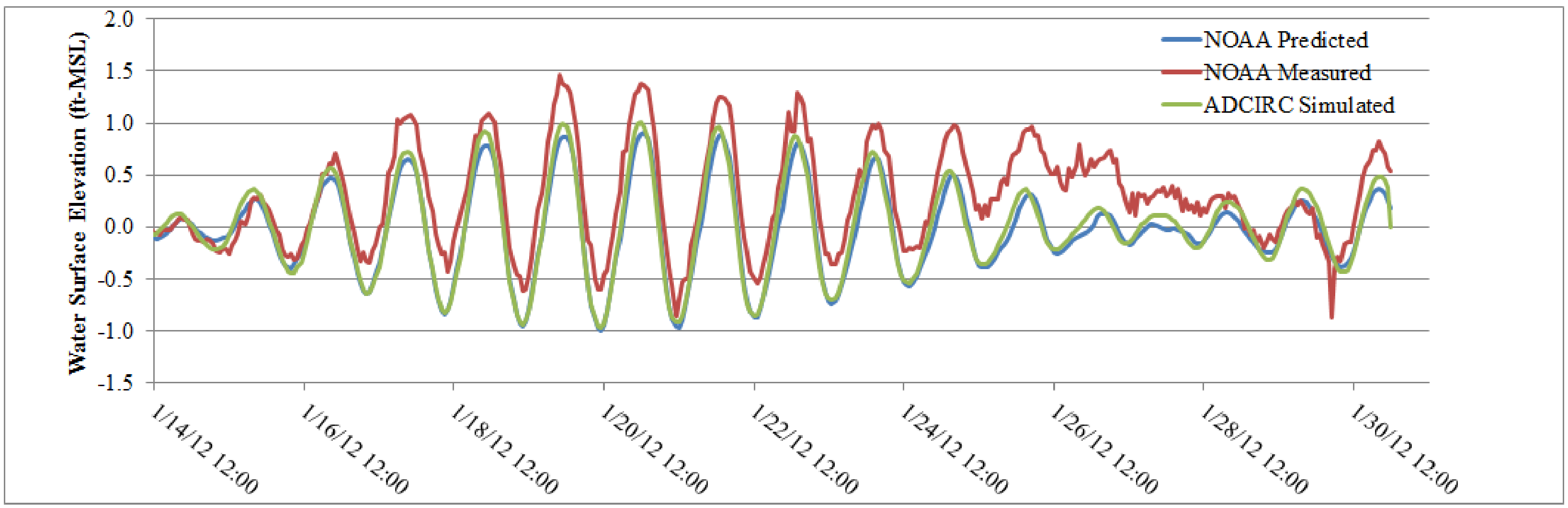


Figure C. 11
30-day calibration comparison modeled versus observed at NOAA gage 8760922

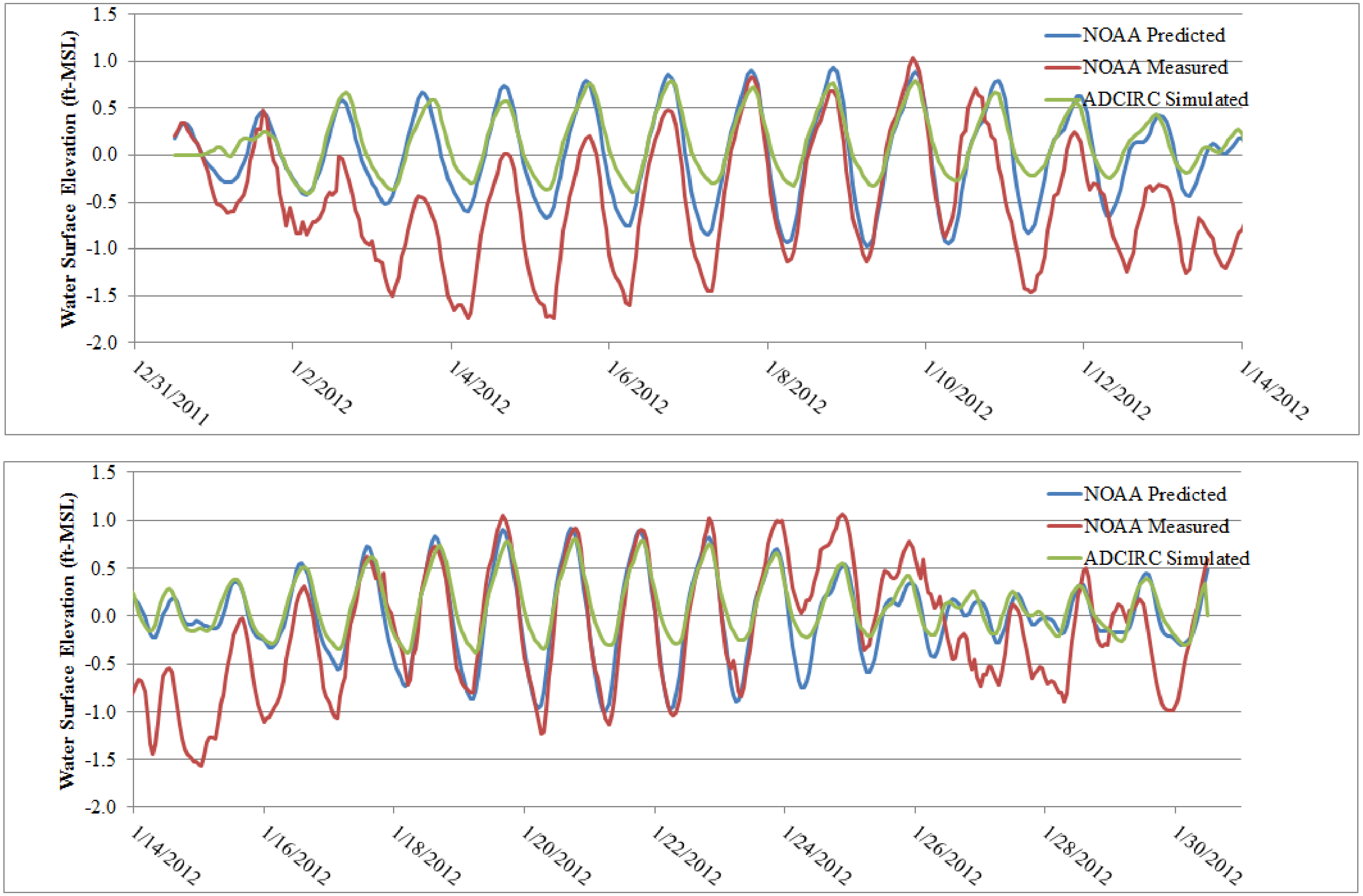


Figure C. 12
30-day calibration comparison modeled versus observed at NOAA gage 8760922

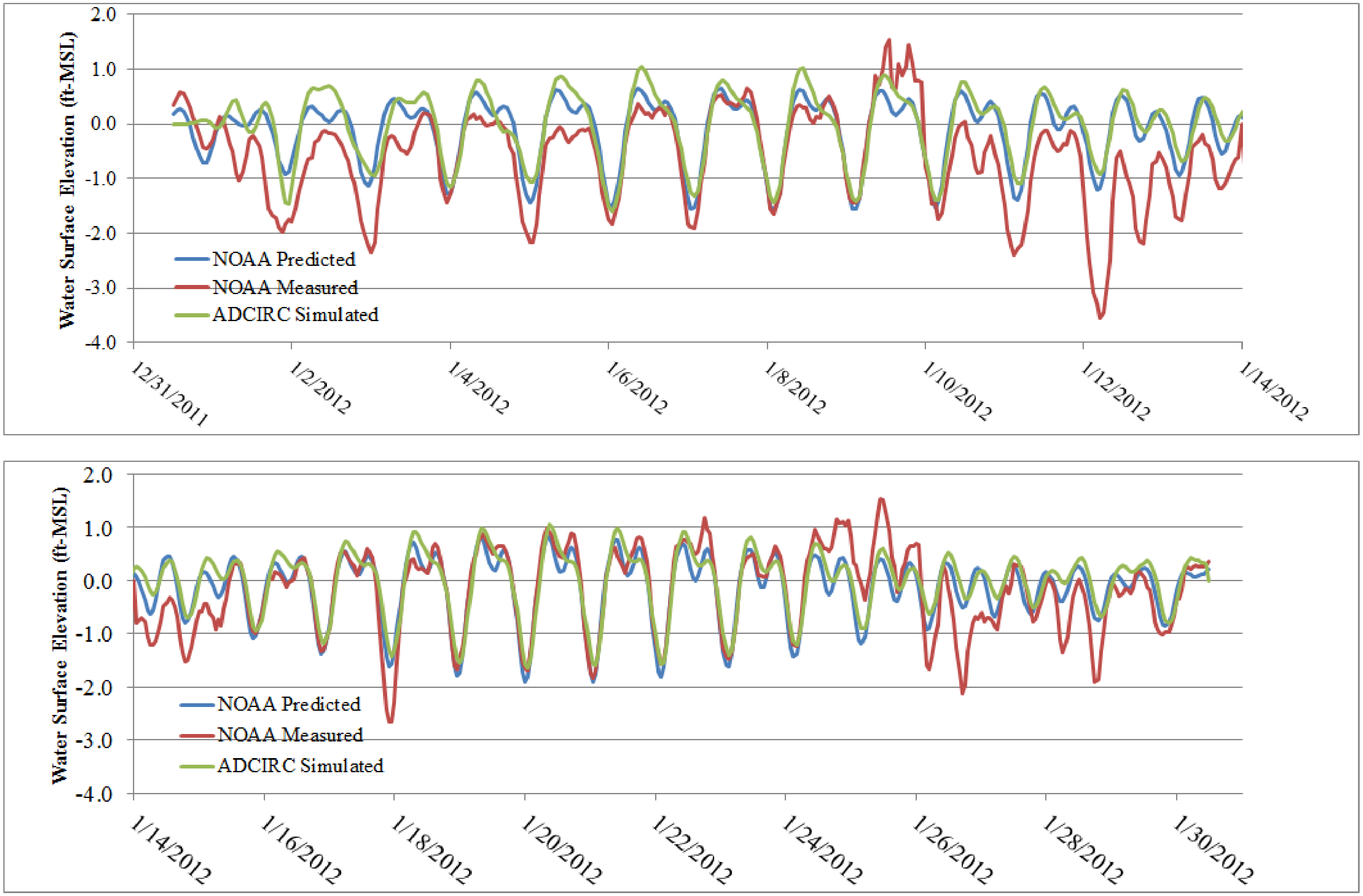


Figure C. 13
30-day calibration comparison modeled versus observed at NOAA gage 8768094

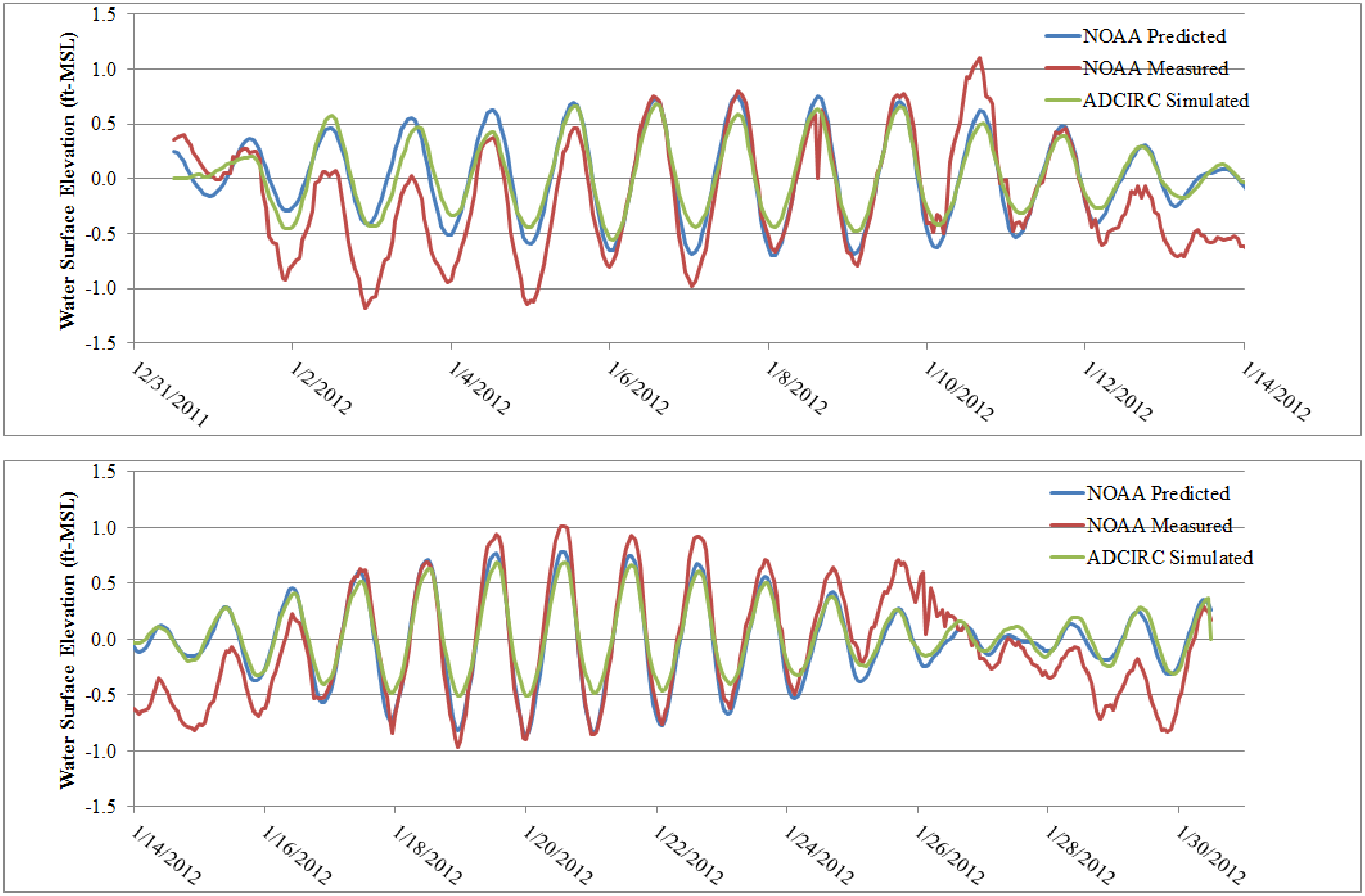


Figure C. 14
30-day calibration comparison modeled versus observed at NOAA gage 8761724

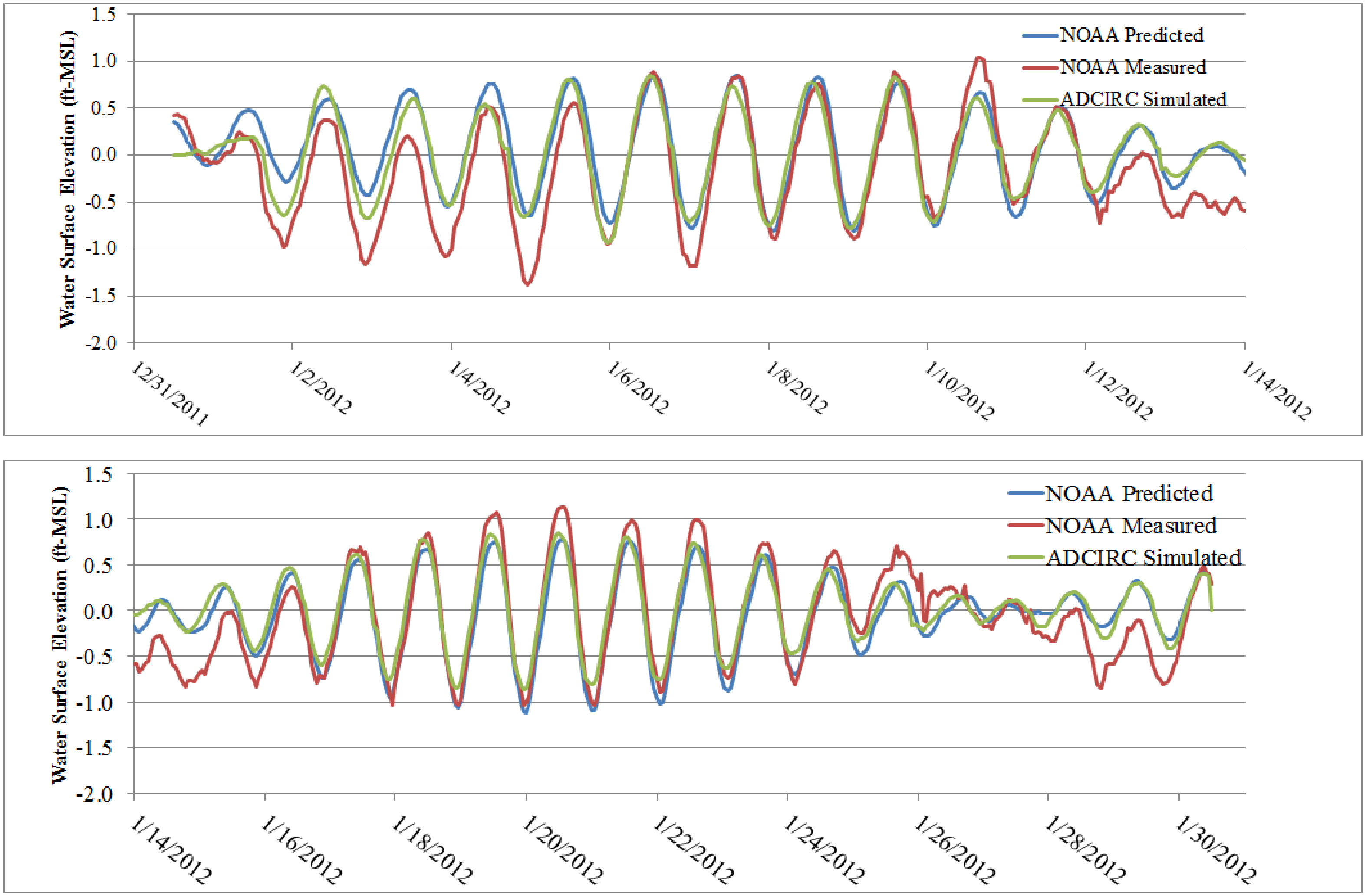


Figure C. 15
30-day calibration comparison modeled versus observed at NOAA gage 8762075

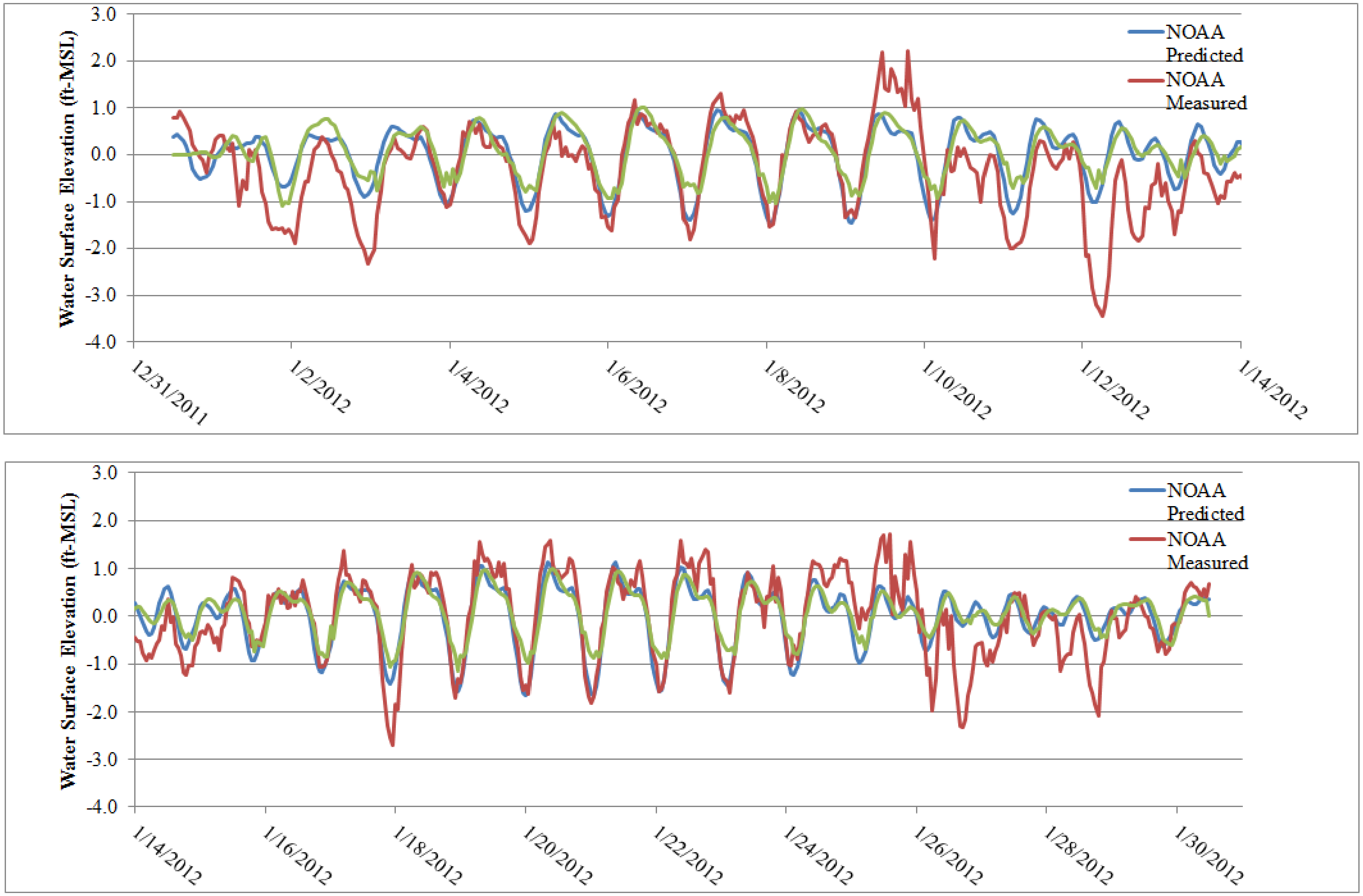


Figure C. 16

30-day calibration comparison modeled versus observed at NOAA gage 8766072

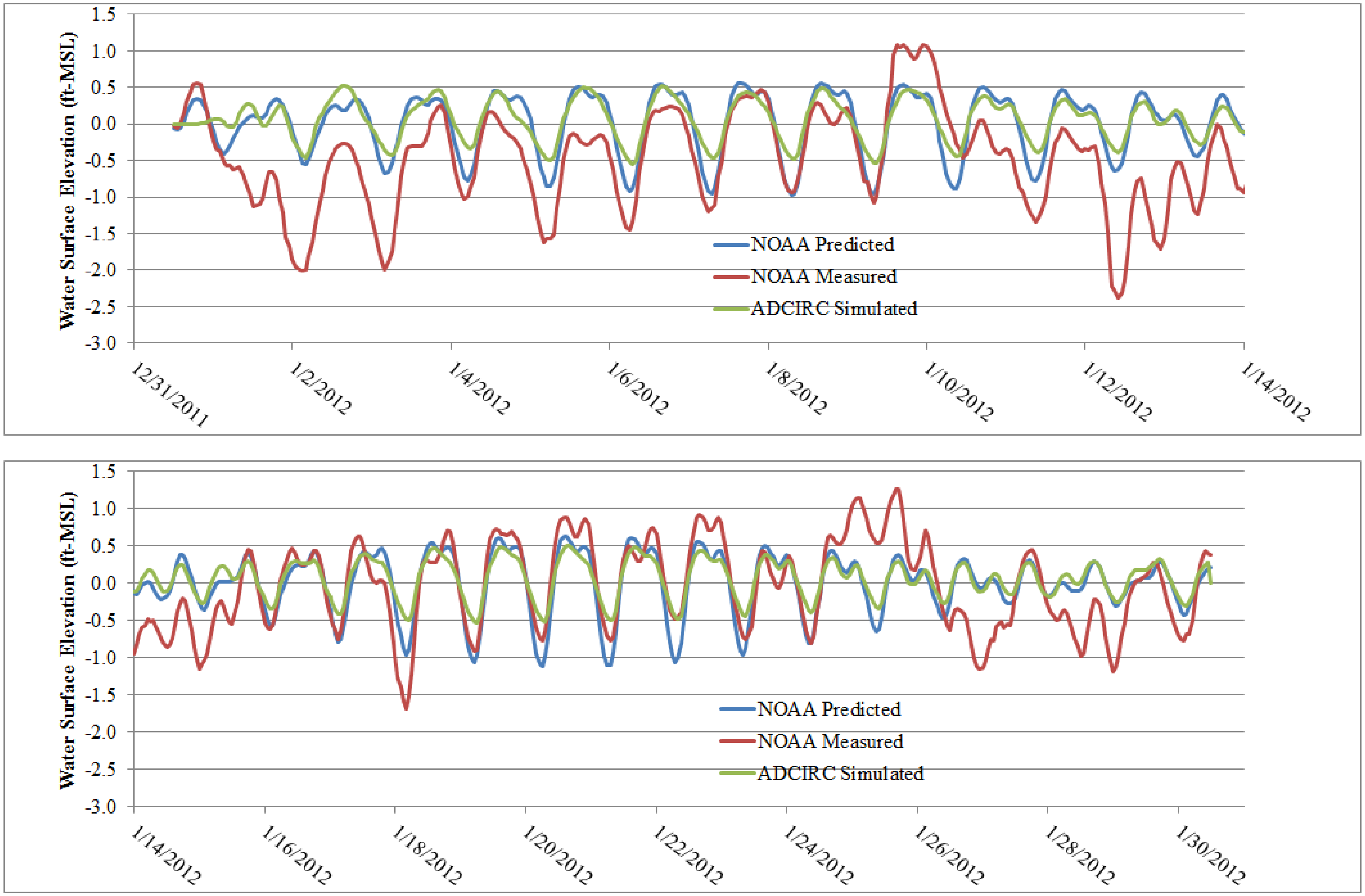


Figure C. 17
30-day calibration comparison modeled versus observed at NOAA gage 8767961

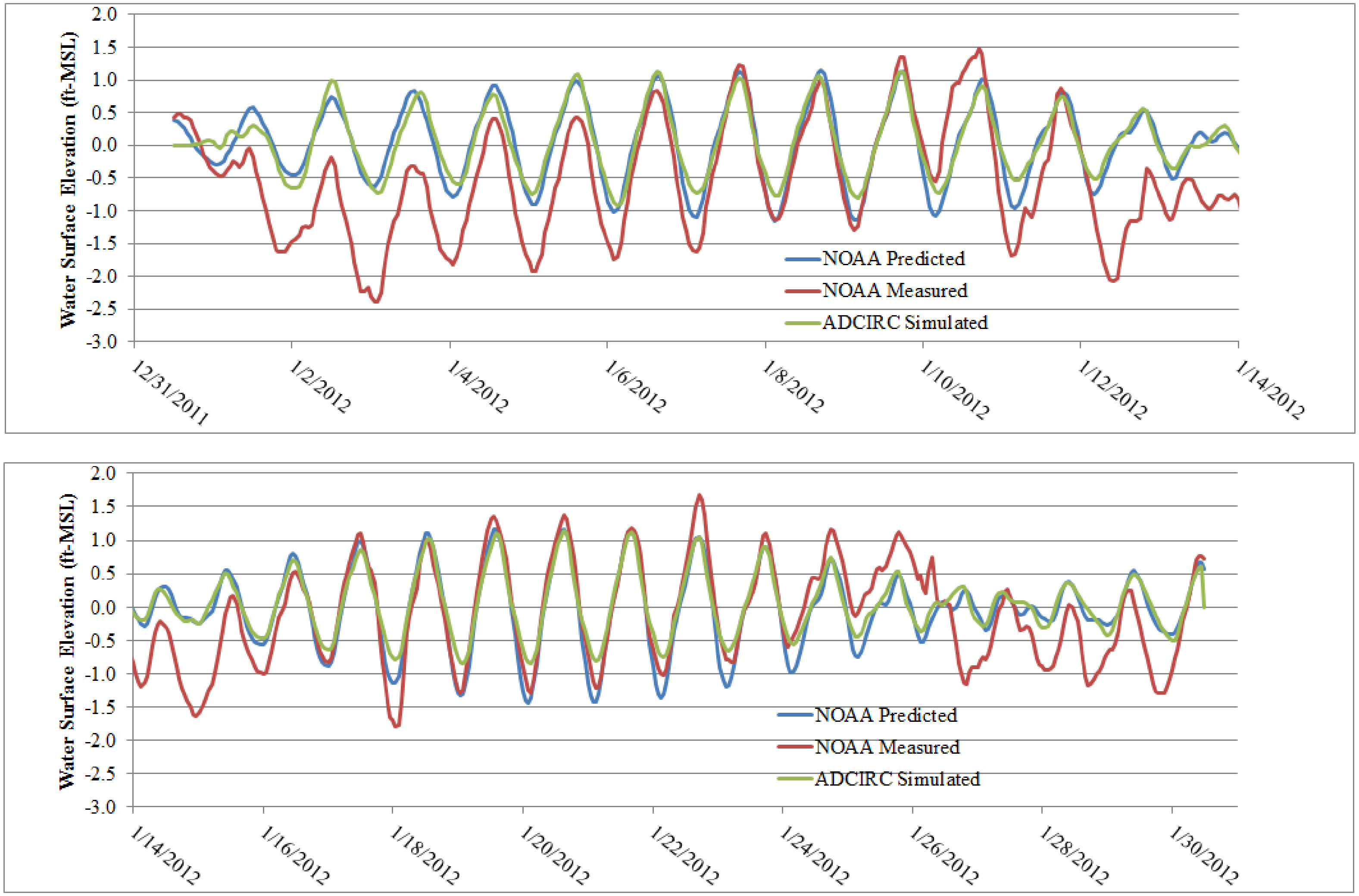


Figure C. 18
30-day calibration comparison modeled versus observed at NOAA gage 8747437

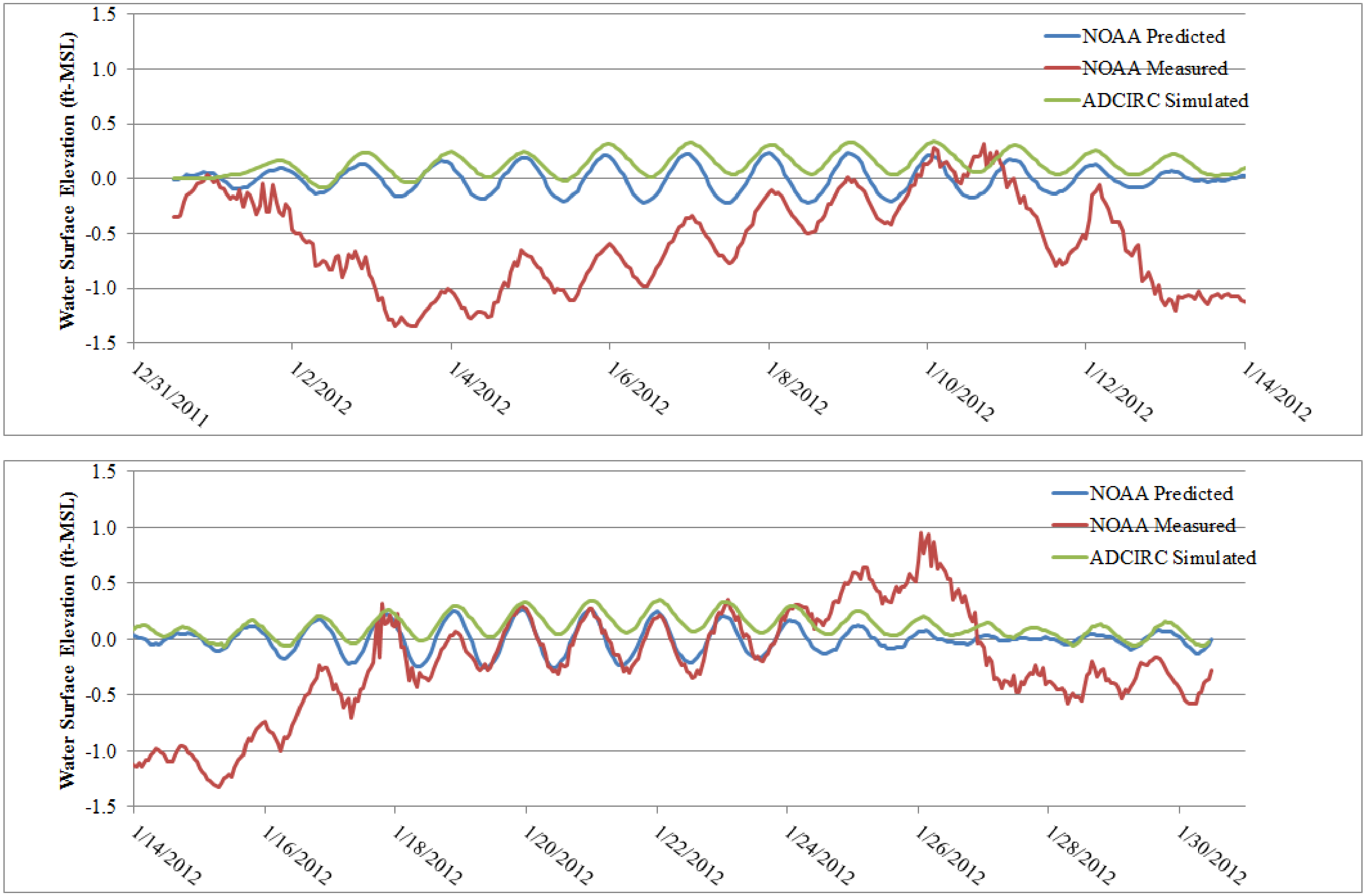


Figure C. 19
30-day calibration comparison modeled versus observed at NOAA gage 8761927

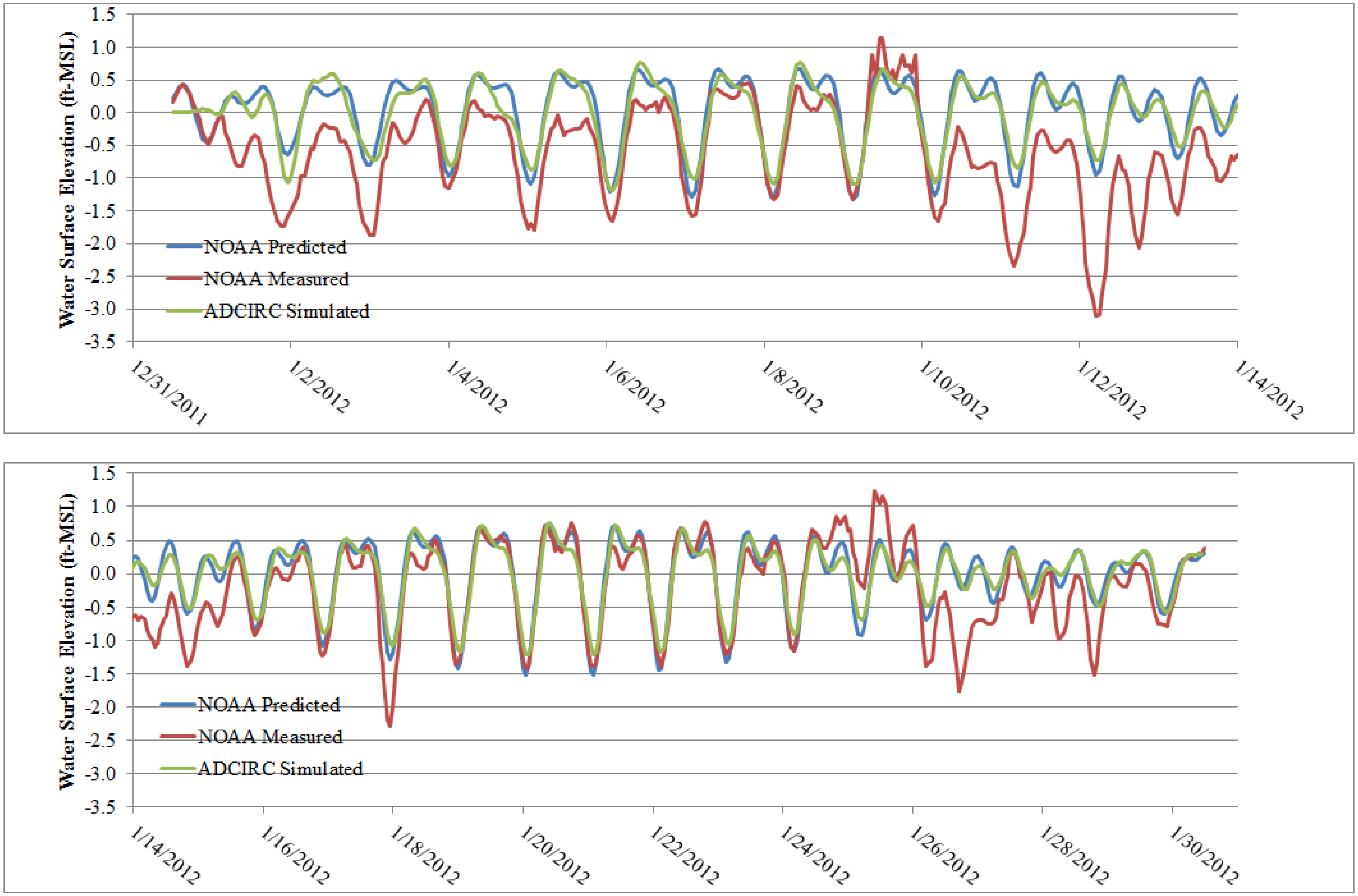


Figure C. 20
30-day calibration comparison modeled versus observed at NOAA gage 8770570

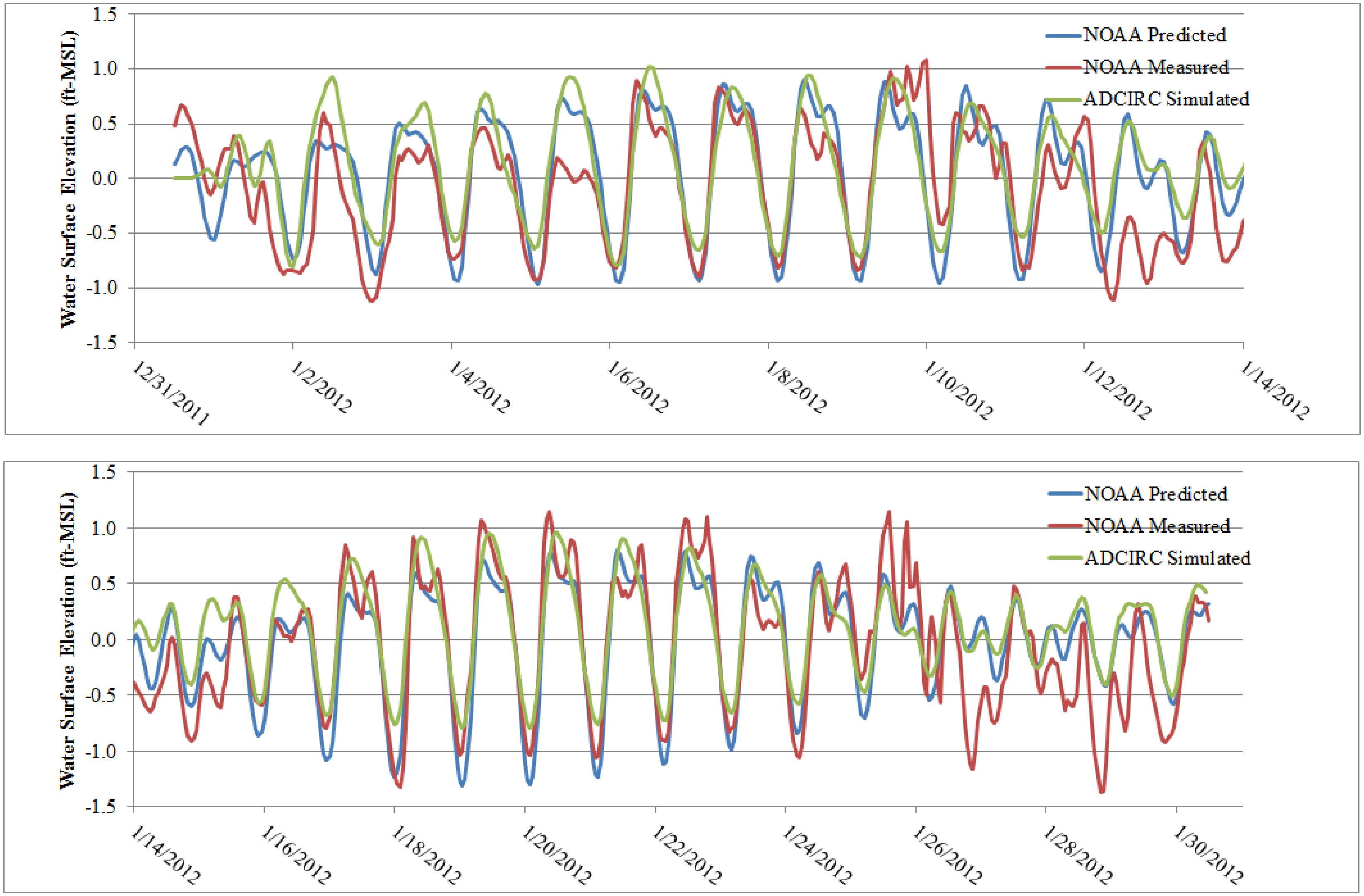


Figure C. 21
30-day calibration comparison modeled versus observed at NOAA gage 8764227

Table C. 1
ADCIRC tidal calibration summary for NOAA measured tides

Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
8747437	-0.17	0.50	12%
8760922	0.28	0.36	14%
8761305	0.09	0.79	28%
8761724	-0.03	0.27	12%
8761927	-0.20	0.24	11%
8762075	-0.07	0.27	11%
8762372	NA	NA	NA
8762482	NA	NA	NA
8764044	NA	NA	NA
8764227	-0.15	0.39	15%
8765251	NA	NA	NA
8766072	-0.06	0.60	11%
8767961	-0.10	0.46	13%
8768094	-0.16	0.51	10%
8770570	-0.19	0.45	10%

Table C. 2
ADCIRC tidal calibration summary for NOAA predicted tides

Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
8747437	-0.06	0.19	5%
8760922	-0.01	0.12	4%
8761305	-0.11	0.24	9%
8761724	-0.05	0.13	5%
8761927	-0.13	0.15	6%
8762075	-0.02	0.14	6%
8762372	NA	NA	NA
8762482	NA	NA	NA
8764044	NA	NA	NA
8764227	-0.10	0.22	9%
8765251	NA	NA	NA
8766072	-0.06	0.27	5%

Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
8767961	-0.06	0.19	5%
8768094	-0.10	0.24	5%
8770570	0.01	0.17	4%

The next section demonstrates the ADCIRC models ability to reproduce water surface elevation fluctuations caused by meteorological events (hurricanes and tropical storms). These comparisons evaluated the effect of two hurricanes on water surface elevation. Figure C. 22 through Figure C. 44 present the results of the hurricane verification simulations. In the figures, the blue line represents the water surface elevation at the gage location predicted by ADCIRC and the red line represents the measured water surface elevation at the gage.

Hurricane Katrina made landfall along the southeastern coastline of Louisiana and finally near the Louisiana-Mississippi boarder on the morning of August 29, 2005. Given this landfall location, the storms effects were limited to the eastern half of Louisiana. As such, this verification provides insight into the models ability to reproduce storm surge in eastern Louisiana. Figure C. 22 through Figure C. 29 present the comparisons for Hurricane Katrina at the eight NOAA gages that where operating during the storm.

As the figures illustrate, in most cases, the ADCIRC model results agree with the observations along the eastern Louisiana coast. There are, however, discrepancies at one gage, which is due to changes to the levee system on Lake Pontchartrain. Comparisons at NOAA gage 8762372 (Figure C. 24) show similar trends in the water surface elevations but different magnitudes. The trends demonstrated in the figure result from local wind setup/set down. As Hurricane Katrina approached landfall east of the lake, the wind direction in Lake Pontchartrain was generally from the north. This results in local wind setup as the hurricane wind pushes water to the south side of the lake. Both the simulated and measured water surfaces show this super-elevation of the water surface along the south bank of Lake Pontchartrain. As the hurricane makes landfall, the wind switched to the south. This results in local wind set down along the southern shoreline as the hurricane wind pushes water to the north side of the lake. Again, both the simulated and measured results reflect the effect on the water surface elevation of the shift in wind direction. The differences in the magnitude of these trends in measured and simulated water surface elevation are due to the levee failure. While the model mesh assumes the new levee will not fail, the existing levee did fail during Hurricane Katrina. The effect of the failure is evident in the measured water surface elevations. The increased storage area created when the levee failed reduced the potential peak water surface in Lake Pontchartrain as water flooded areas behind the levee. When the wind shifted direction, pushing water away from the southern shoreline the water surface remained elevated at the gage location as water flowed out of the flooded areas. If the levee did not break, as the model simulates, the water would accumulate against the levee producing a higher water surface at the gage. When wind shifts, the relatively (compared to the volume stored behind the damaged levee) small volume water at the gage, drops to a much lower elevation than the measured value. The comparisons presented in Figure C. 24 show the assumption that the levees do not fail produces a higher water surface, which from a wave vulnerability standpoint, is a conservative assumption.

Simulated water surface at the remainder of the western gages (8760922, 8761724, 8762372, and 8762482) agreed well with the measured values. Unfortunately, simulated water surface at gages along the western coastline (8764044, 8765251, 8766072, and 8768094), where the effects of Hurricane Katrina where not significant, did not agree as well with measured data. These relatively low meteorological and hydraulic conditions are difficult to predict and are not significant contributors to the design conditions.

Hurricane Rita made landfall on September 24, 2005, near Sabine Pass in southwestern Louisiana. Given the location of the storm's landfall, the storm's effects were greater in southwestern Louisiana. As such, this verification provides insight into the models ability to reproduce storm surge in western Louisiana than previous verification. Figure C. 30 through Figure C. 44 present comparisons between measured and simulated water surface elevations for Hurricane Rita at NOAA and USGS gages. As the figures illustrate, the ADCIRC simulated water surfaces agree well with the measured data at these gages.

Table C. 3 and Table C. 4 summarize results of the hurricane verifications. As the tables demonstrate, ADCIRC predicts water surface elevations well within FEMA's tolerance for hurricane verification. The lowest error for the Hurricane Katrina verification was 6 percent at gage 8760922 (located near the landfall), the highest is 40 percent at gage 8764044 (approximately 115 miles west of the landfall), and the average for all gages was 19 percent. For Hurricane Rita, the lowest error was 6 percent (LA9b and LC8a), the highest was 32 percent (LA10), and the average for all gages is 13 percent. Notably, the gages with the largest percent error occur where the surge was low for that event.

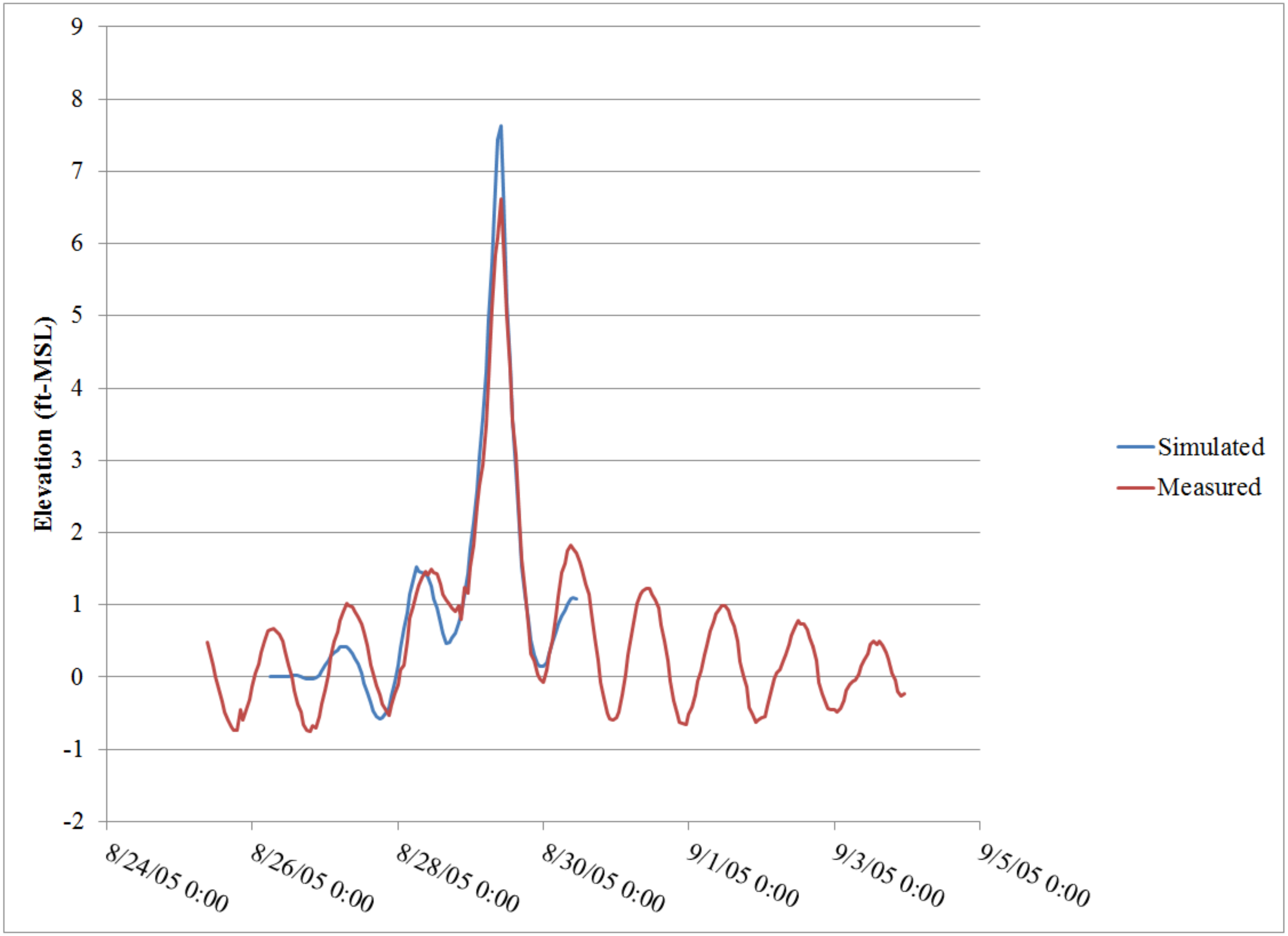


Figure C. 22
Hurricane Katrina calibration comparison modeled versus observed at NOAA gage 8760922

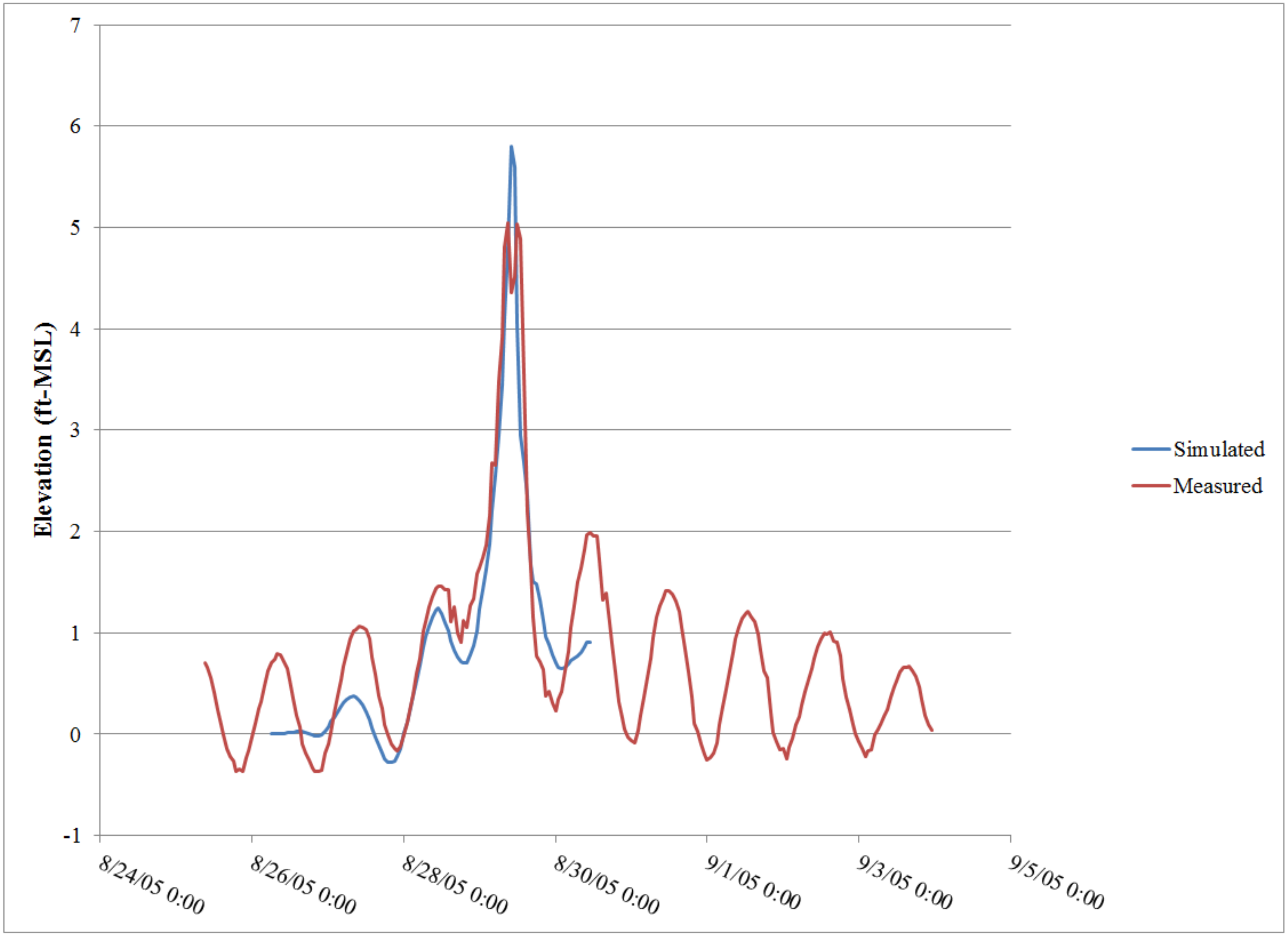


Figure C. 23
Hurricane Katrina calibration comparison modeled versus observed at NOAA gage 8761724

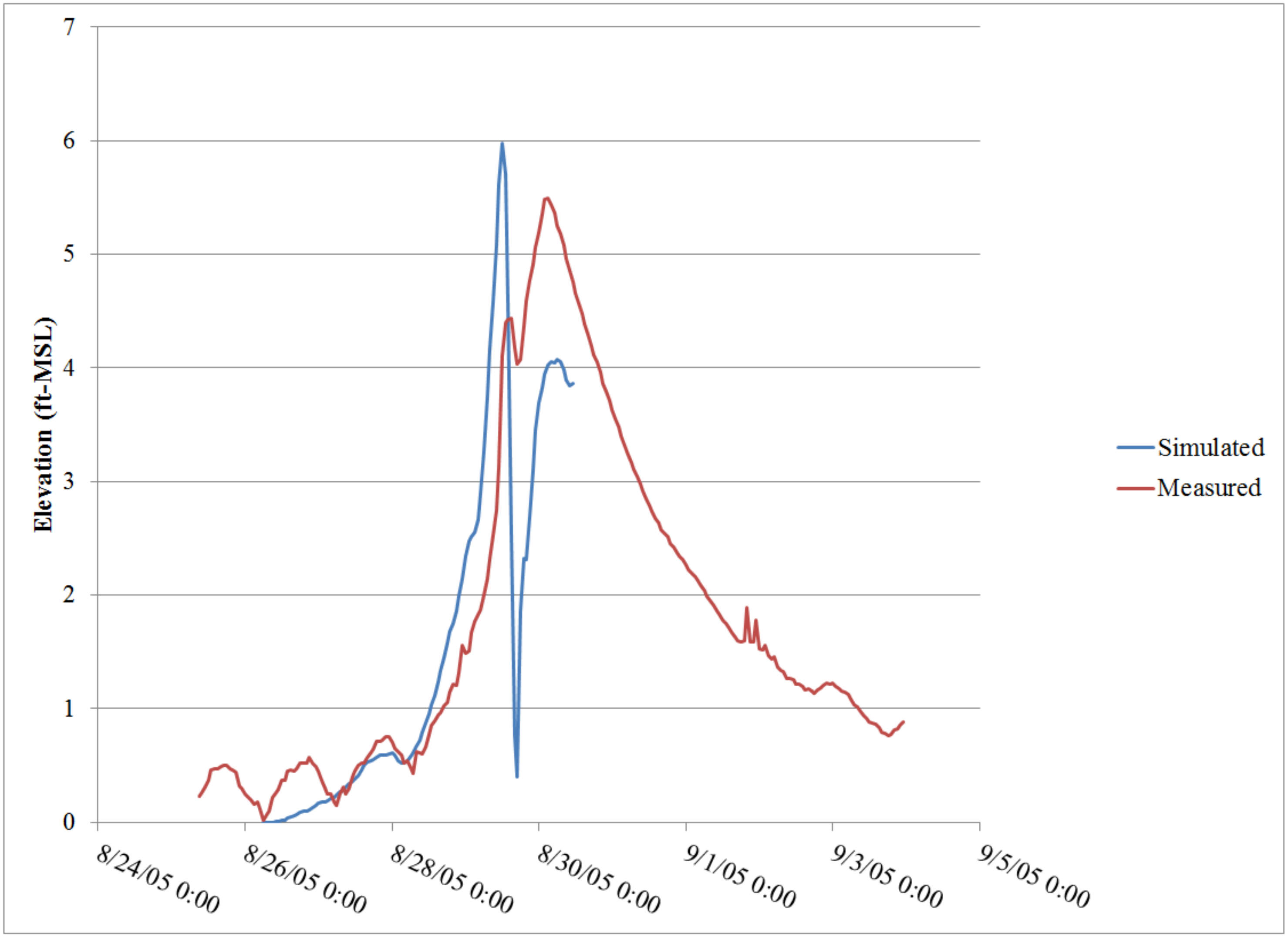


Figure C. 24
Hurricane Katrina calibration comparison modeled versus observed at NOAA gage 8762372

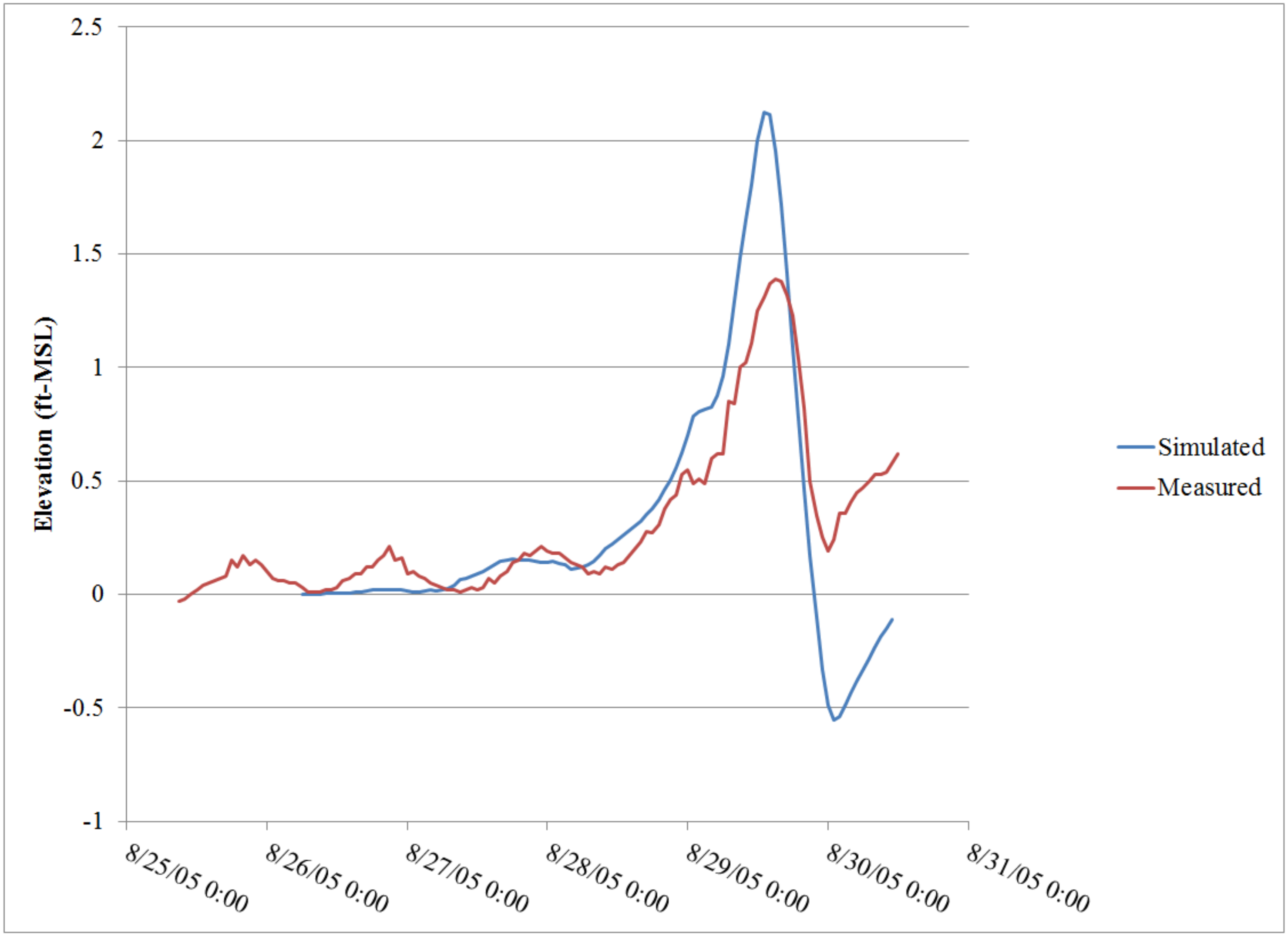


Figure C. 25
Hurricane Katrina calibration comparison modeled versus observed at NOAA gage 8762482

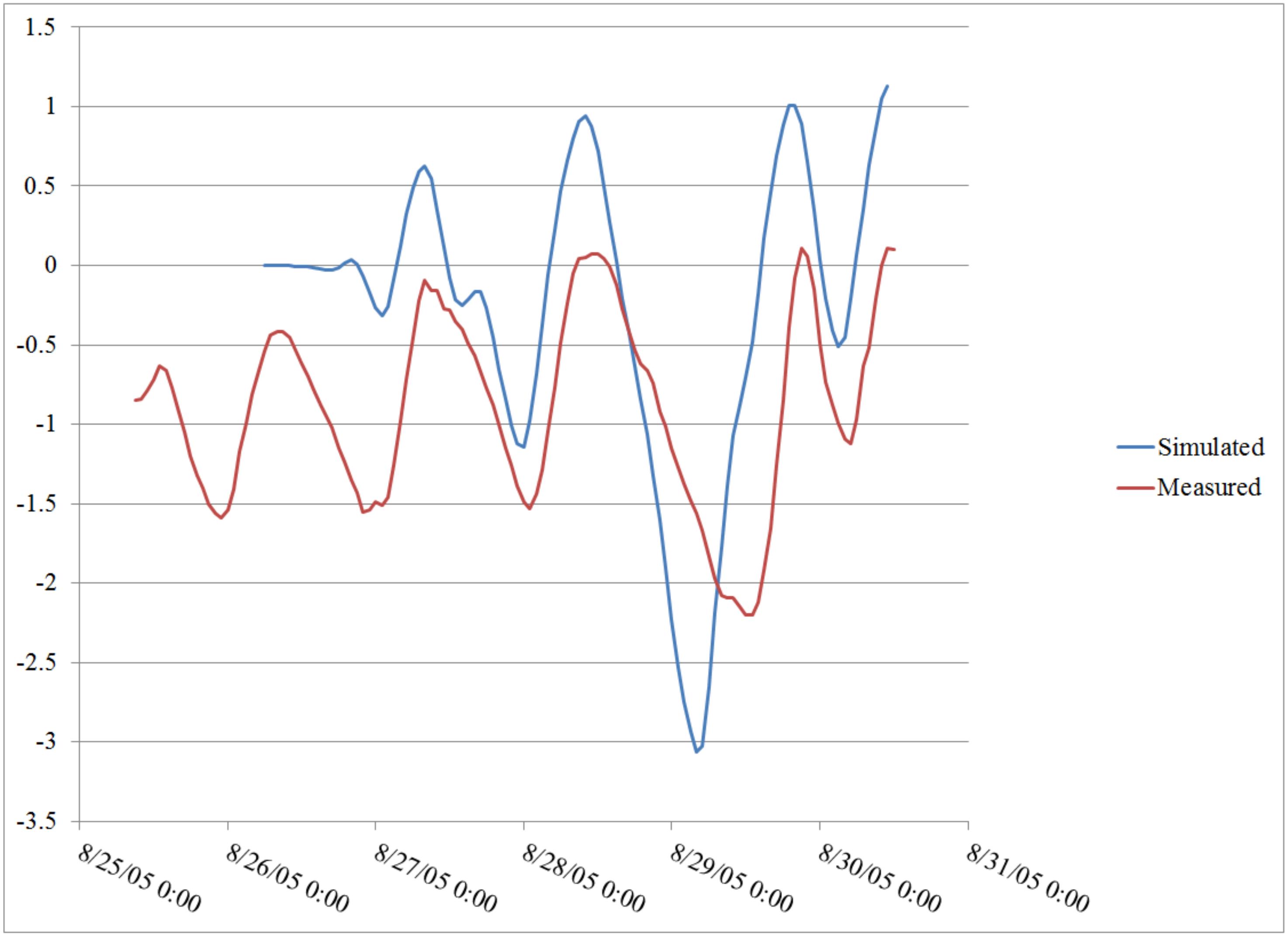


Figure C. 26
Hurricane Katrina calibration comparison modeled versus observed at NOAA gage 8764044

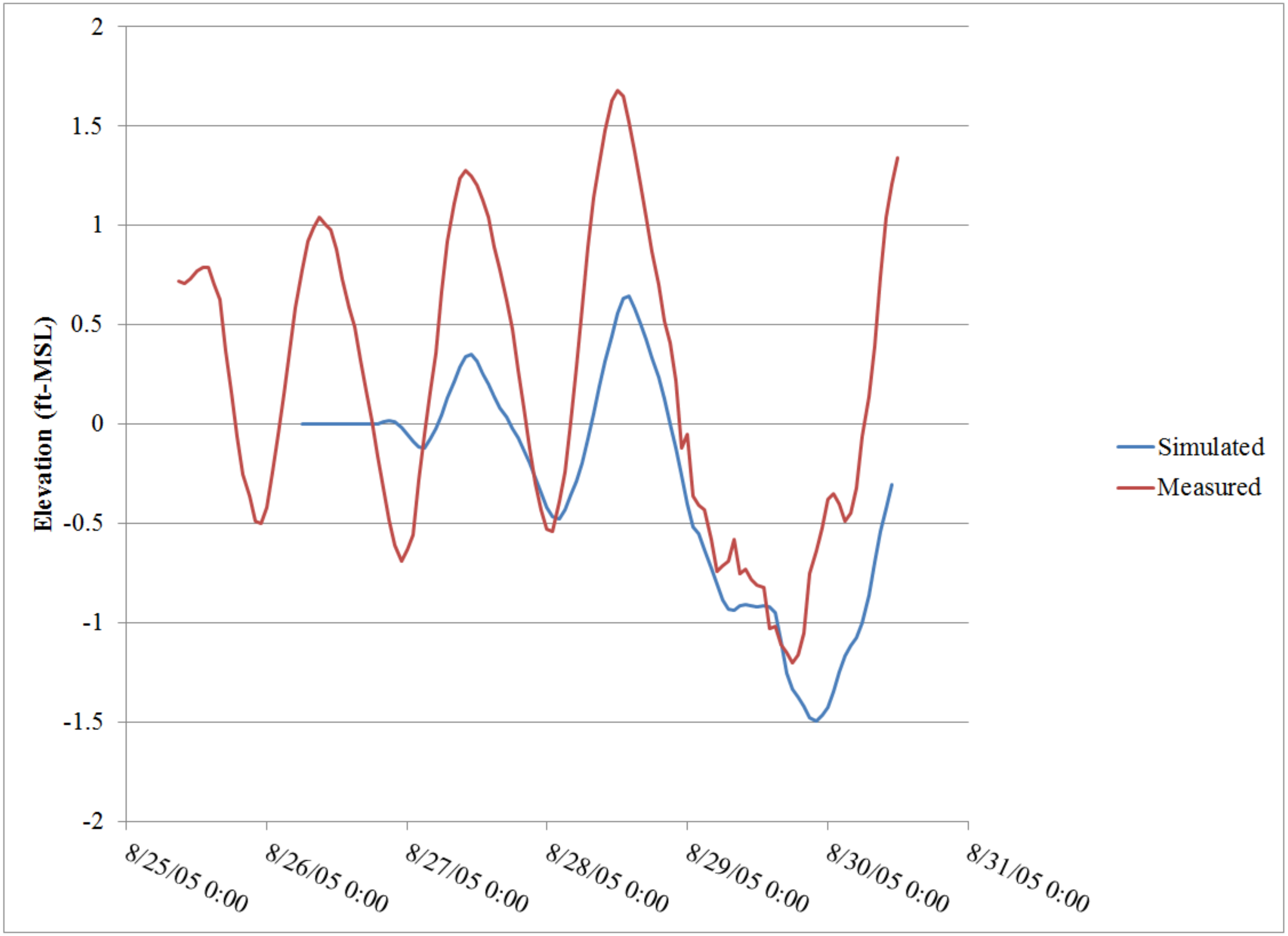


Figure C. 27
Hurricane Katrina calibration comparison modeled versus observed at NOAA gage 8765251

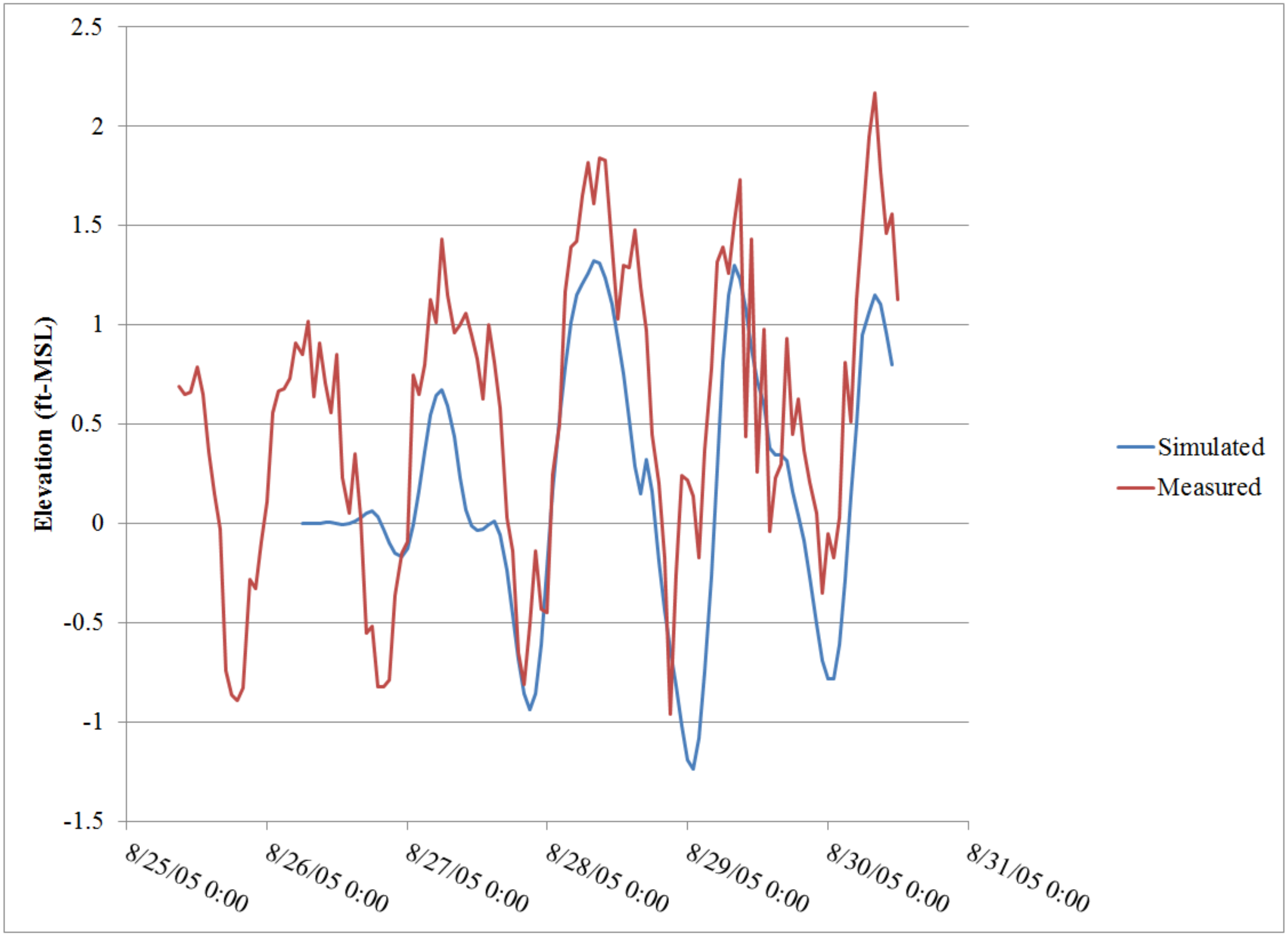


Figure C. 28
Hurricane Katrina calibration comparison modeled versus observed at NOAA gage 8766072

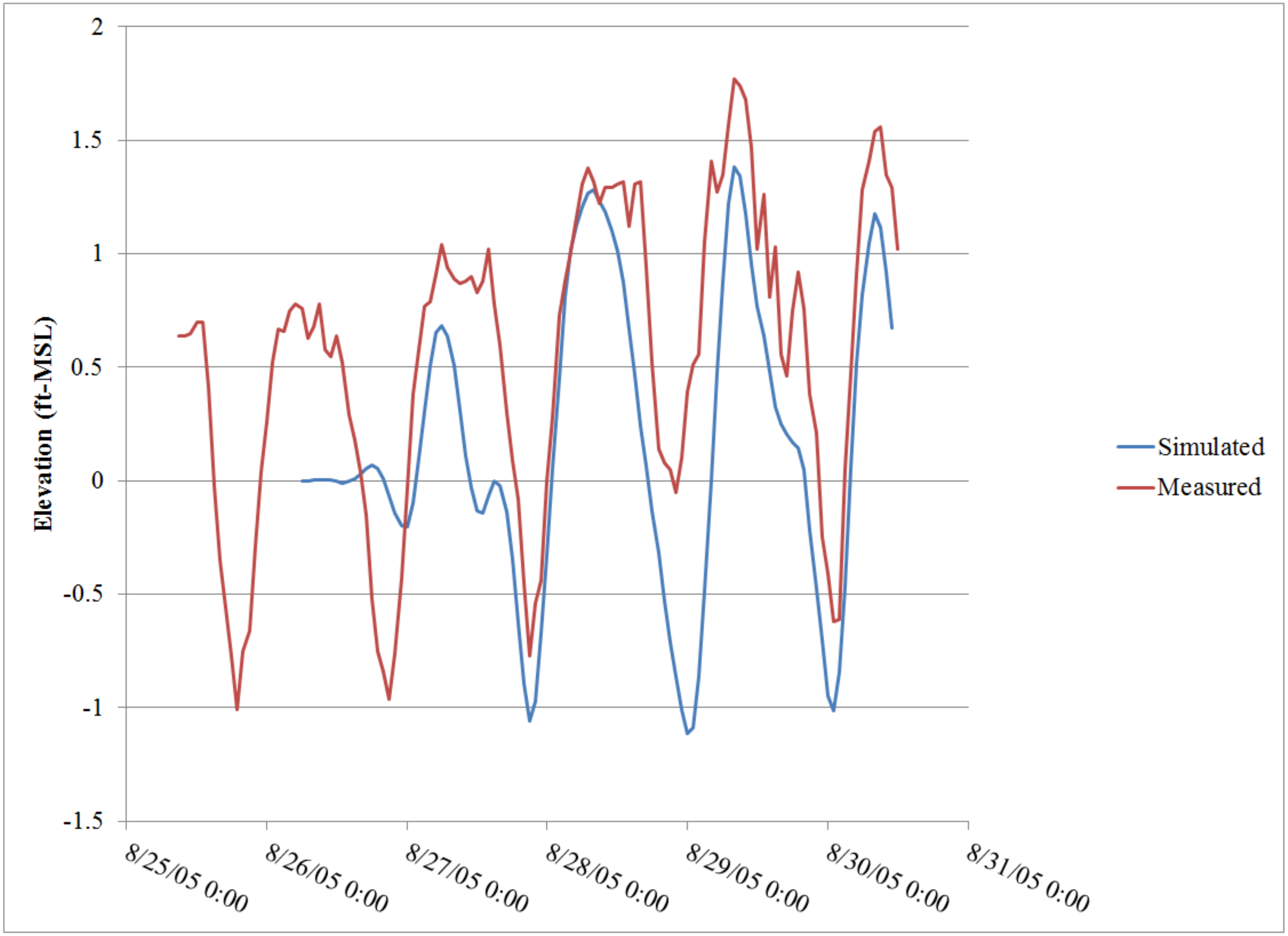


Figure C. 29
Hurricane Katrina calibration comparison modeled versus observed at NOAA gage 8768094

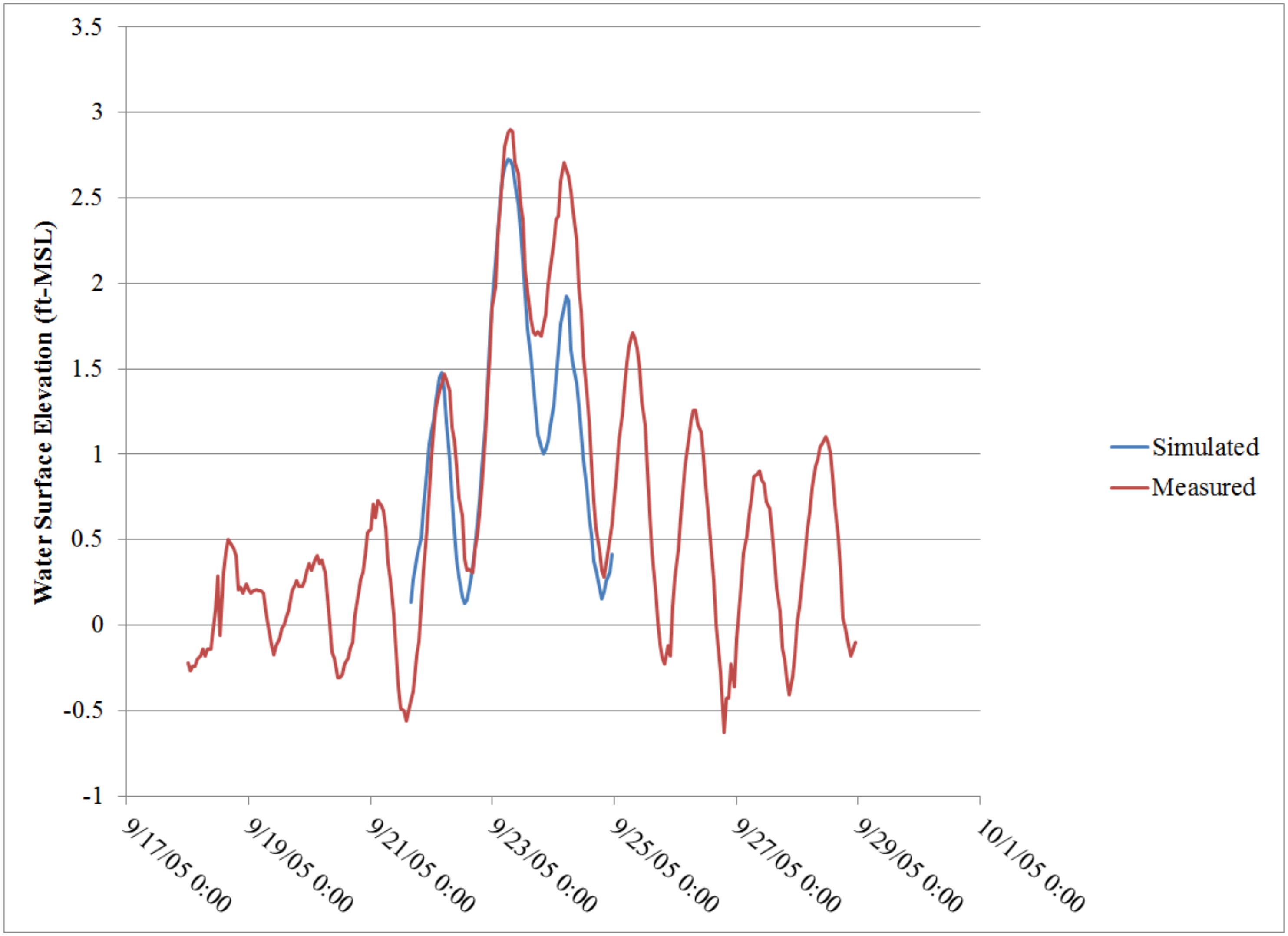


Figure C. 30
Hurricane Rita calibration comparison modeled versus observed at NOAA gage 8760922

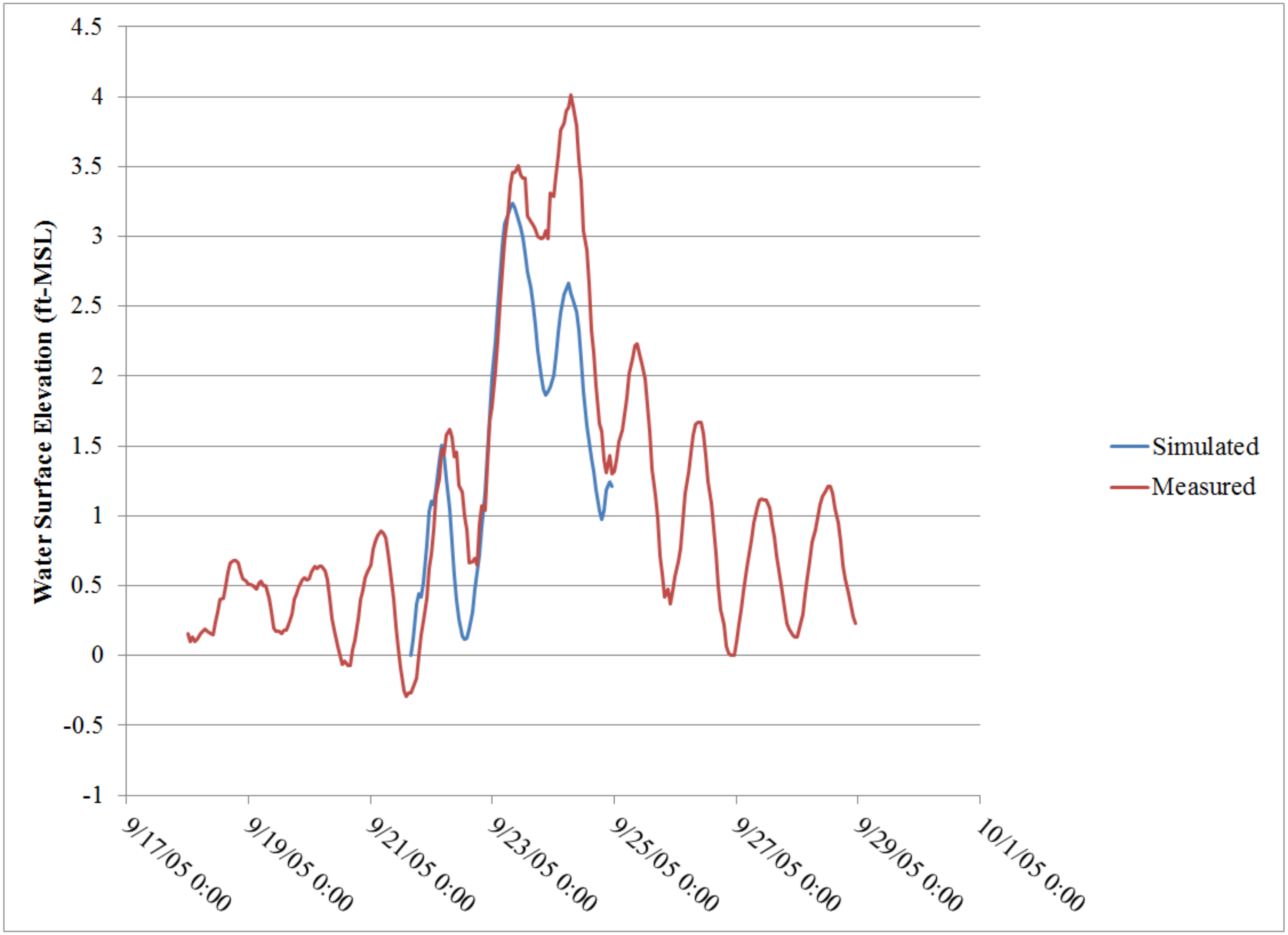


Figure C. 31
Hurricane Rita calibration comparison modeled versus observed at NOAA gage 8761724

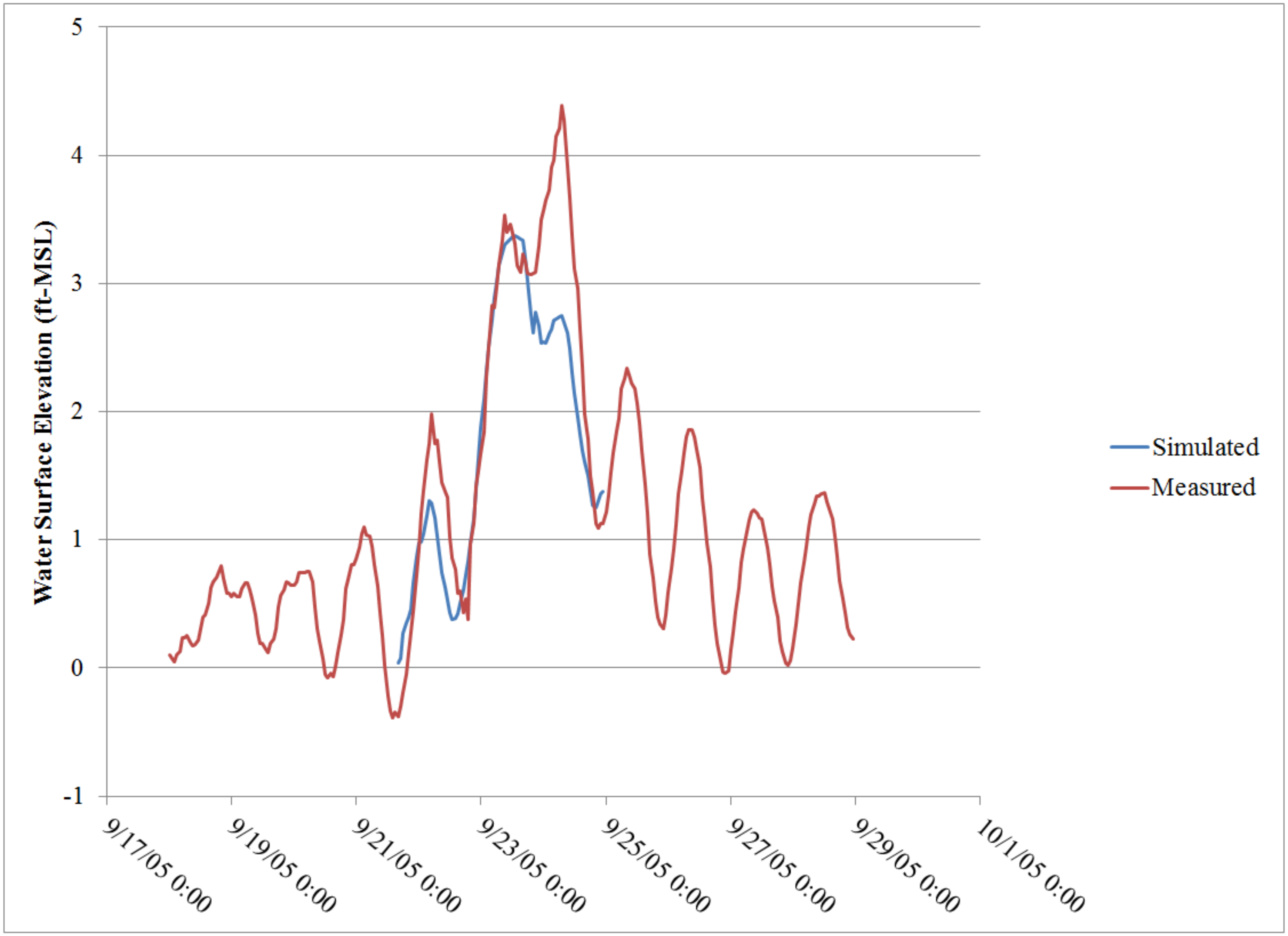


Figure C. 32
Hurricane Rita calibration comparison modeled versus observed at NOAA gage 8762075

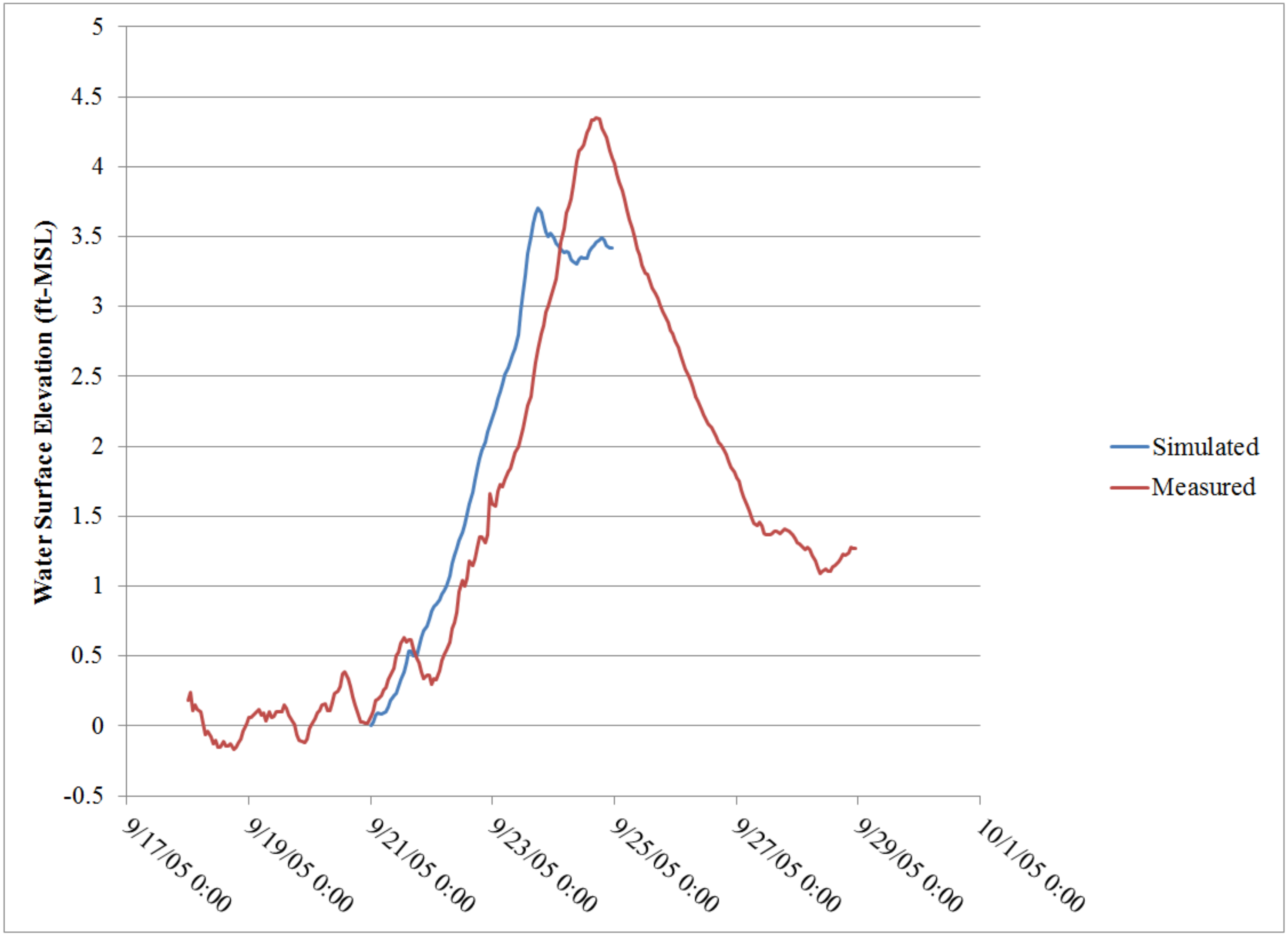


Figure C. 33
Hurricane Rita calibration comparison modeled versus observed at NOAA gage 8762372

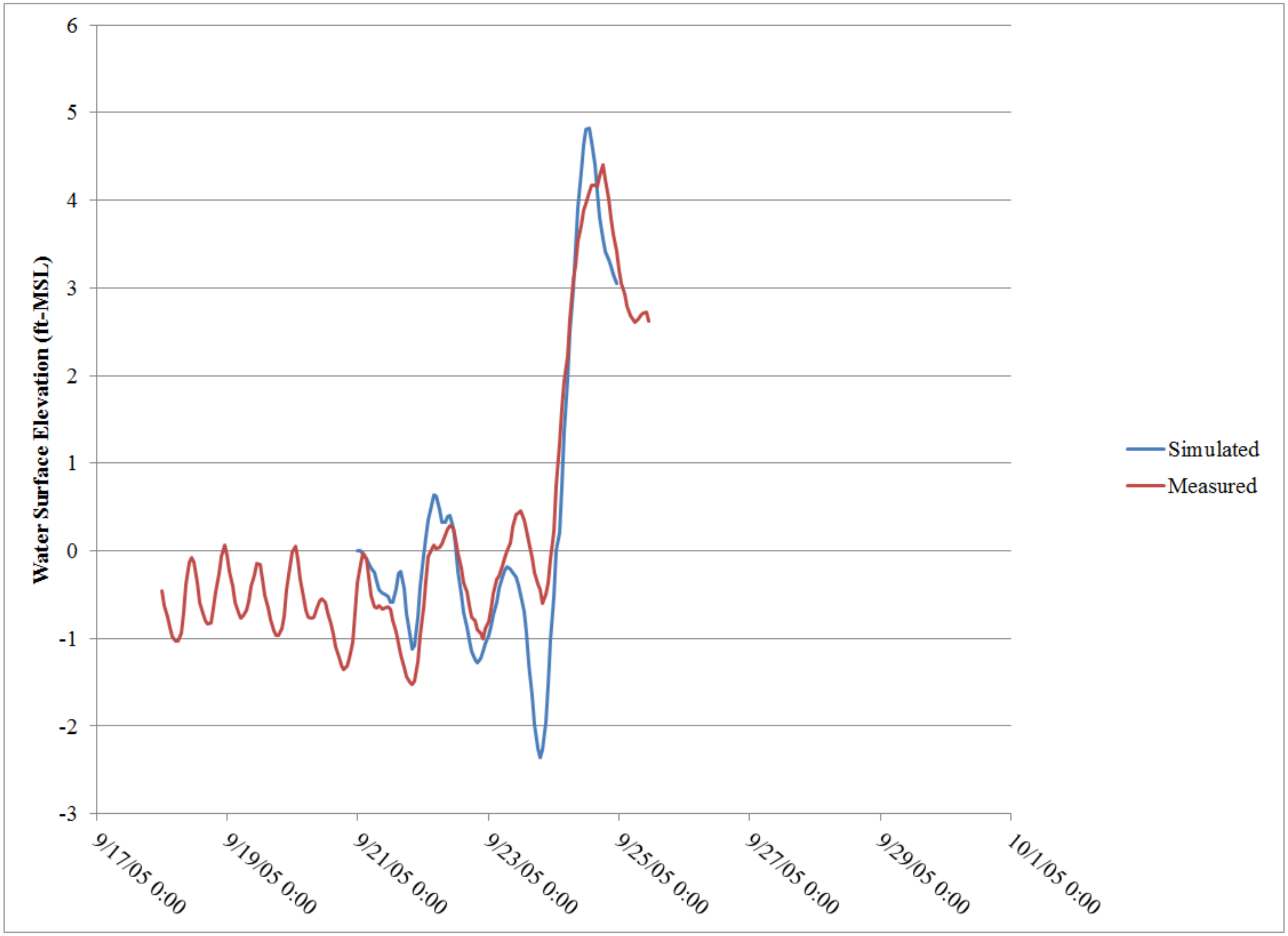


Figure C. 34
Hurricane Rita calibration comparison modeled versus observed at NOAA gage 8764044

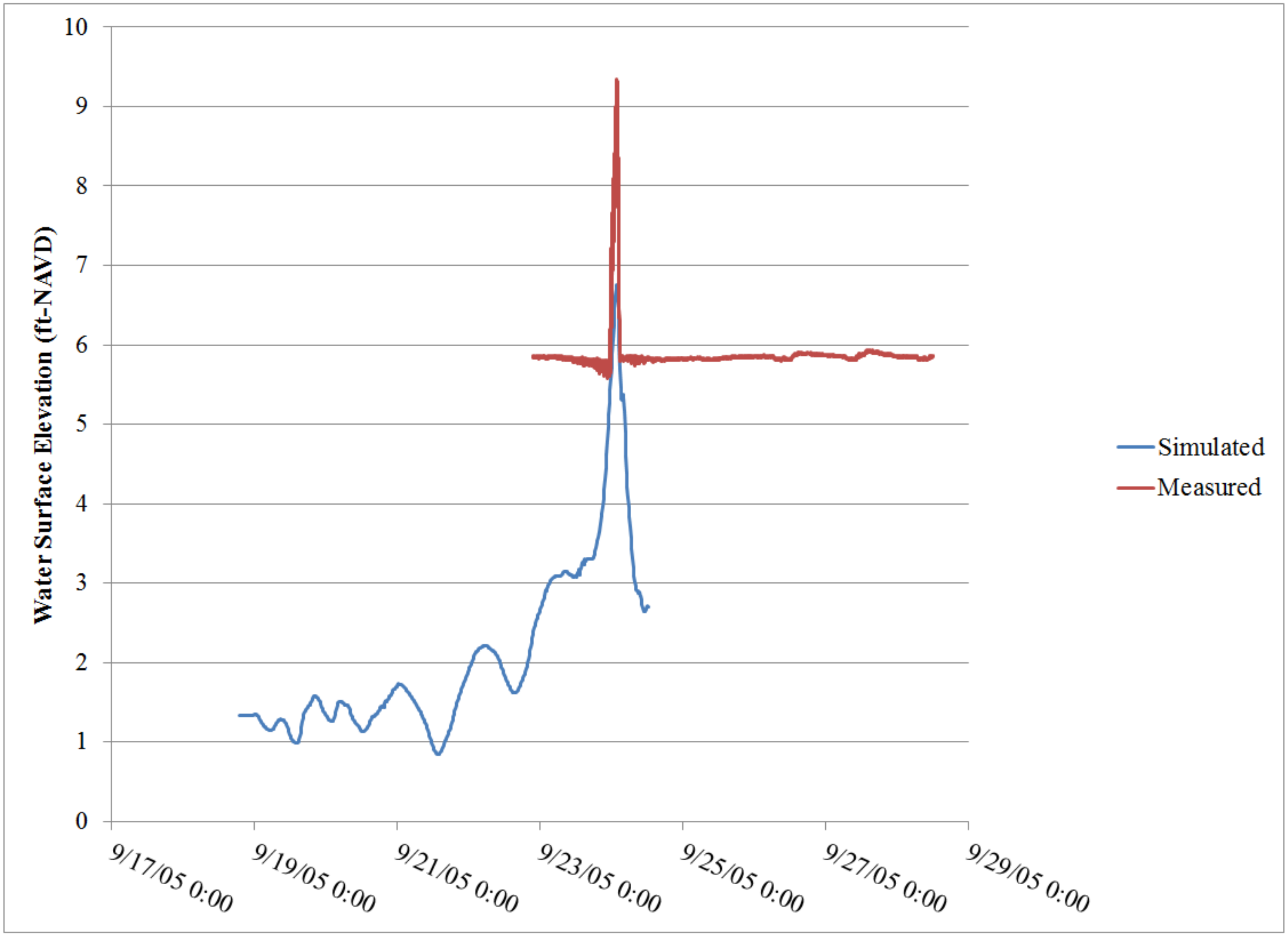


Figure C. 35
Hurricane Rita calibration comparison modeled versus observed at USGS gage b15b

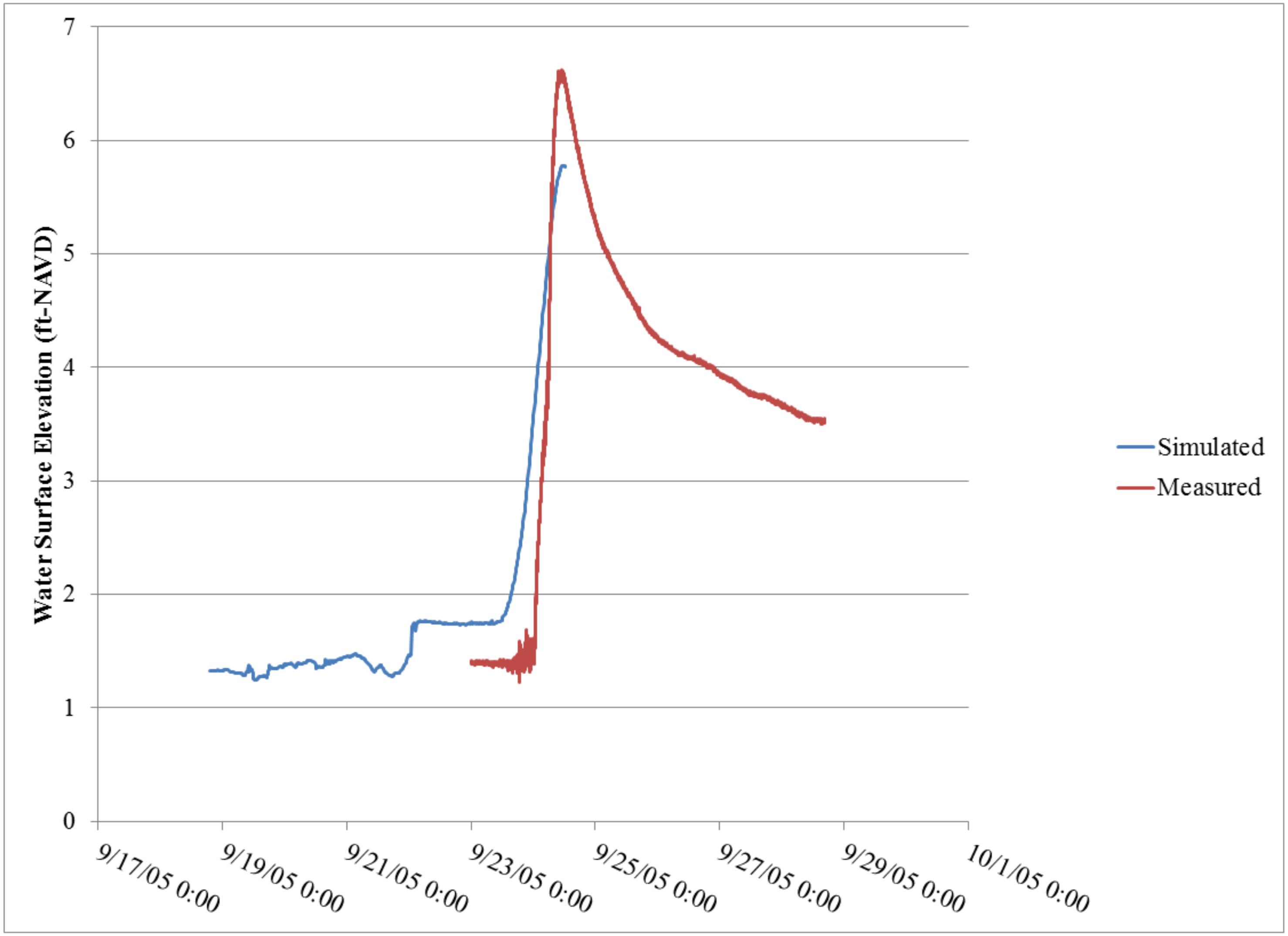


Figure C. 36
Hurricane Rita calibration comparison modeled versus observed at USGS gage LA9

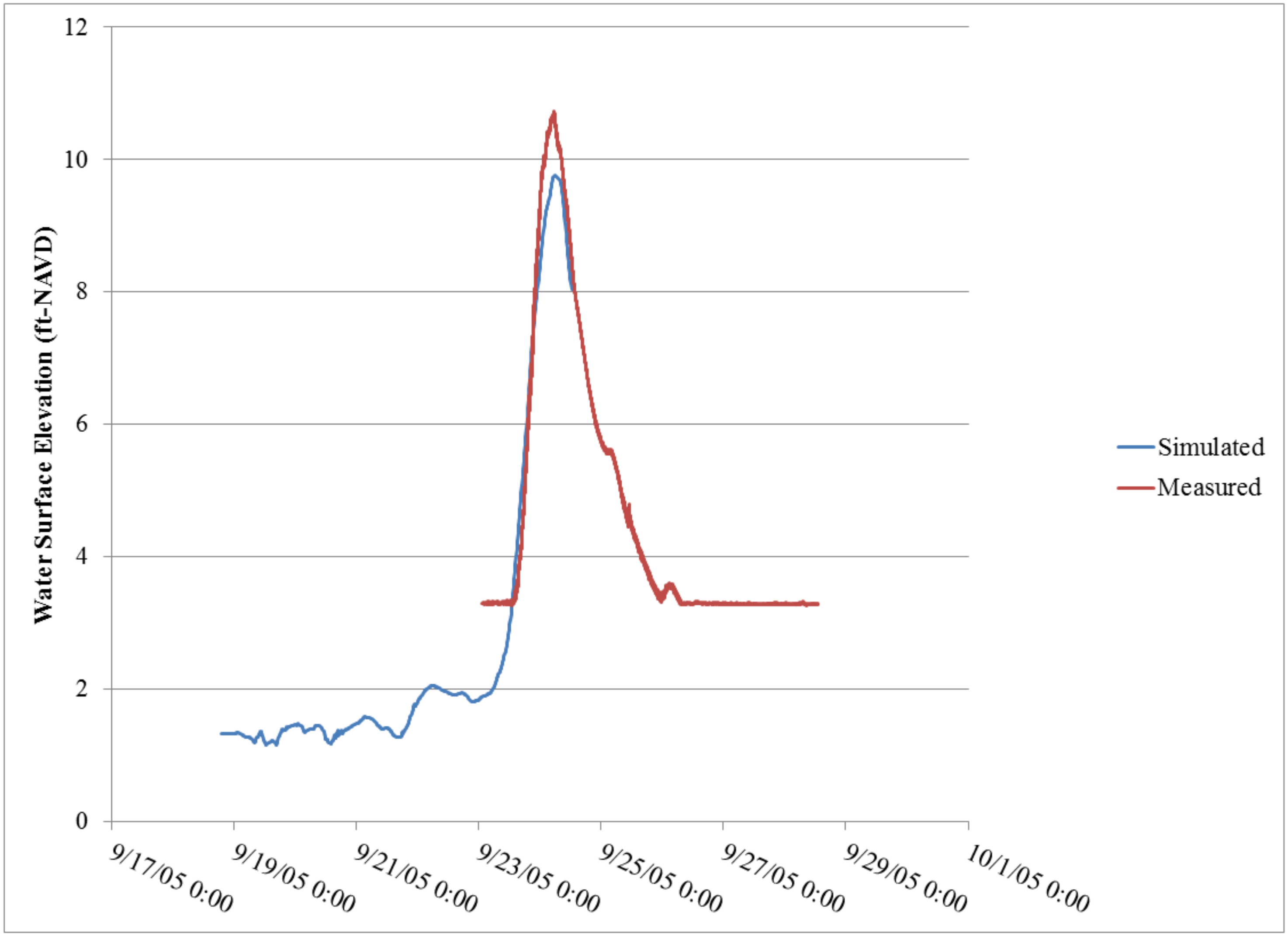


Figure C. 37
Hurricane Rita calibration comparison modeled versus observed at USGS gage LA9b

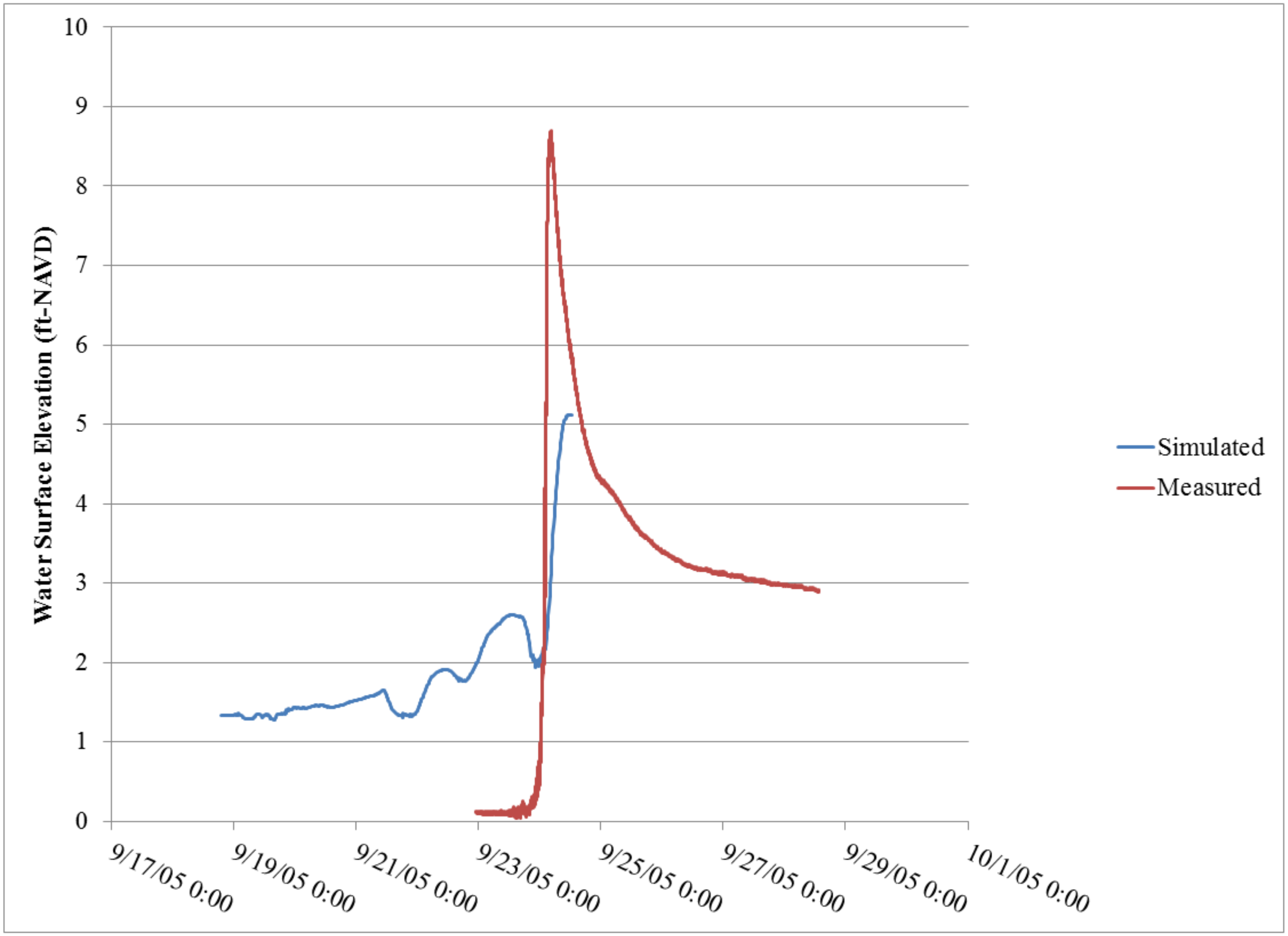


Figure C. 38
Hurricane Rita calibration comparison modeled versus observed at USGS gage LA10

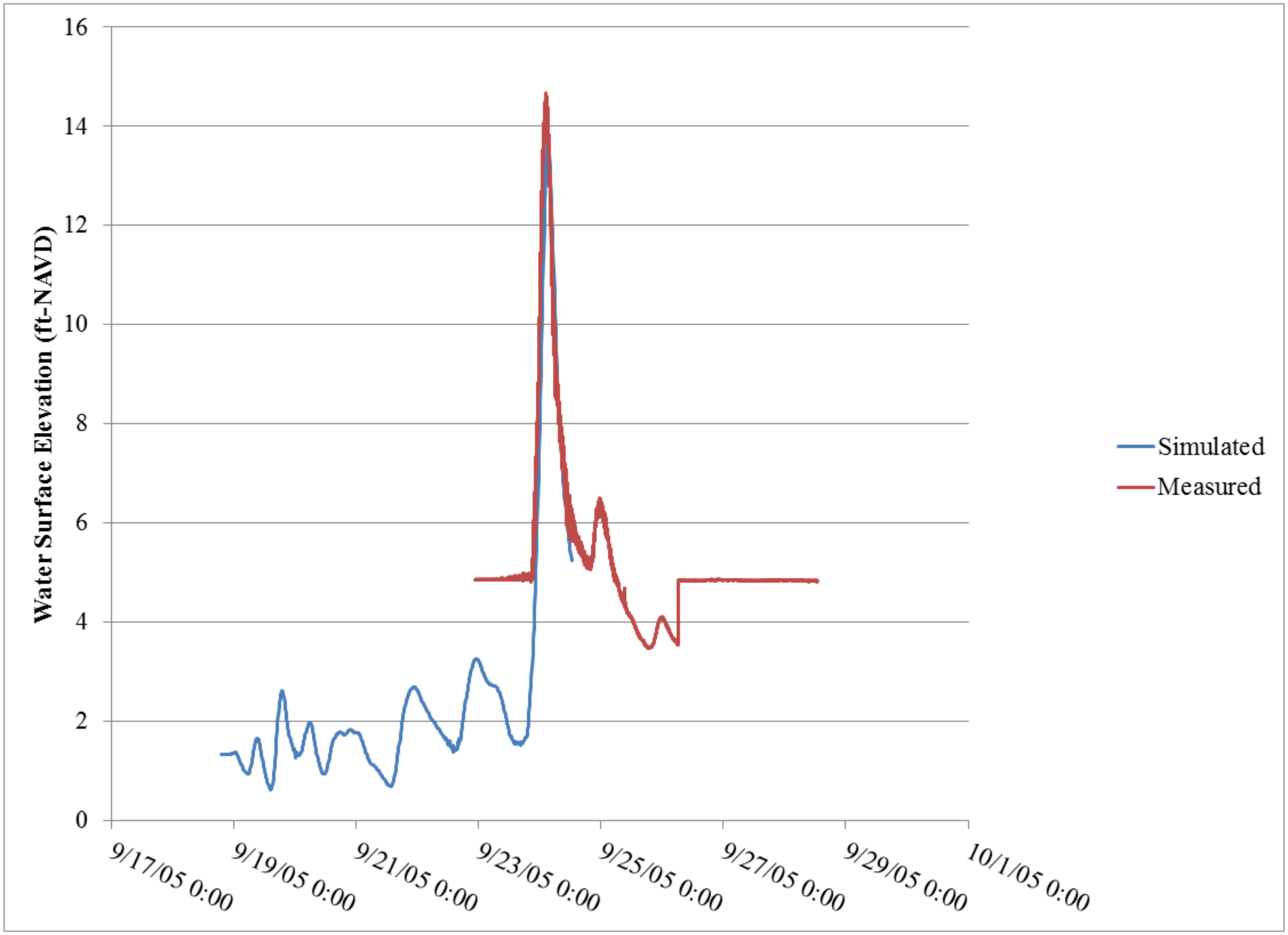


Figure C. 39
Hurricane Rita calibration comparison modeled versus observed at USGS gage LA11

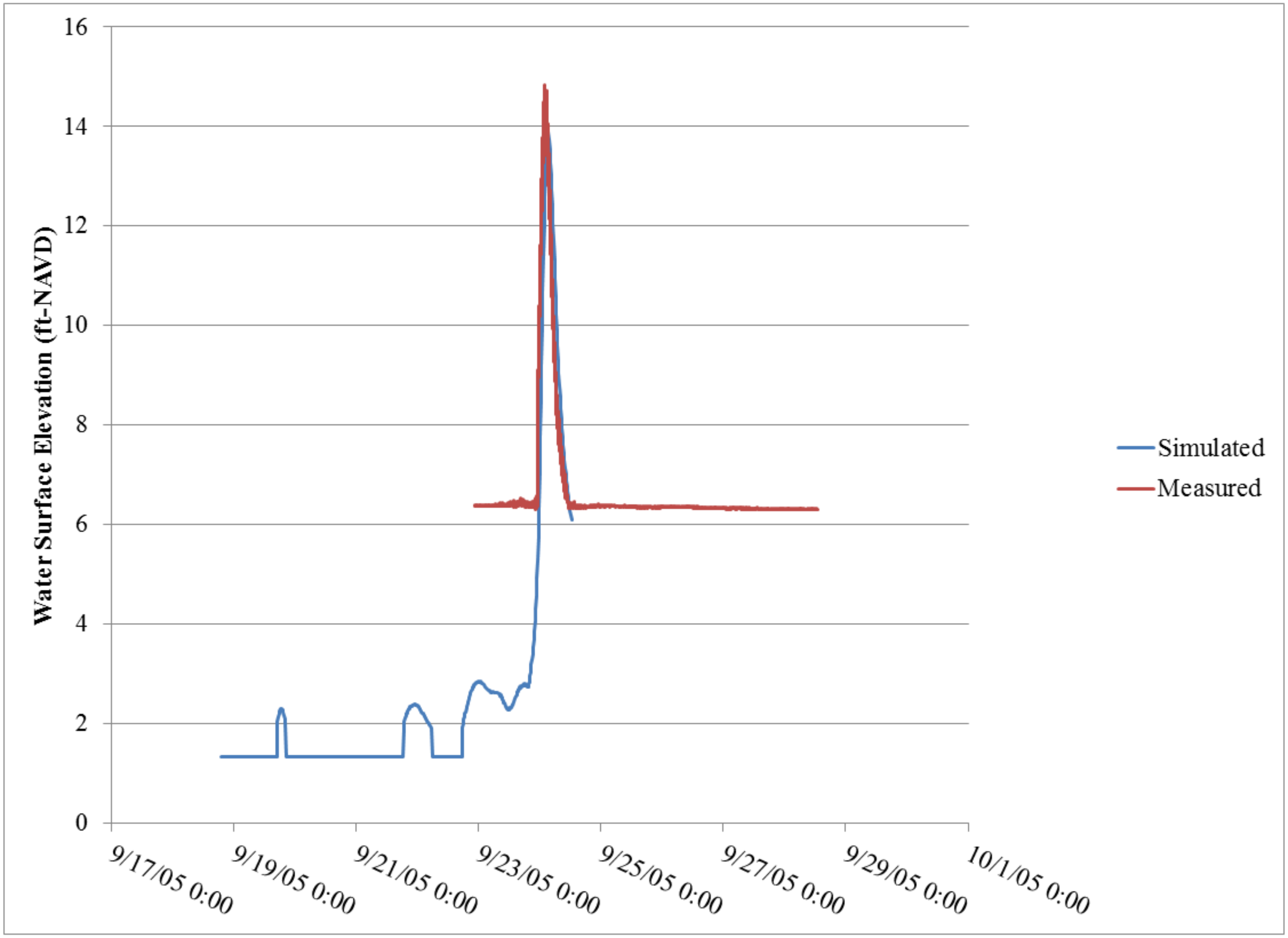


Figure C. 40
Hurricane Rita calibration comparison modeled versus observed at USGS gage LA12

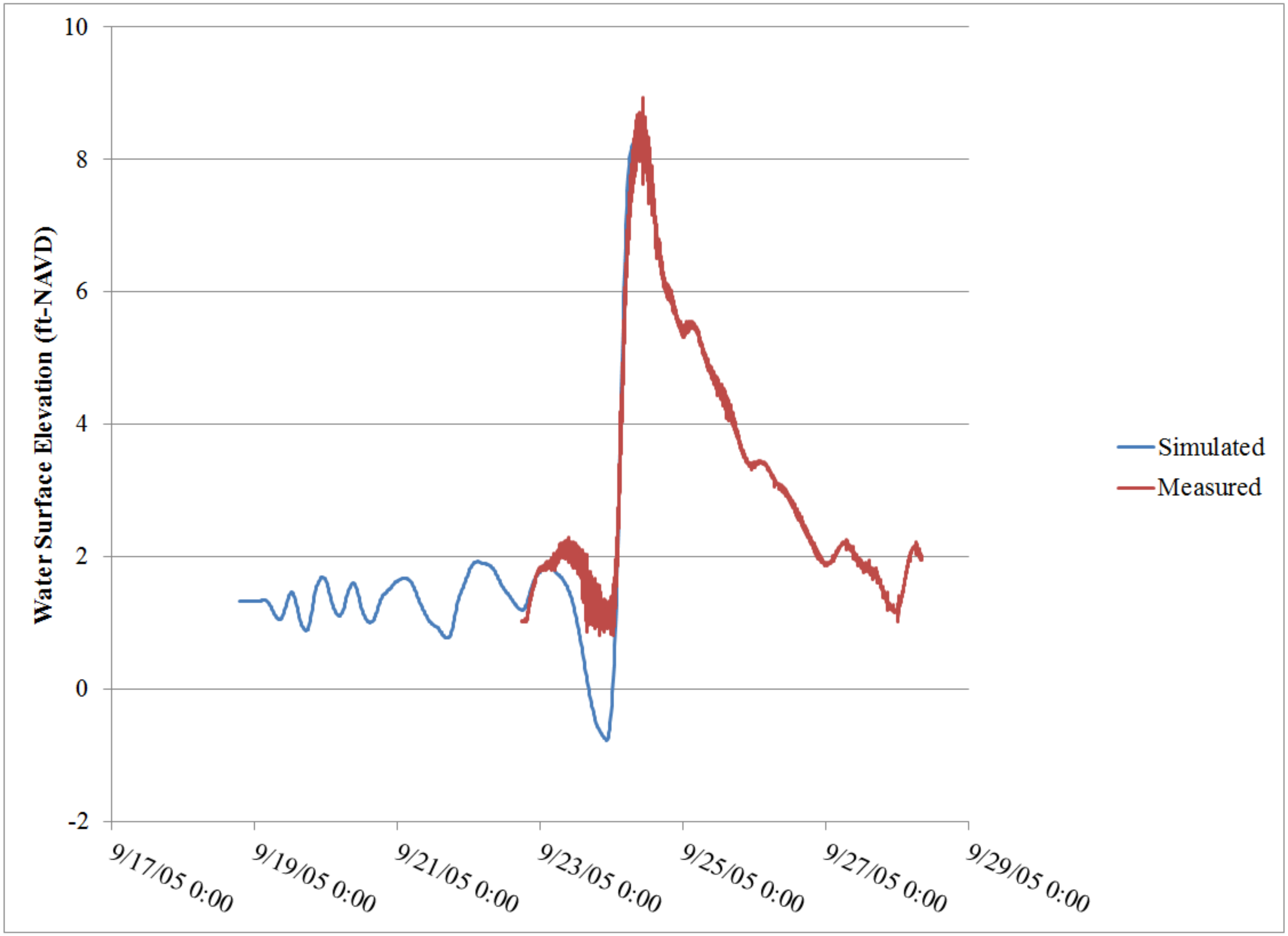


Figure C. 41
Hurricane Rita calibration comparison modeled versus observed at USGS gage LC2a

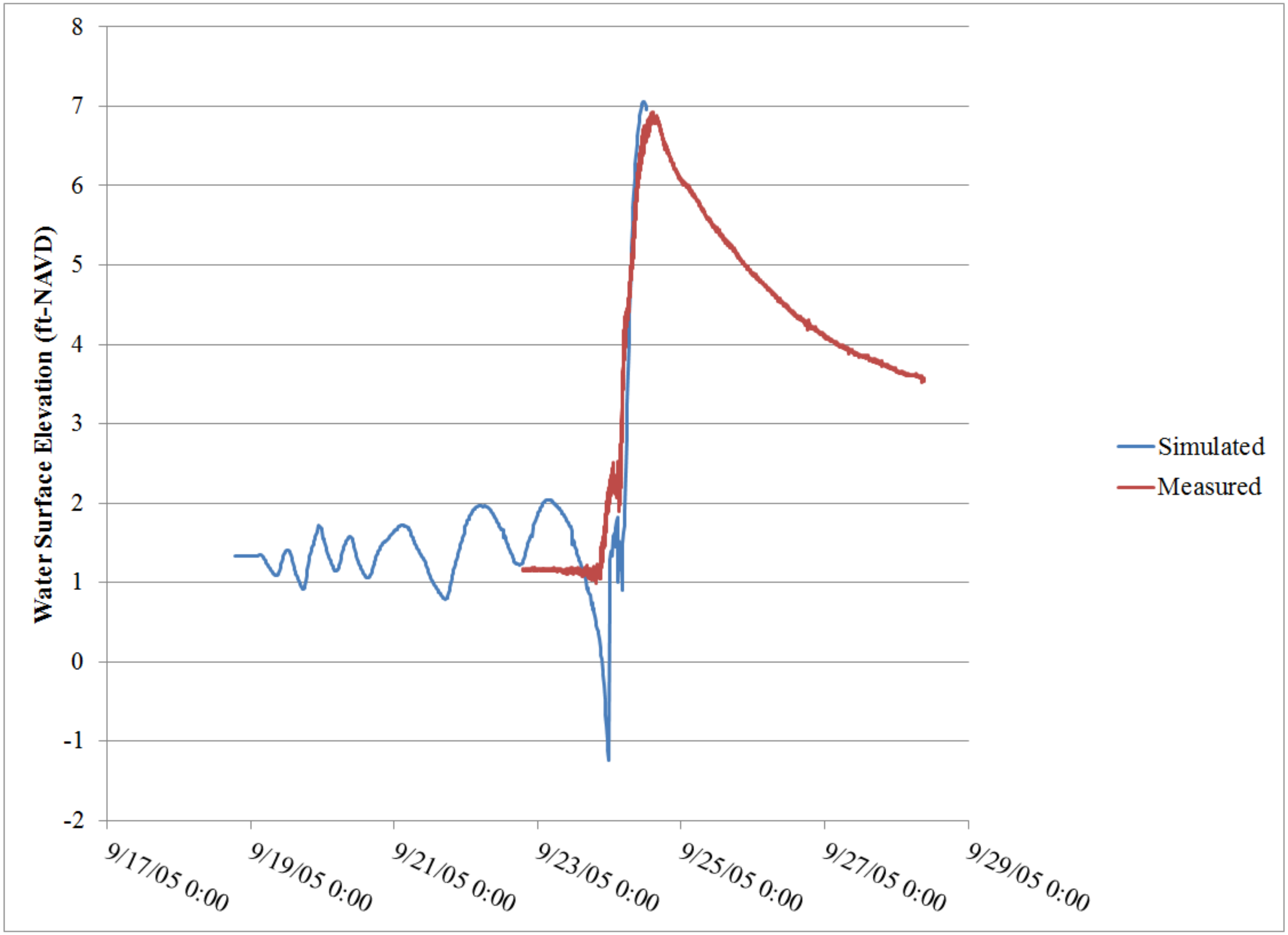


Figure C. 42
Hurricane Rita calibration comparison modeled versus observed at USGS gage LC5

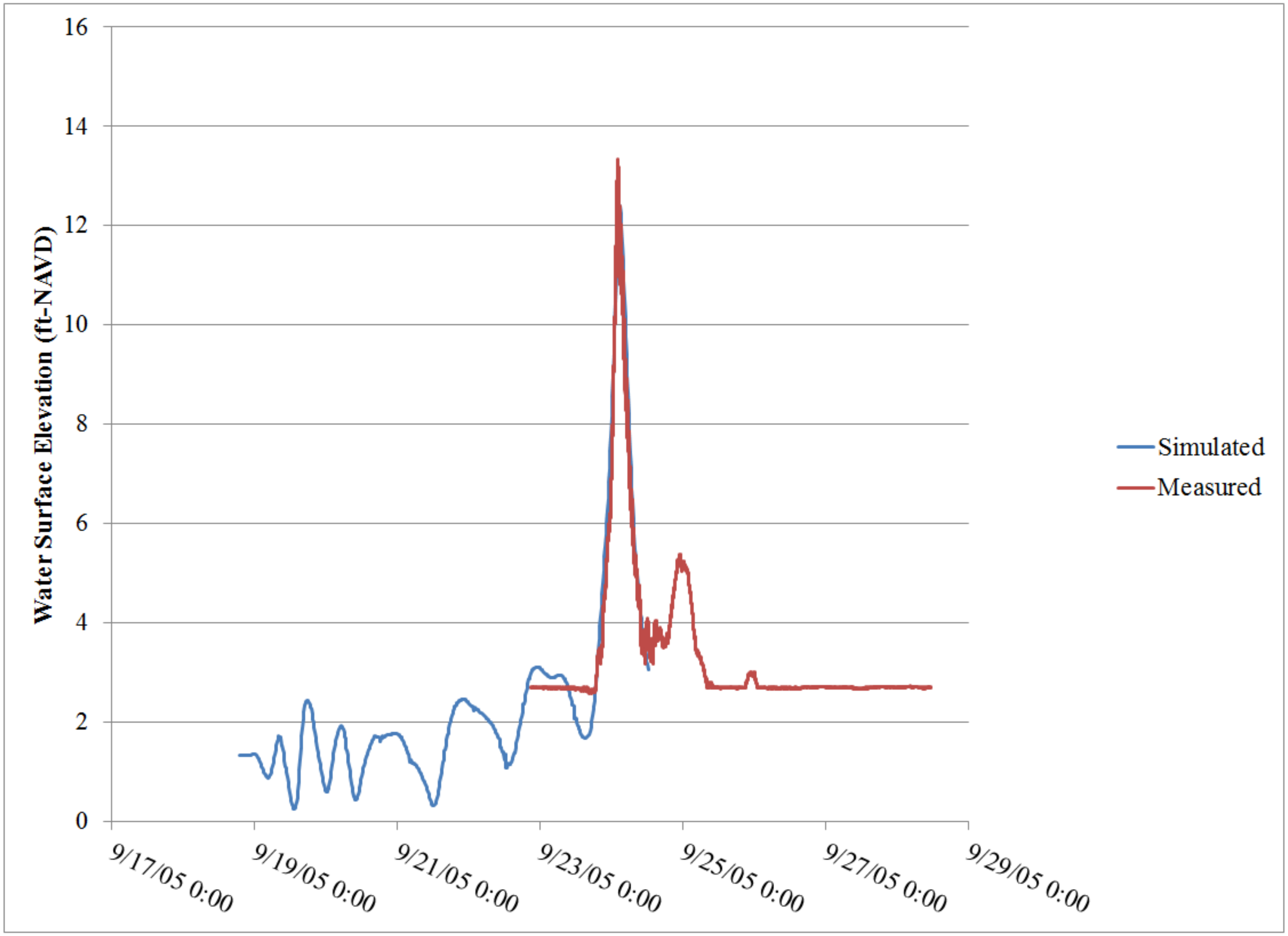


Figure C. 43
Hurricane Rita calibration comparison modeled versus observed at USGS gage LC8a

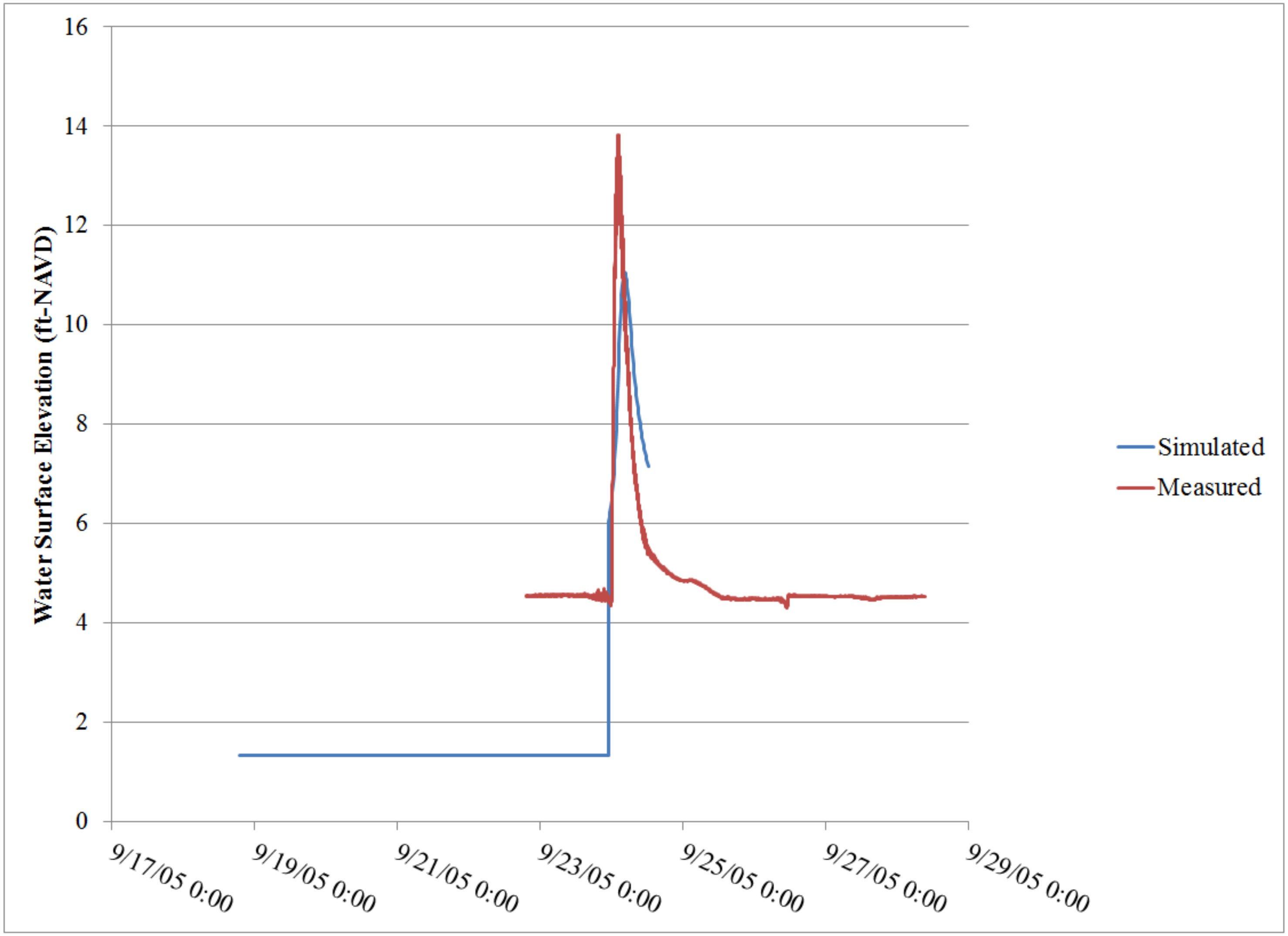


Figure C. 44
Hurricane Rita calibration comparison modeled versus observed at USGS gage LC9

Table C. 3
ADCIRC Hurricane Katrina verification results summary

Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
8747437	NA	NA	NA
8760922	0.05	0.45	6%
8761305	NA	NA	NA
8761724	-0.19	0.44	8%
8761927	NA	NA	NA
8762075	NA	NA	NA
8762372	0.23	0.7	13%
8762482	0.12	0.25	17%
8764044	0.59	0.96	40%
8764227	NA	NA	NA
8765251	-0.40	0.68	24%
8766072	-0.38	0.60	19%
8767961	NA	NA	NA
8768094	0.45	0.63	23%
8770570	NA	NA	NA

Table C. 4
ADCIRC Hurricane Rita verification results summary

Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
8747437	NA	NA	NA
8760922	-0.21	0.47	13%
8761305	NA	NA	NA
8761724	-0.44	0.73	17%
8761927	NA	NA	NA
8762075	-0.29	0.61	13%
8762372	0.21	0.64	16%
8762482	NA	NA	NA
8764044	-0.21	0.72	12%
8764227	NA	NA	NA
8765251	NA	NA	NA
8766072	NA	NA	NA
8767961	NA	NA	NA
8768094	NA	NA	NA
8770570	NA	NA	NA

Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
B15b	-1	1.2	13%
LA9	0.7	1.1	17%
LA9b	-0.3	0.7	6%
LA10	0.3	2.8	32%
LA11	0.9	1.1	8%
LA12	1.2	1.3	10%
LC2a	0.3	0.6	7%
LC5	-0.4	1	15%
LC8a	0.1	0.7	6%
LC9	0.1	0.7	10%

There is significant high water mark data available, as can be seen in Figure C. 5 and Figure C. 6. The ADCIRC results were also compared to high water marks collected after the passage of Hurricanes Katrina and Rita. It is important to remember that, unlike the ADCIRC simulations, the measured high water mark values are not actual measurements of the peak water surface elevation, but rather the elevation of debris lines. Although attempts are made to collect high water marks in protected areas, they can still include the effects of wave height and wave run-up. That said, the protected areas where the values are collected could also limit flow and represent elevations below the peak value.

Figure C. 45 and Figure C. 46 present the location of the high water marks for Hurricanes Katrina and Rita. In the figures, the measured high water mark is given as “M” and the simulated peak water surface elevation is given as “S.” Figure C. 47 and Figure C. 48 present a comparison between the ADCIRC predicted peak still water elevation and the high water marks for the hurricanes. In the figure, the x-axis is the simulated maximum water surface elevation and the y-axis is measured high water mark. The blue diamonds represent the values at comparison locations. The solid blue line represents perfect agreement. Values above this line indicate under prediction and those under the line over prediction. In general, there are more diamonds above the line, indicating the model predicts slightly lower water surface elevations than the measured high water marks. This is expected since the simulated values are strictly still water elevations and the measured values may include waves. Table C. 5 presents the mean error and root mean square error (RMS) for the comparisons. As the RMS and mean error demonstrate, the model successfully reproduced water surface elevations for both storms.

Table C. 5
Summary of high water mark comparisons

Hurricane	Mean Error (ft.)	RMS (ft.)
Katrina	0.2	4.8
Rita	-0.3	1.9

Figure C. 45
Location of hurricane high water marks for Hurricane Katrina

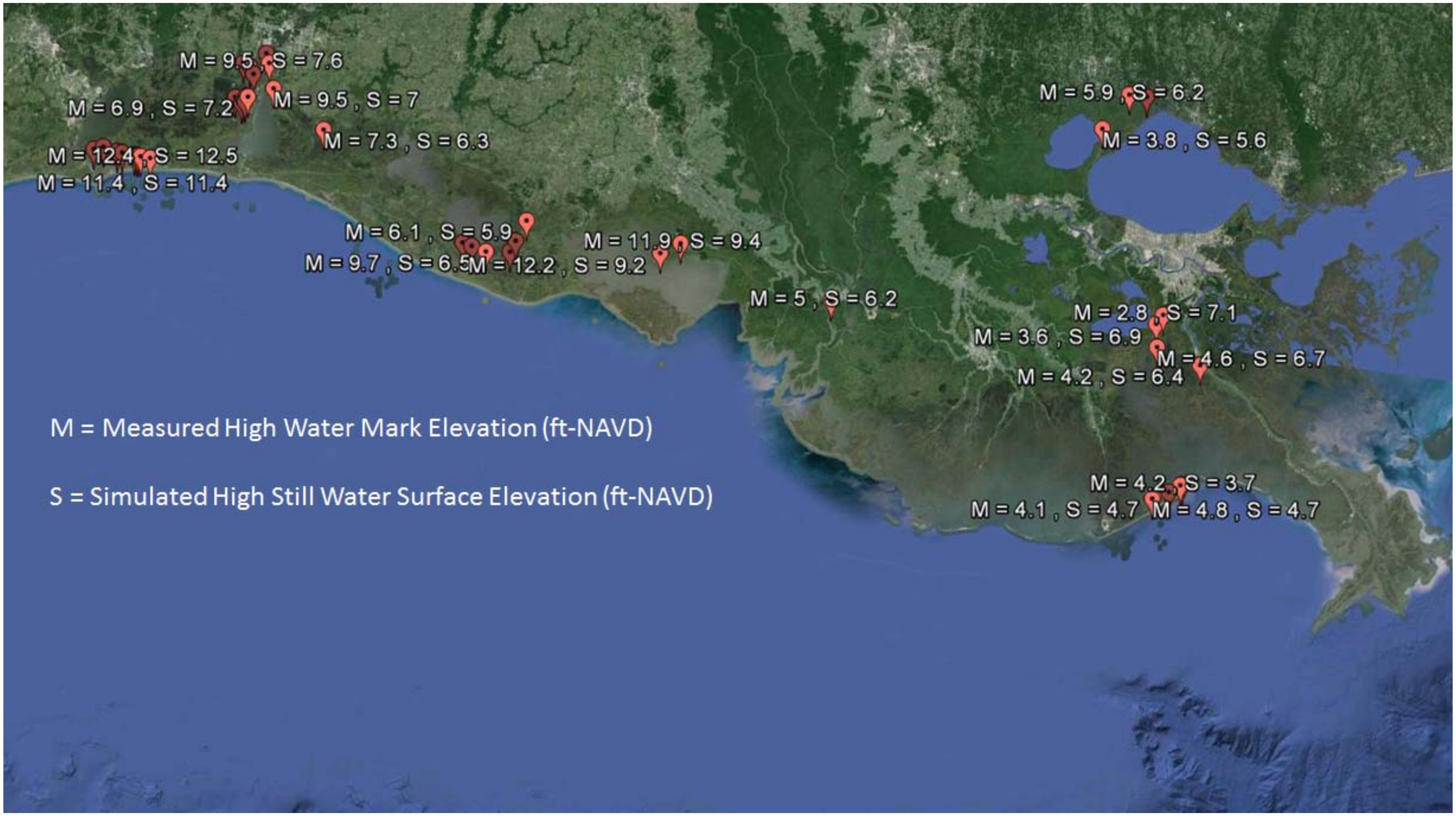


Figure C. 46
Location of hurricane high water marks for Hurricane Rita

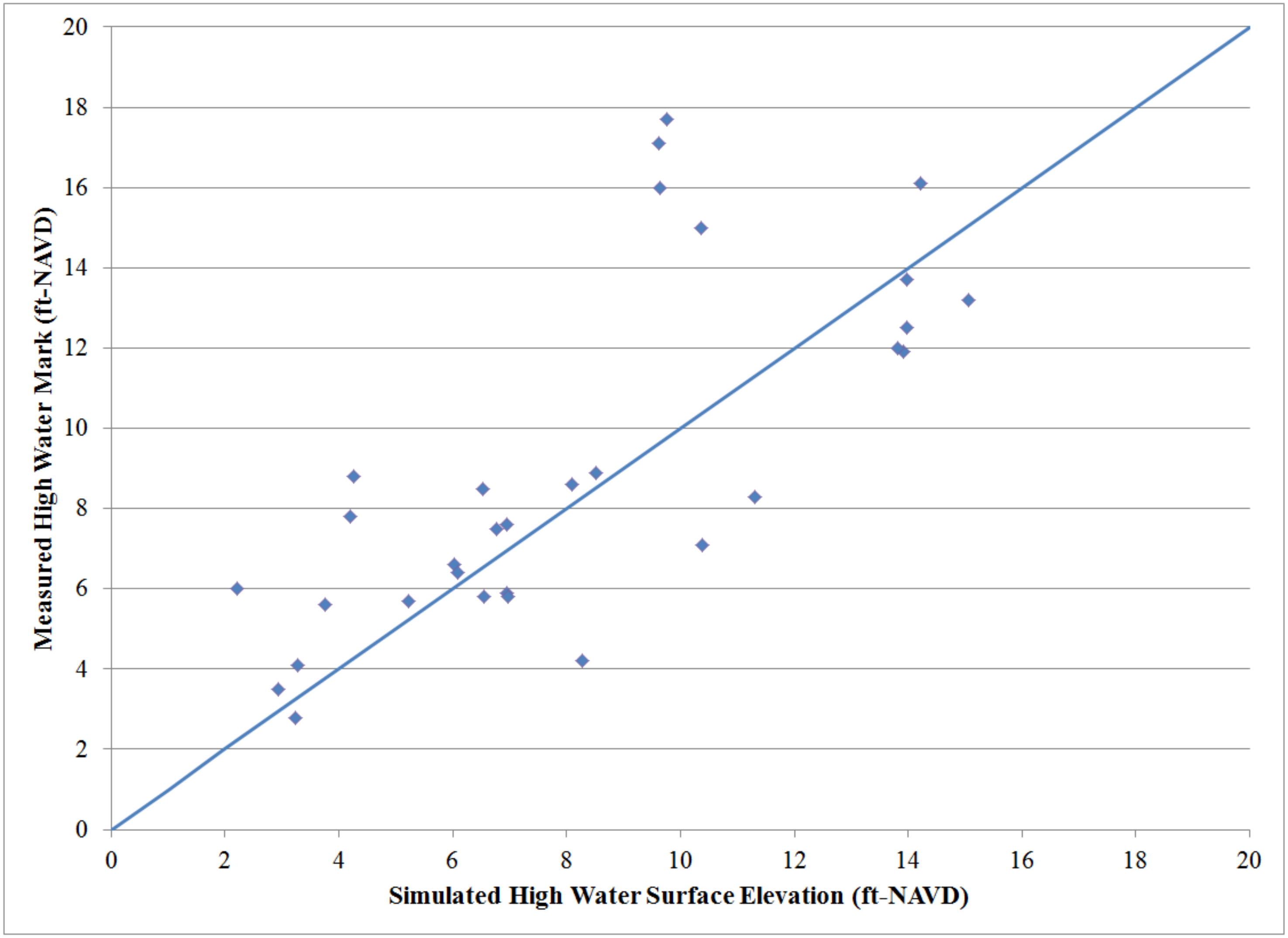


Figure C. 47
Simulated high water surface elevation versus measured high water marks plots for Hurricane Katrina

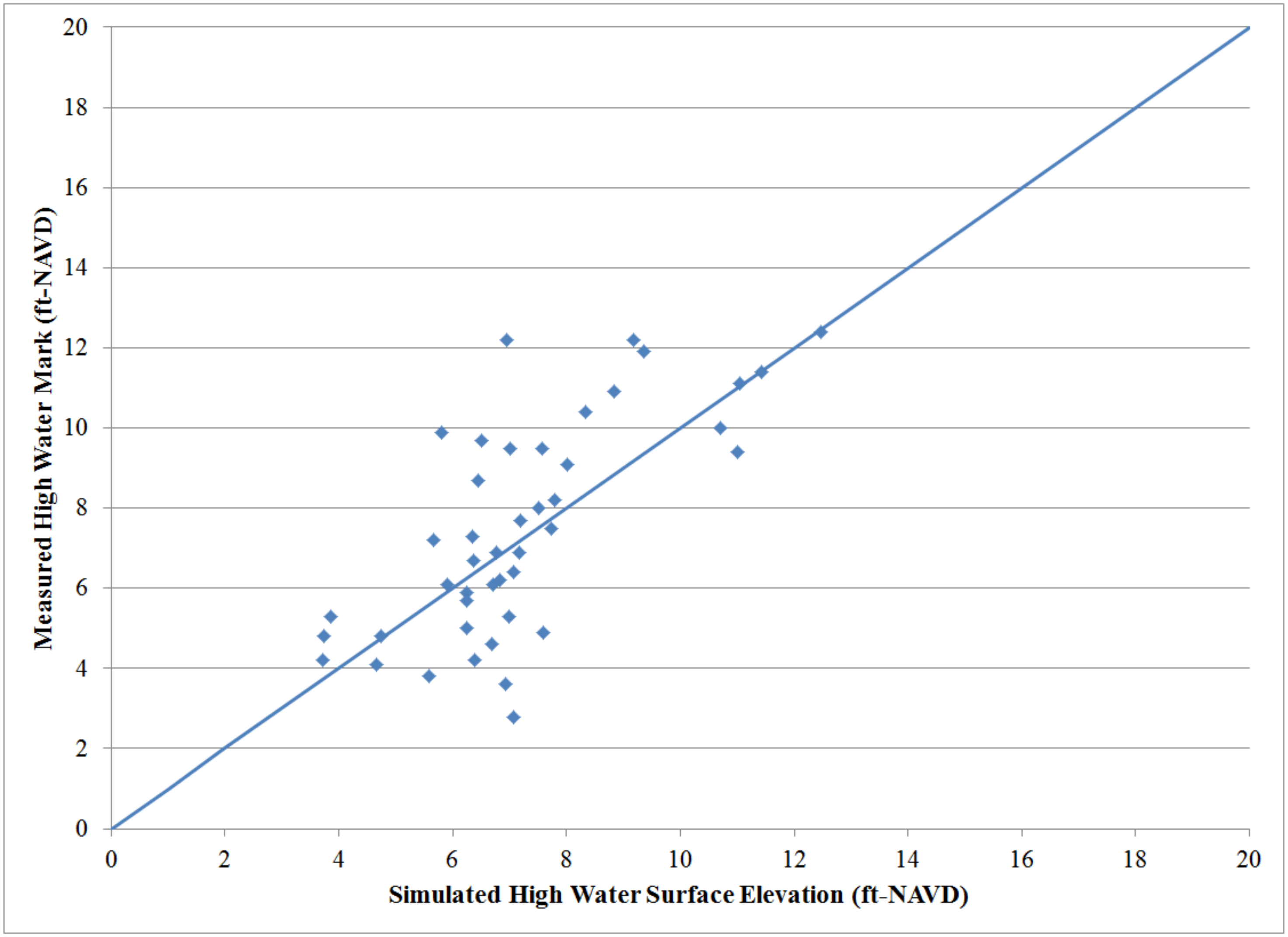


Figure C. 48
Simulated high water surface elevation versus measured high water marks plots for Hurricane Rita

SWAN Model Calibration

Calibration of the SWAN model focused on the four National Data Buoy Center (NDBC) wave stations and two USACE gages with locations shown in Figure C. 49. Figure C. 50 through Figure C. 58 present comparisons between SWAN predicted and NDBC and USACE measured significant wave heights at the four NDBC and two USACE stations. Significant wave height is the average height of the one-third highest waves in a wave spectrum. Qualitatively, the model did a good job of predicting significant wave height. That said, there are some deviations, particularly in the days leading up to the storm. This is likely due to the presence of very small waves and the difficulty of predicting both meteorology and wave climate during times of relative quiescence. Table C. 6 presents a summary of the results. Positive values indicate over prediction of wave height and negative values under prediction. The average percent error ranged from a low of 7 percent to a high of 23 percent and an average of 13.9 percent. SWAN results consistently compared better with the observations at the near shore gage —42040. This is due to the higher mesh resolution in the near shore region. Notably the mesh resolution is highest near the bridges, so one would expect better results in these areas. Given the low errors and the slight tendency to over predict, the calibration was deemed within acceptable bounds and as such, the wave model was considered calibrated.

Figure C. 49
NOAA NDBC wave station locations

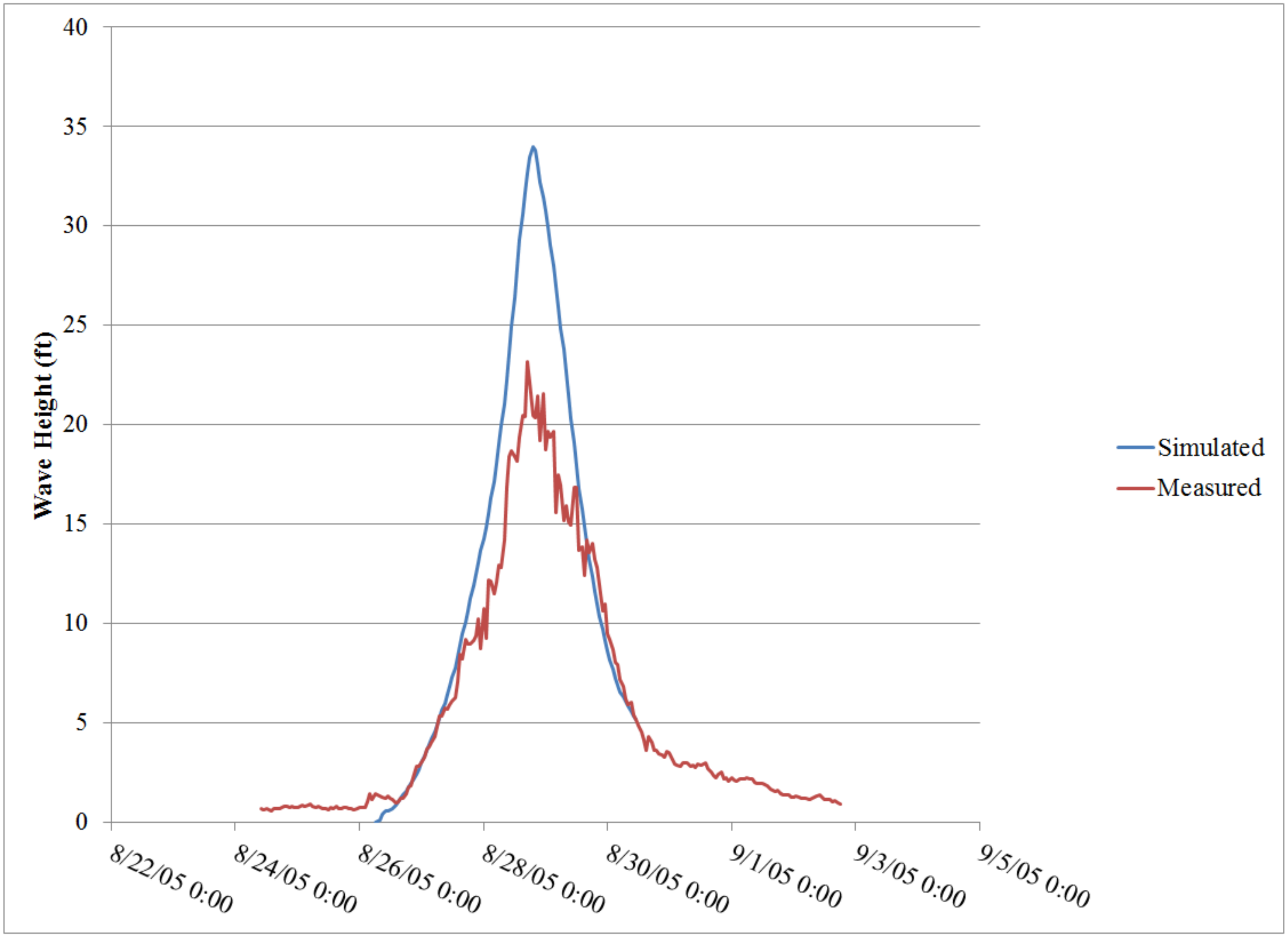


Figure C. 50
Hurricane Katrina SWAN calibration comparison simulated versus measured at NOAA NDBC station 42001

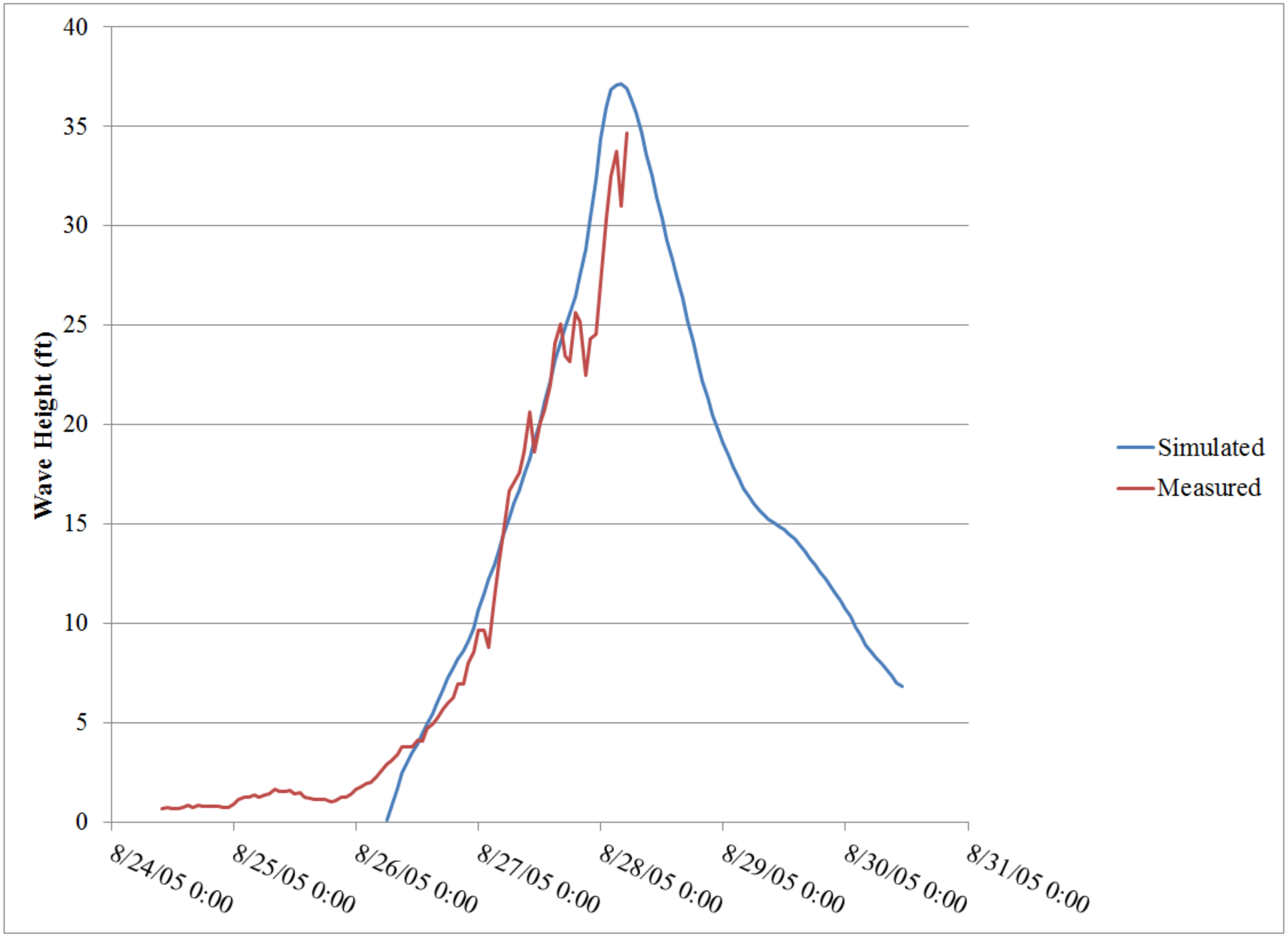


Figure C. 51
Hurricane Katrina SWAN calibration comparison simulated versus measured at NOAA NDBC station 42003

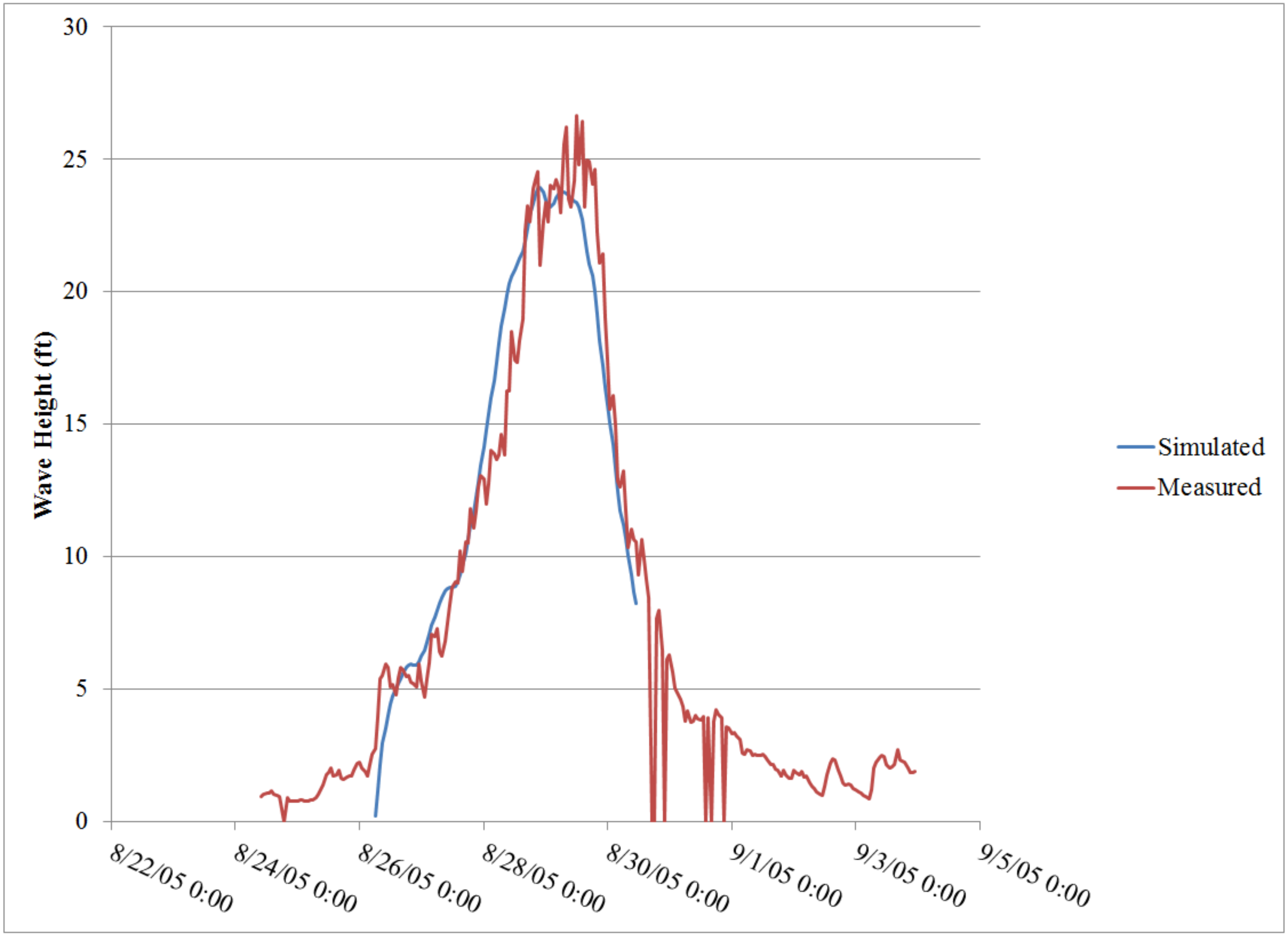


Figure C. 52
Hurricane Katrina SWAN calibration comparison simulated versus measured at NOAA NDBC station 42039

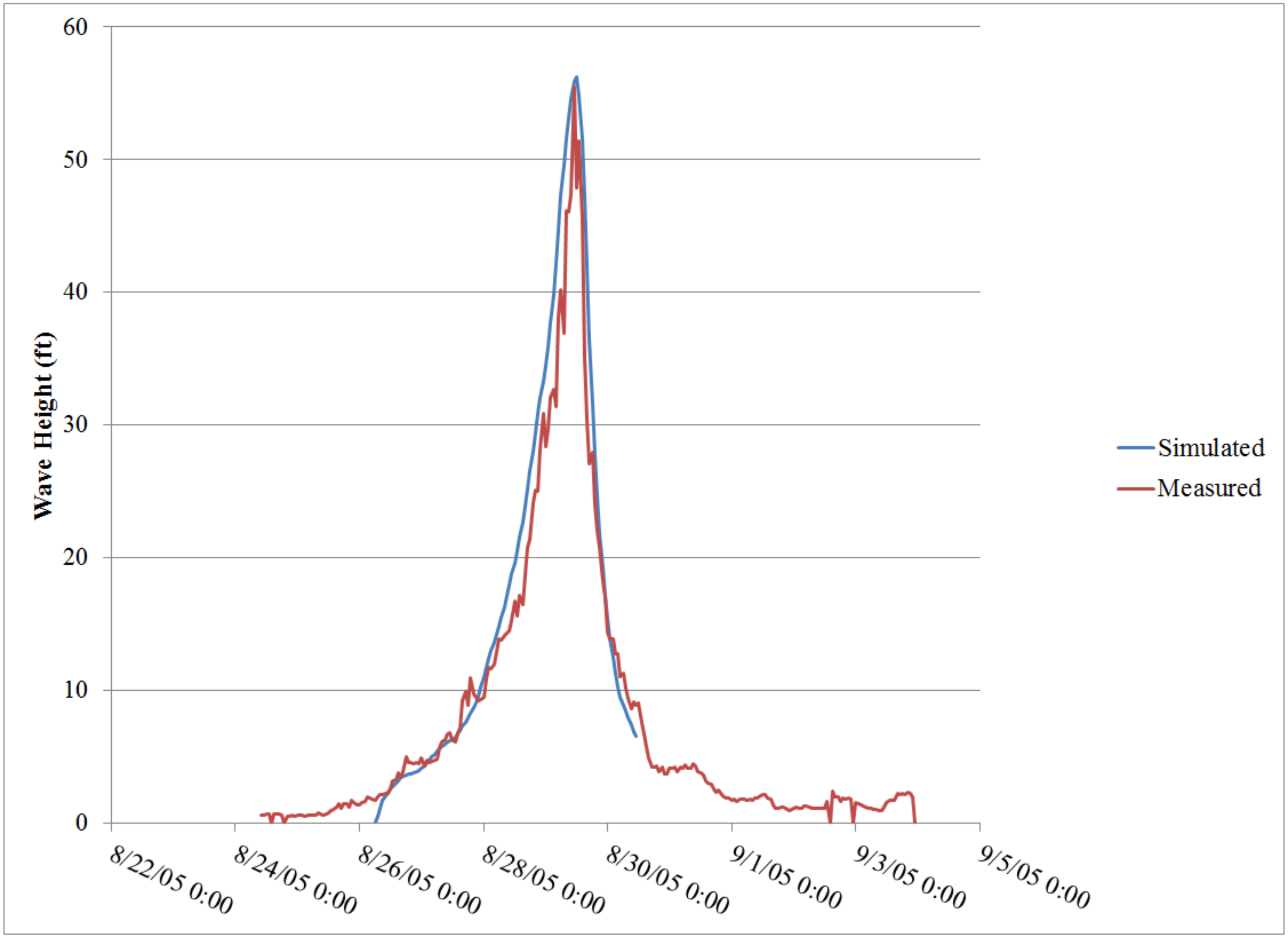


Figure C. 53
Hurricane Katrina SWAN calibration comparison simulated versus measured at NOAA NDBC station 42040

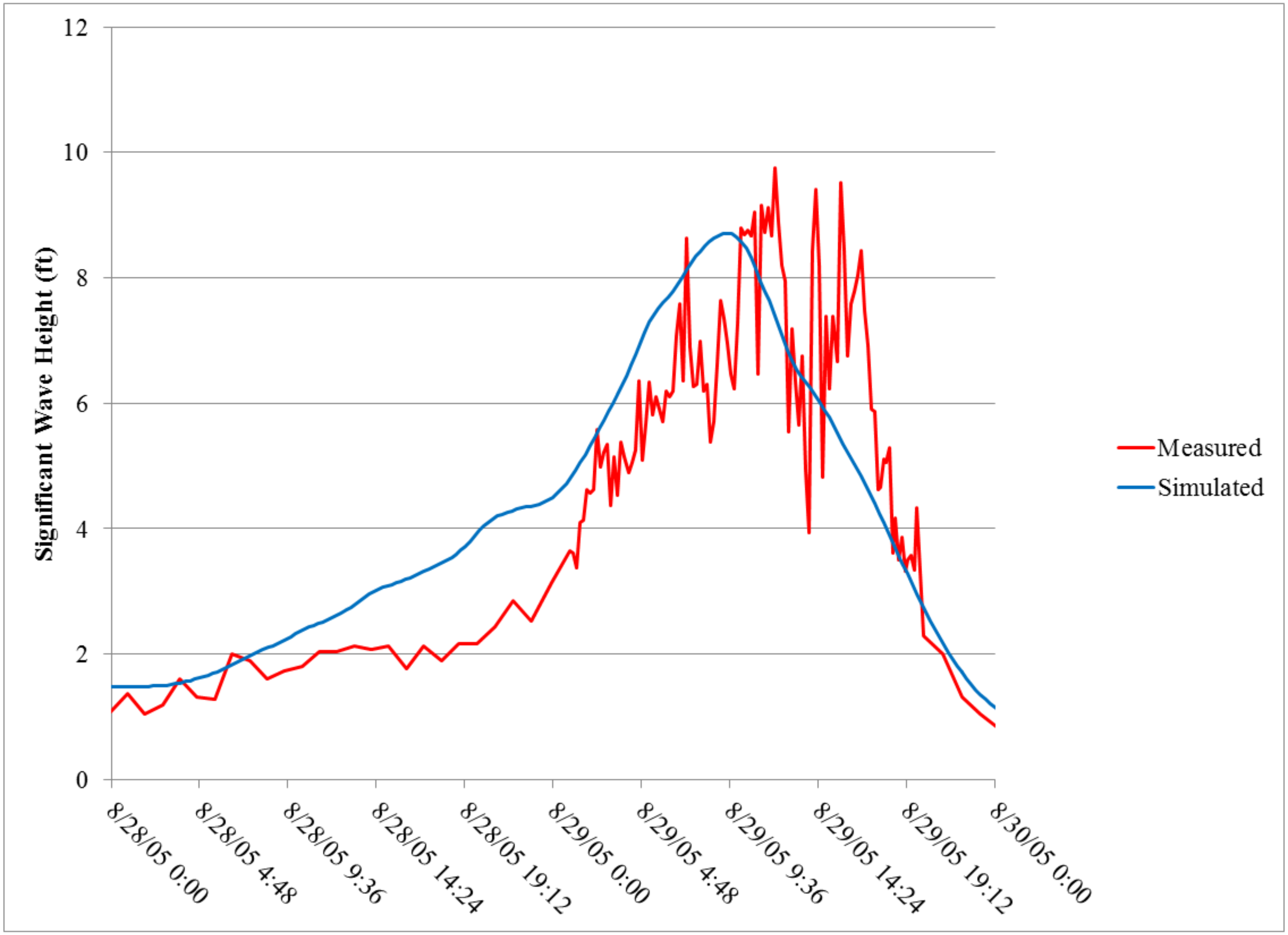


Figure C. 54
Hurricane Katrina SWAN calibration comparison simulated versus measured at USACE station 22

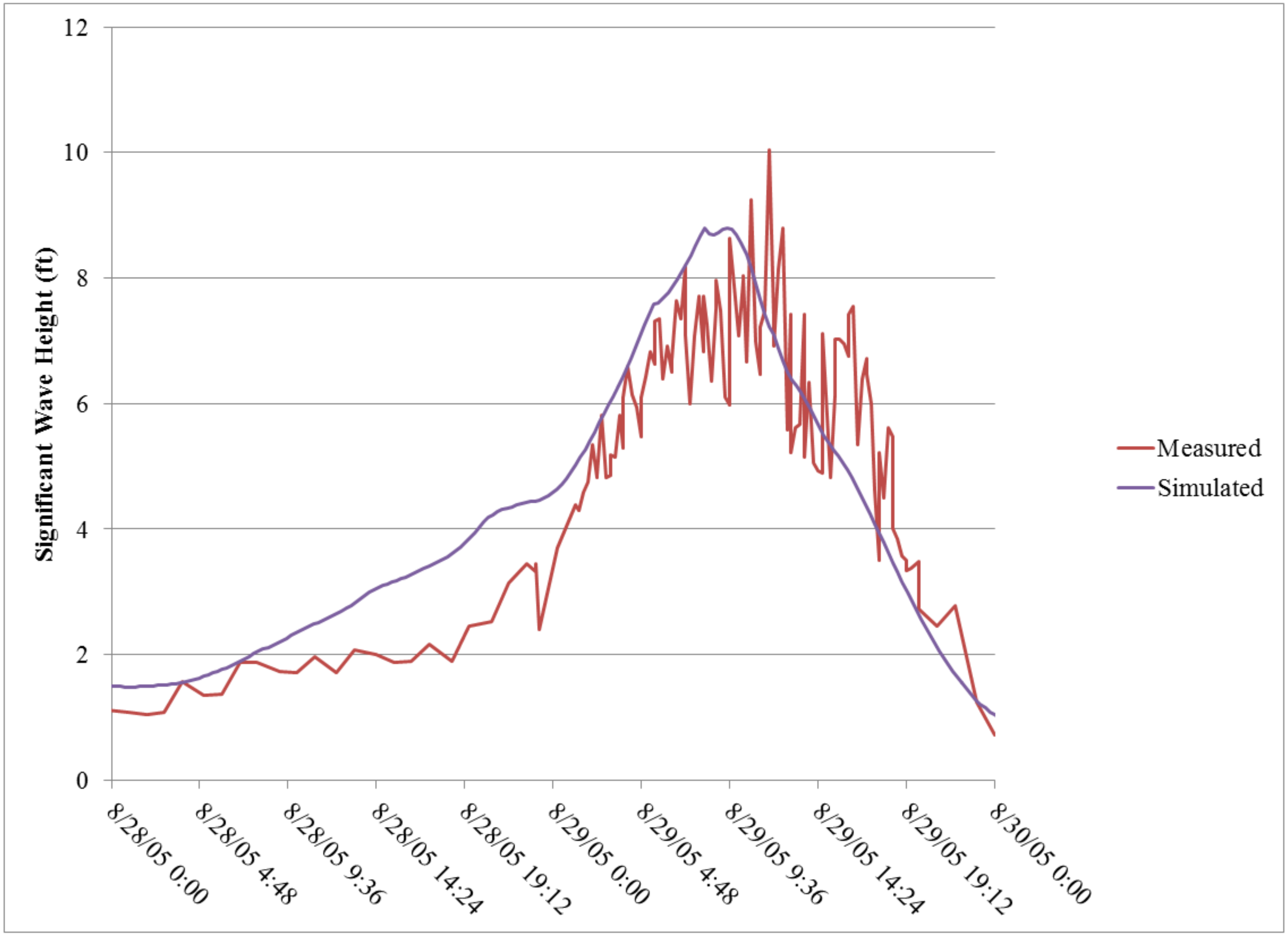


Figure C. 55
Hurricane Katrina SWAN calibration comparison simulated versus measured at USACE station 23

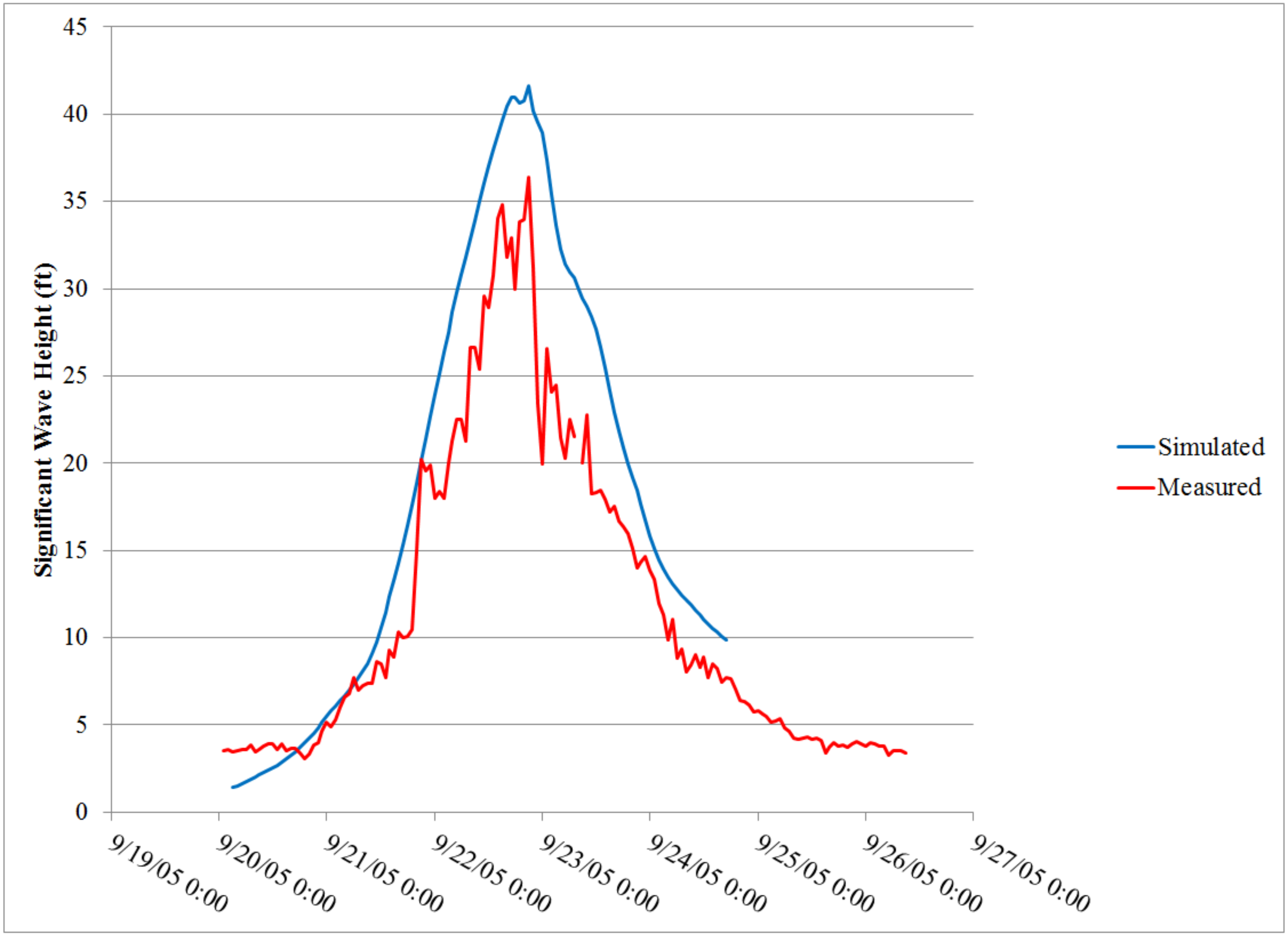


Figure C. 56
Hurricane Rita SWAN calibration comparison simulated versus measured at NOAA NDBC station 42001

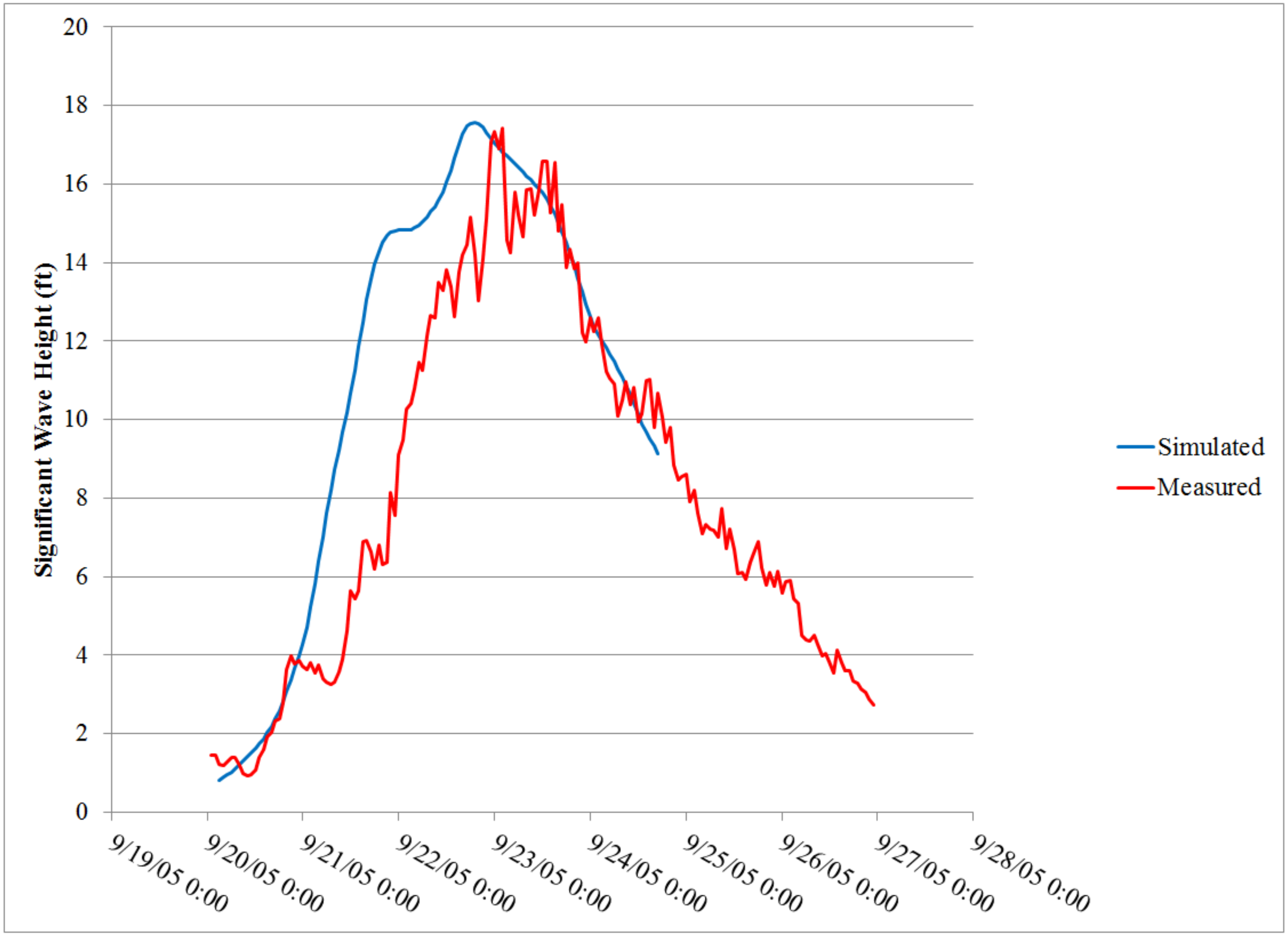


Figure C. 57
Hurricane Rita SWAN calibration comparison simulated versus measured at NOAA NDBC station 42040

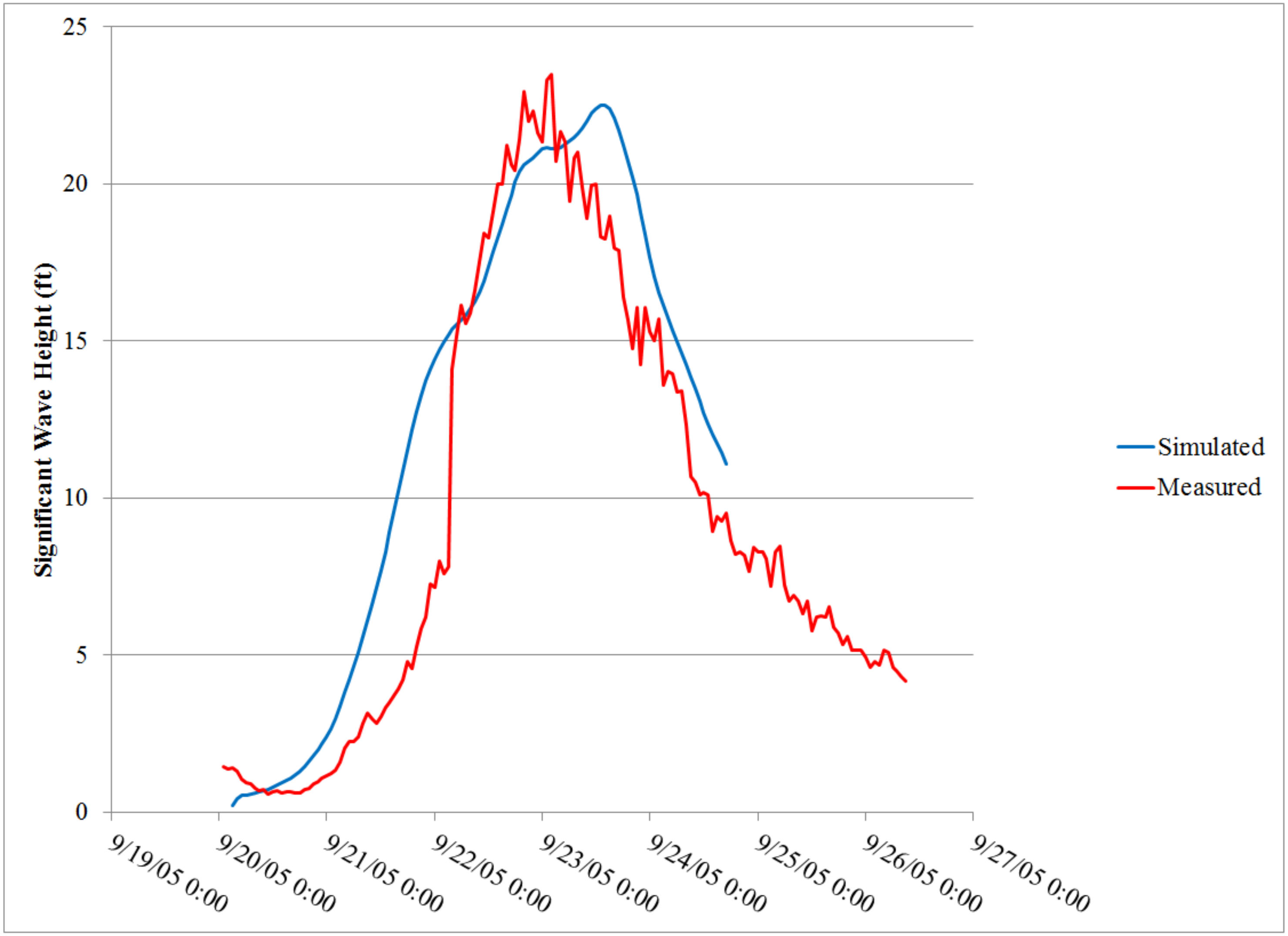


Figure C. 58
Hurricane Rita SWAN calibration comparison simulated versus measured at NOAA NDBC station 42039

Table C. 6
SWAN calibration summary

Hurricane Katrina

Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
42001	3.04	5.26	23%
42003	1.23	2.82	8%
42039	0.02	1.76	7%
42040	1.85	3.96	7%
22	0.47	1.09	12%
23	0.43	0.92	9%

Hurricane Rita

Gage	Mean Error (ft.)	RMS Error (ft.)	Average Percent Error
42001	4.68	7.00	19%
42003	NA	NA	NA
42039	2.35	4.03	23%
42040	2.36	3.95	17%

References

C.1. Federal Emergency Management Agency. Guidelines and Specifications for Flood Hazard Mapping Partners. Region VI and FEMA Headquarters, 2007.

APPENDIX D: SHIFTED STORM PATHS

Increasing the amount of data available for the extreme value analyses required shifting the path of each of the selected storms by ½ degree (approximately 30 nautical miles) in either direction from the original path. The initial landfall location for all hurricanes was identified as the reference point. For non-land falling storms, the reference point was chosen as the point closest to the shore. The shift vector was defined as the vector normal to the hurricane path at the reference point (Figure D. 1). The hurricane path was shifted ½ degrees in both directions along the shift vector. The original path is shown with thick solid green and the shifted paths are shown with dashed red lines. The magenta arrow shows the hurricane path at the reference point and the black arrows show the shift vectors normal to it.

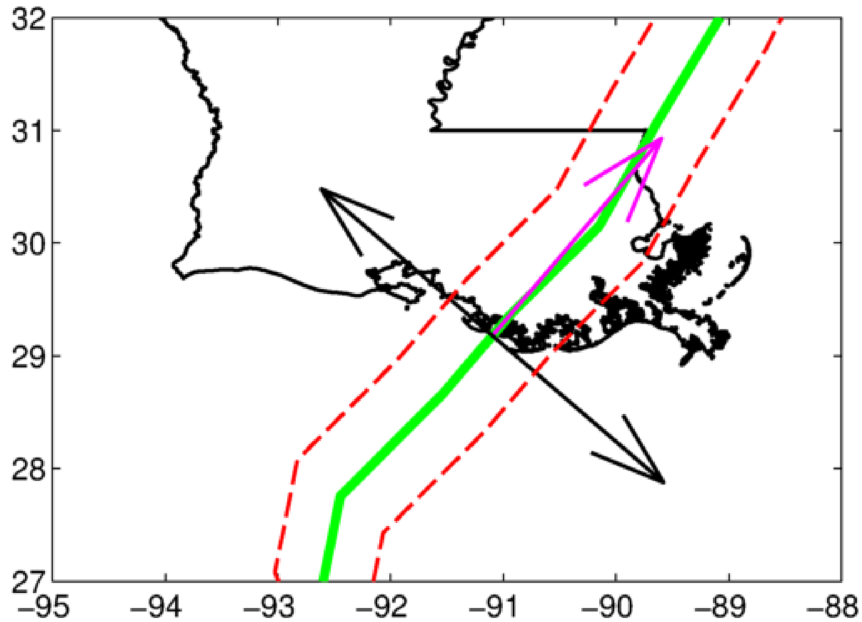


Figure D. 1
Example of hurricane path shift showing unit vectors

These three storm paths do not have equal probability of occurrence. Calculating these probabilities first required identifying all the storms with similar strengths and headings. Figure D. 2 shows the similar hurricane paths for the example storm. Next, the locations where each of these similar storms intersect the shift vector were identified as well as the distance from the reference point. These distances provide the basis to create a hurricane path probability distribution. A kernel density estimator was employed to create a continuous function to calculate probabilities for the original and shifted paths (Figure D. 3). The probabilities calculated for the three paths were normalized to add up to one giving relative probabilities for each.

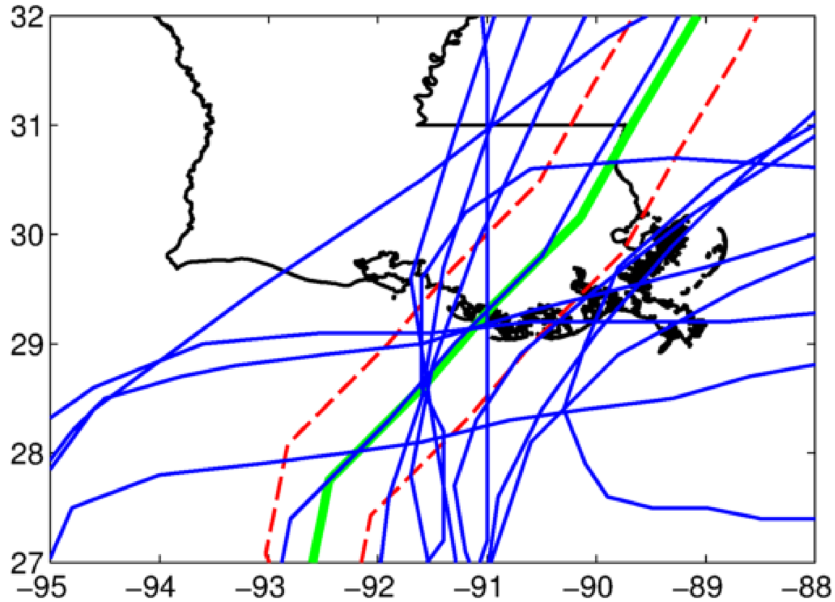


Figure D. 2
Hurricanes with similar strengths and headings

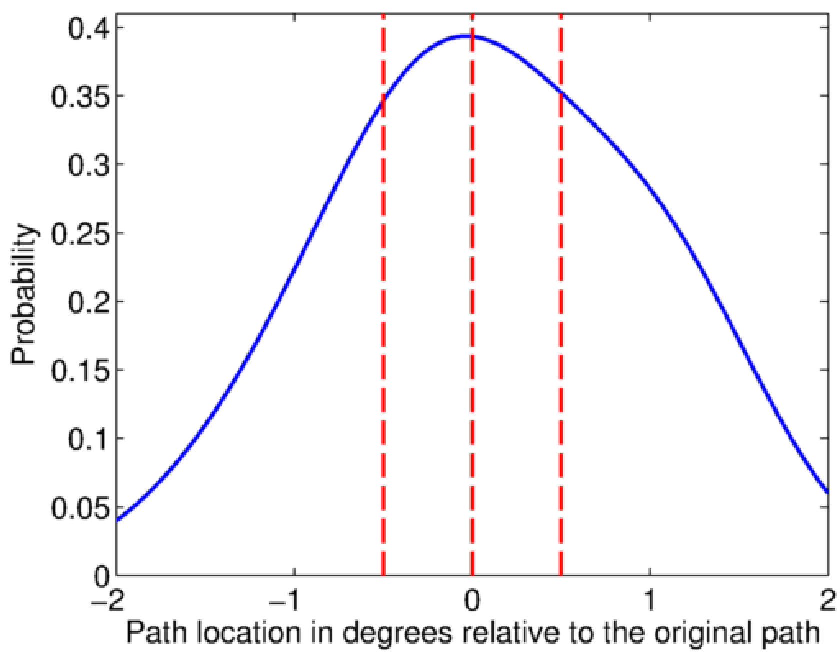


Figure D. 3
Hurricane path probability distribution

Table D. 1 presents the computed path shift relative probabilities for a few example hurricanes along with the shift vector and number of similar storms employed in the calculations.

Table D. 1
Example hurricane path shifts

Hurricanes		Relative Probabilities			Number of Similar Hurricanes	Shift Unit Vector	
		Shifted	Original	Shifted			
Name	Date	Left	Path	Right		Lon	Lat
Not Named	04-Sep-1947	0.31	0.34	0.35	29	-0.48	-0.88
Not Named	27-Sep-1949	0.26	0.50	0.23	6	-0.81	0.58
AUDREY	25-Jun-1957	0.49	0.29	0.22	10	-0.98	0.21
ETHEL	14-Sep-1960	0.12	0.31	0.56	7	-0.99	-0.12
HILDA	28-Sep-1964	0.31	0.47	0.22	20	-1.00	0.00
BETSY	27-Aug-1965	0.41	0.32	0.27	21	-0.65	-0.76
CAMILLE	14-Aug-1969	0.37	0.37	0.26	9	-0.93	-0.36
EDITH	05-Sep-1971	0.32	0.34	0.34	20	-0.59	0.81
CARMEN	29-Aug-1974	0.40	0.34	0.26	24	-0.91	-0.41
FREDERIC	29-Aug-1979	0.35	0.33	0.32	38	-0.99	-0.14
DANNY	12-Aug-1985	0.30	0.34	0.36	6	-1.00	-0.09

APPENDIX E: EXTREME VALUE ANALYSES DETAILS

Statistics at Bridge Sites

The purpose of the hindcasts is to capture the statistical properties of the hydrodynamics for the region including water surface elevations and wave heights. Water surface elevations due to astronomical tides can amplify or reduce the effects of a storm depending on the phase of the tide during hurricane landfall. This phasing is a random parameter, independent of the storm itself. In order to capture more of the variability of the storm effects, the phase of the tide was treated as a random parameter. One month of tide was simulated without wind and the results stored. The storms were simulated without tide and the tide values superimposed on the results for approximately 1,000 different phases for each storm. This superposition methodology was tested and found to be a valid approach as detailed in Astronomical Tides section of this Appendix.

Extreme value analysis typically involves fitting a probability distribution such as the Generalized Extreme Value Distribution to the data and the desired return interval values obtained from the distribution. The simulated storms were chosen such that every large storm that affected at least one coastal bridge in the state was included in the data set. This means that some of the storms only affected a portion of the study area. Using the entire data set for a particular location would mean including storms that were not extreme events for that location skewing the results. There are distributions, such as Generalized Pareto (GP) distribution, that only use data larger than a defined threshold. However, there are no methods for choosing the thresholds and this procedure cannot be automated. Manually choosing the thresholds for dozens of locations for two different parameters is not practical. Since in this case there is 480 years of data (with the caveats discussed in Extreme Value Analysis Section) and it is the 100-year conditions that are of interest, the empirical cumulative distribution functions or CDF method provides the most appropriate methodology for this application.

With the availability of 480 years of historical data, the 100-year return interval for the parameters of interest were calculated directly via the empirical cumulative distribution function (CDF) method. Figure E. 1 presents an example return interval value plot created with empirical CDFs. The y-axis displays the sorted return values and the x-axis shows the corresponding return values calculated from the following equation:

$$\mathrm{RI} = \frac{Ty}{i - 0.5} \qquad \text{(E-1)}$$

where,

i = ranking starting with the highest value, and

T_y = total observation period (480 years)

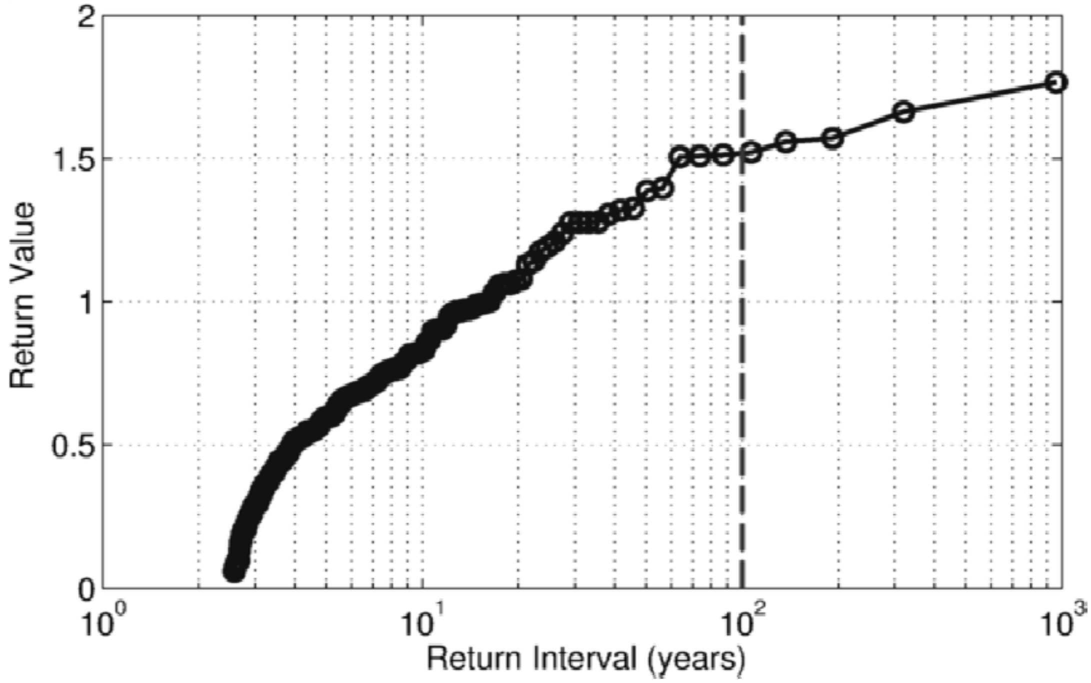


Figure E. 1
Example return interval plot (dashed vertical line illustrates 100-year return period)

Bootstrapping

Bootstrapping is a statistical method for finding confidence intervals for sample estimates. For this project, bootstrapping was employed to include different tide phases and different probabilities of occurrence for each storm into the statistical analysis. During the application of the bootstrapping method, data is re-sampled with replacement from the original dataset. Due to the replacement, some data points from the original data set can appear more than once in the new data set, while others do not appear at all. This re-sampling process was repeated 1,000 times yielding 1,000 predictions of the desired statistic (for example, the 100-year wave height at the time of maximum water surface elevation at a particular bridge pier location). Finally, the median of the 1,000 values is calculated to produce the most likely value (the one employed in this study).

The paths of each simulated storm have a probability of occurrence as determined by examining the paths of the storms affecting Louisiana coastal waters. This includes the actual storm paths as well as those created by shifting the paths. Note that the shifted path storm may have a higher probability of occurrence than the actual path (Appendix D).

In this application of the bootstrapping method, the storms are resampled randomly based on their probability of occurrence. Once a storm is selected (resampled), the time series results from the one month's tide simulation (with a random phase shift to that of the storm) are superimposed on the corresponding values from the storm simulation. For example, the phase shifted tide generated water surface elevations are added to the water surface elevations produced by the storm simulation at each mesh node and each time step. The desired quantities (such as the wave heights at the point in time of maximum water surface elevation) at all nodes are then extracted from the resulting time series. The desired quantity is extracted for all 124 storms and the 100-year return value is calculated. This process was repeated 1,000 times yielding 1,000 100-year return values for the desired quantity. These values were ranked in size starting with the smallest value. The median of this data provides the values reported in Extreme Value Analysis Results Section. The same procedure was repeated for different parameters of interest. A flowchart of the procedure is shown in Figure E. 2

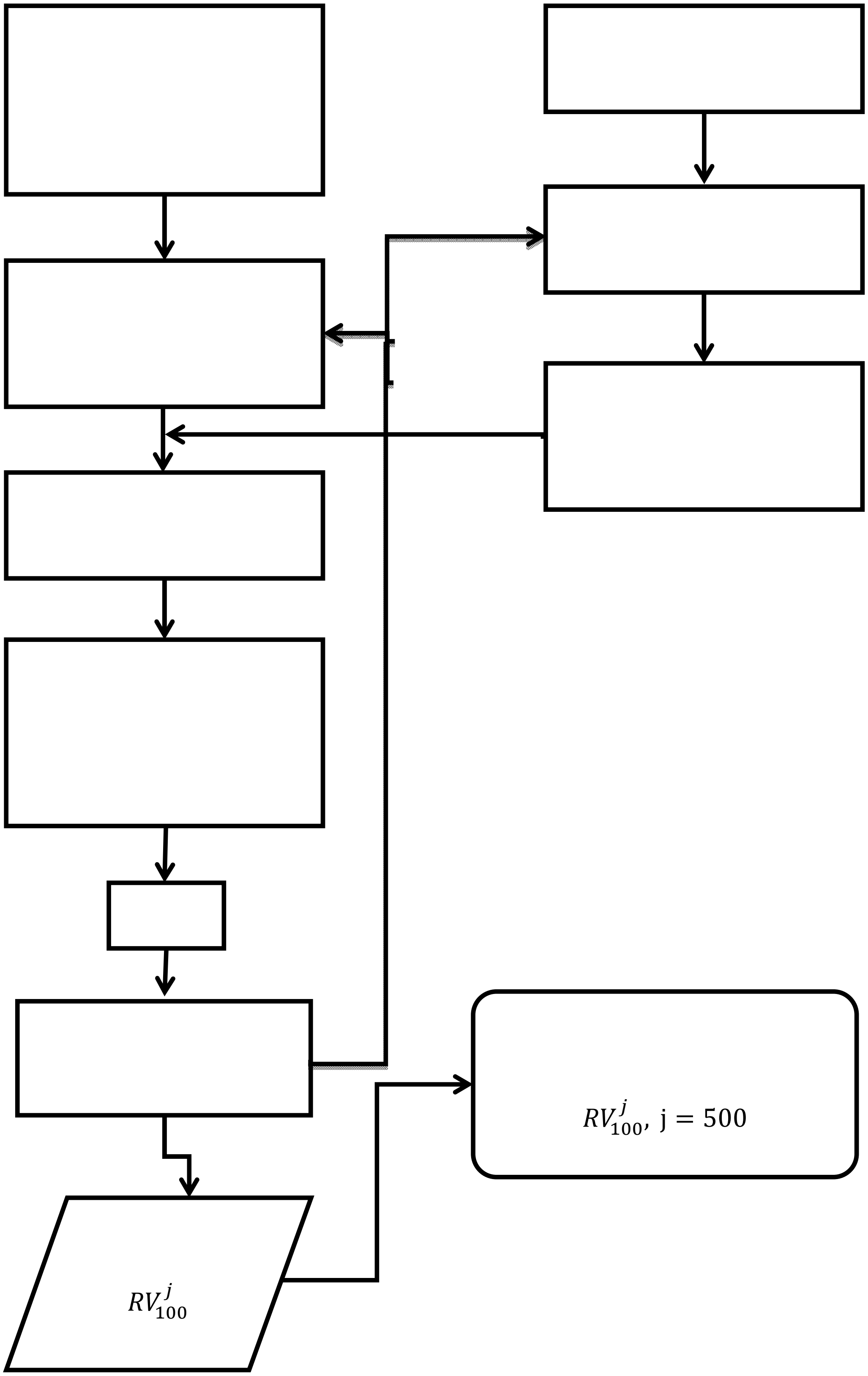


Figure E. 2
Flowchart of the return value calculation process for bridge locations via non-parametric bootstrapping

Whole Domain Statistics

One hundred-year return values were also calculated at all of the more than 600,000 nodes that comprise the ADCIRC+SWAN model mesh for use in the GIS application and contour plots. However, the bootstrapping method employed for the bridge sites is computationally demanding and cannot be performed at all the nodes. At the nodes, the extreme value statistics were calculated once via the empirical CDF method, taking the different probabilities for hurricanes into account. Root mean squared values for tidal WSE were added to get the final result. Even though the mean tidal WSE is zero, their effect on the 100-year values is positive. Adding the root mean squared values provides a reasonable conservative method to account for tidal effects. Due to this difference in methodology, the reported parameters at a bridge site calculated by the two different methods may be slightly different. The values calculated at the bridge sites via the bootstrapping method are more accurate and should be used when available.

Statistics for Associated Parameters

The parameters of wave height at the time of maximum water surface elevation, peak period at the time of maximum water surface elevation, water surface elevation at the time of maximum wave height, and peak period at the time of maximum wave height are not independent values. These values are correlated with their associated parameters: maximum water surface elevation and maximum significant wave height. As such, independent statistical analysis cannot be performed on these parameters. Instead, the associated parameters were correlated with their main parameters via linear regression. Figure E.3 illustrates an example of this calculation. In the figure, the vertical axis is the associated water surface elevation and the horizontal axis is the maximum wave height. The magenta line shows the linear regression fit. Note that only the largest ten values on the x-axis are included in the correlation since only large values are relevant to the 100-year value. The red dashed line is the 100-year value for the maximum wave height (h_h) and the green star is the 100-year value for the associated water surface elevation (wse_h) — taken at the intersection of the red and magenta lines. In the plot, the two parameters are highly correlated with a negative correlation coefficient. All the associated parameters were calculated via this methodology for both the bridge locations and GIS maps.

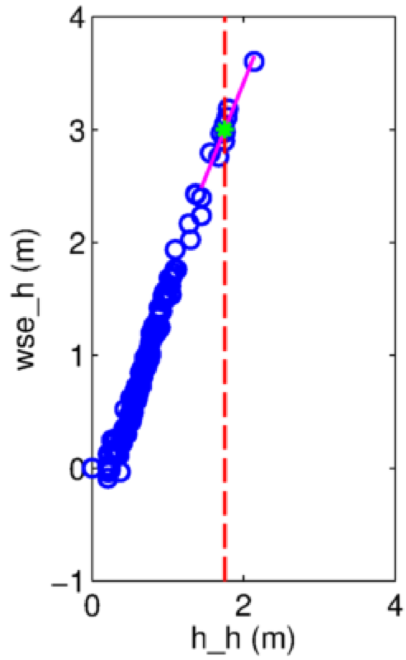


Figure E. 3
Example of correlations of associated parameters to their main parameters

Astronomical Tides

The validity of superimposing the tides was investigated during a similar study performed in North Carolina in 2012. For that study, water surface elevations and wave heights generated from calibration hindcasts were compared to those generated by superimposing the tide and storm surge. Figure E. 4 and Figure E. 5 present comparisons of water surface elevation and wave height at different bridge locations throughout North Carolina. Since the physical principles behind the process do not change from location to location, this analysis is valid in Louisiana. In the figures, the vertical axes are the results from the superimposed tide method, the horizontal axis is the hindcasted (simulation with the tide) result, and each point represents the maximum value of the parameter during the storm at one bridge location. The diagonal line in the figures represents an exact agreement between the two methods, points above the line are cases where the superimposed tide method prediction is higher, and points below the line are cases where the hindcasted value is greater. As the figures demonstrate, the superposition method is more accurate for water surface elevation, but less accurate for wave height. That said, the differences are not biased in either direction, but rather are random. Bias in prediction influences 100-year return values more than random errors, since random errors will cancel each other out. There is very little over prediction bias introduced by superposition. For the wave height results, there is no superposition of simulation results since the tide-only simulations do not include wind. However, tides still have an impact on wave heights.

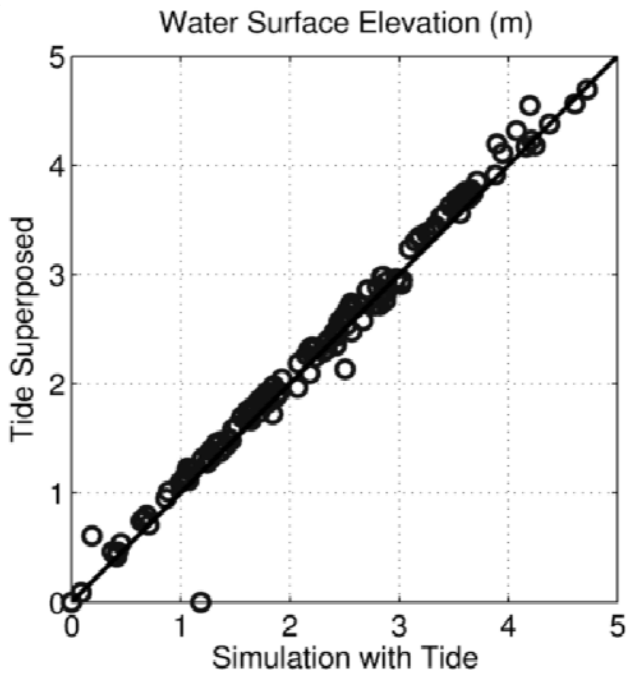


Figure E. 4
Accuracy of superposition method for maximum water surface elevations at NC bridge locations during Hurricane Isabel (2003)

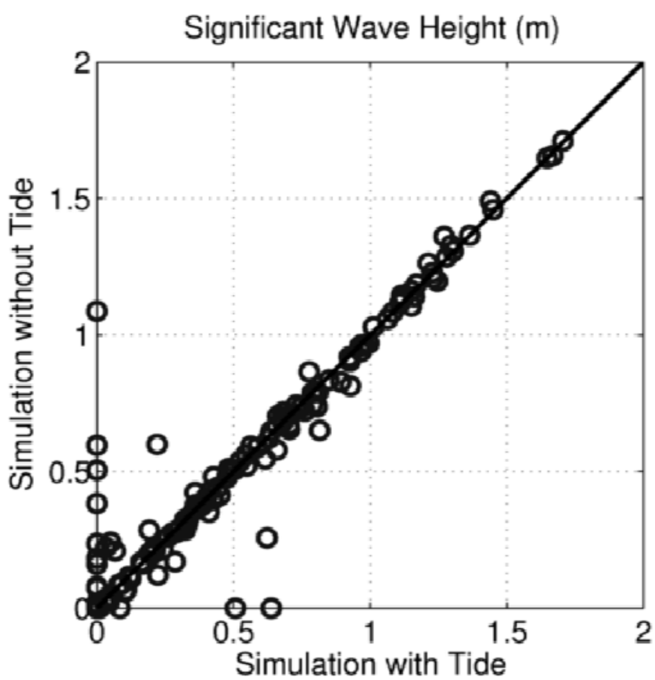


Figure E. 5
Accuracy of superposition method for maximum significant wave height at NC bridge sites during Hurricane Isabel (2003)

APPENDIX F: DESIGN WAVE PERIOD

As per the AASHTO guide specifications, the design wave height employed in the analysis of surge/wave forces on bridge superstructures is 1.8 H_s where H_s is the significant wave height (average of the one-third highest waves). This height is, however, subject to the depth-limited constraint,

$$H_{max} \leq 0.65 d_s \tag{F-1}$$

The distribution of periods (and wave lengths) associated with maximum wave heights in coastal waters under hurricane conditions were investigated as part of Level 3 application for the bridges surrounding Tampa Bay, FL, for the Florida Department of Transportation. The results of that analysis are summarized below.

Wave time series can be constructed from a given wave spectra *[F.1]*. Constructing these time series requires the assumption of random phases for each of the wave components. Due to this random phasing of components, a different time series results for each construction. If, however, a large number of constructions are performed, the statistical properties of the design wave height and associated period can be calculated.

Six hurricanes out of 150 that were hindcasted for Tampa Bay were selected for additional analysis. Time series constructions employed wave spectra at the time of maximum wave heights at 6 different locations within the modeled area for each storm. One-thousand time series were constructed for each wave spectra. A zero-crossing analysis identified the individual waves. Each time series had approximately 120 waves or a total of approximately 120,000 waves for each spectrum. This large number of simulations was required since only a very small portion of the waves were close to the design wave height. All waves with a wave height greater than 1.7 times the significant wave height were extracted along with their periods for analysis. The significant wave period (average period of the 1/3 highest waves) for these waves was computed. This led to the following relationship between the significant wave period and significant wave height, H_s.

$$\mathrm{T_s}(\text{for H} > 1.7\mathrm{H_s}) = \alpha\sqrt{\mathrm{H_s}} \tag{F-2}$$

where the constant α was found to equal 2.0 s/ft$^{1/2}$ with two standard deviation confidence limits of 1.8 s/ft$^{1/2}$ and 2.3 s/ft$^{1/2}$. Note that these values were developed for locations within bays and somewhat protected waters and are expected to be larger in the open ocean. Since surge/wave forces on bridge superstructures are a complex function of wave length, span width, span low chord elevation, etc. a range of periods need to be considered. Wave forces were calculated employing three different periods for each wave height considered in this study: two from the equation above using 1.8 s/ft$^{1/2}$ and 2.3 s/ft$^{1/2}$ coefficients and the peak period from the wave model.

References

F.1. Dean, R.G. and Dalrymple, R.A. Water Wave Mechanics for Engineers and Scientists. World Scientific Publishing Co. Pte. Ltd., New Jersey, 1991.

APPENDIX G: STORM SURGE AND WAVE GIS DATABASE

Overview

A public domain ArcReader 10.1 GIS Reader is provided with the Storm Surge and Wave Database. The ArcReader10 program requires installation on the computer(s) that will access the database. The database is approximately 2 GB in size and can be either copied to the computer(s) or accessed via a USB memory stick. To open the database, simply click on the DOTD_Wave_Atlas.pmf file after the ArcReader 10.1 application has been installed.

Workspace Layout

One of the key features in using a geo-referenced GIS map is the ease of navigation. At startup, the image shown in Figure G. 1 is displayed. Note that the screen is divided into three regions or frames; a Data Toolbar Frame, Table of Contents Frame, and a Map Display Frame as displayed in Figure G. 2.

The Data Toolbar Frame contains several common features plus several that are unique to this application. The Table of Contents Frame lists all of the graphical data that can be displayed in the Map Display Frame. Selecting or deselecting (by turning on or off the check box) a dataset or dataset group in the Table of Contents will display or turn off the set or group in the Map Display. The Map Display Frame displays the map of the coverage area at various scales and the graphical information turned on within the Table of Contents. Also, items selected using the specific tools in Data Toolbar will be displayed in tabular form in a pop-up window in or around the Data Map.

The ArcReader 10.1 software also displays information in two different views, Data View and Layout View. The Data View is the initial display mode shown when the software loads the GIS database. This view allows the user to navigate and display information in digital and tabular form. The Layout View within the ArcReader 10.1 software can be accessed by going to Edit-Layout View within the top toolbar. Layout View allows the user to see a print perview of the map with a North Arrow and Scale. Layout View does not show tabular data that is identified from the map. An example of Layout View is shown in Figure G. 3.

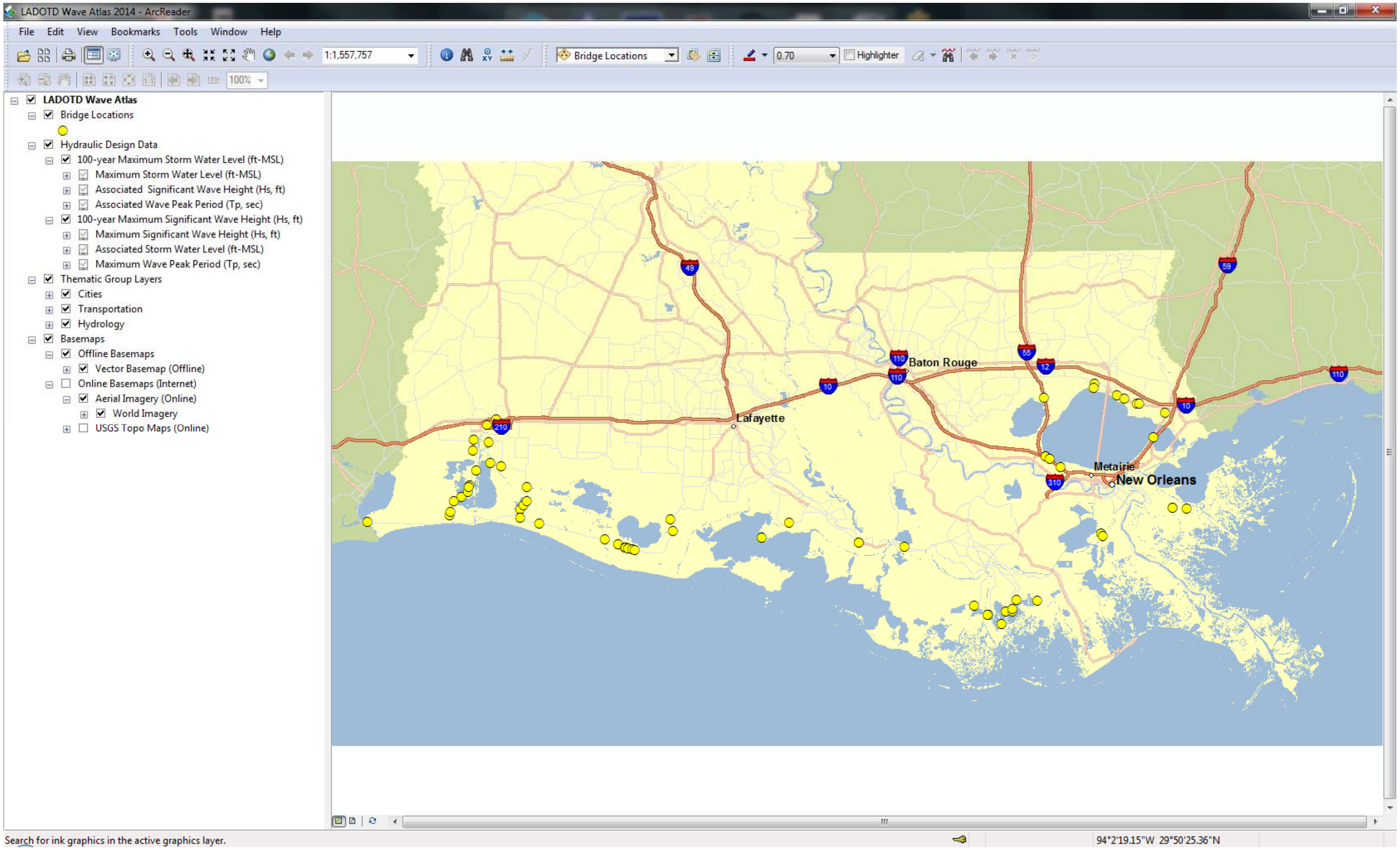


Figure G. 1
ArcGIS default opening screen

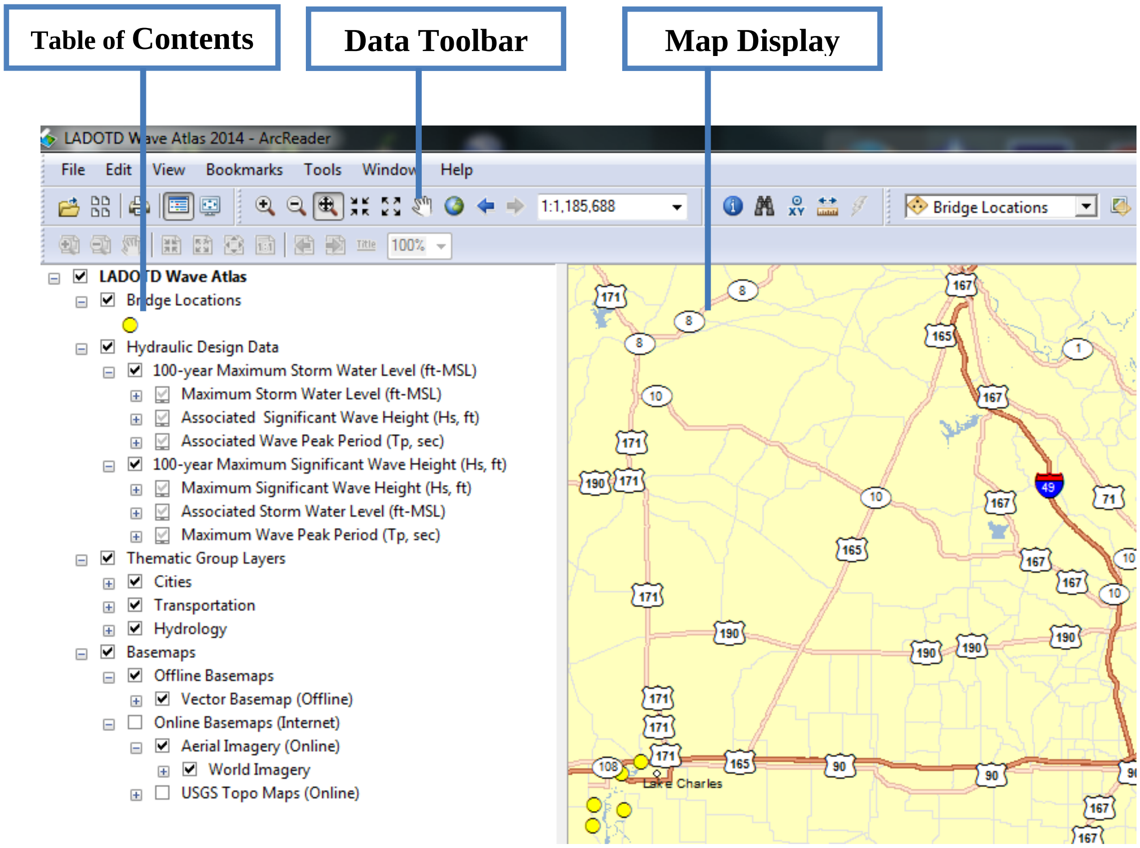


Figure G. 2
ArcGIS navigation frame layout

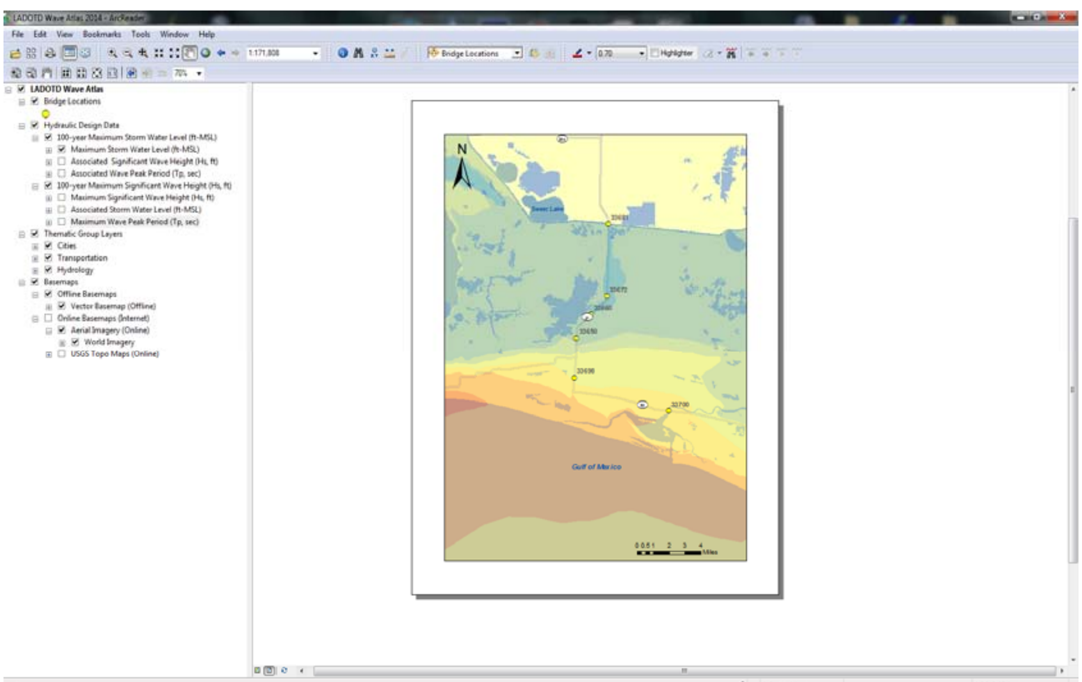


Figure G. 3
ArcGIS layout view

Data Toolbar Frame

Figure G. 4 displays the ArcReader 10.1 Toolbar. Features of this toolbar include printing, zooming, and panning the map as well as selecting various display scales and performing data searches. The data search option includes four tools for accessing and finding data within the map.

The Identify Tool, a blue circle with "i" in the center, identifies database information. The Search Tool, a binoculars symbol, searches on bridge names (for bridges that have been analyzed), parishes, roadways, or features. The Coordinate Search Tool, an XY symbol, searches a specific geographic position via various coordinate systems (Lat. - Long., state plane, etc.) and can be used to find bridges that have not been analyzed. The Distance Measure Tool, a ruler symbol, measures distance between any two points on the map.

The search tools in the toolbar displays the desired information at a particular location on the map in a window in tabular form in the Map Frame.

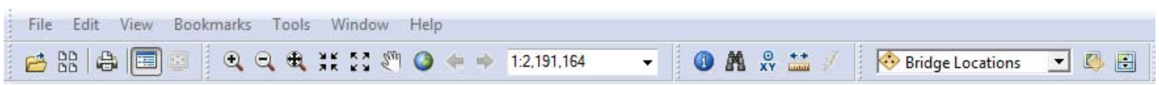


Figure G. 4
ArcGIS Reader 10.1 toolbar

Table of Contents Frame

Figure G. 5 shows the ArcReader 10.1 Navigation Frame. This frame lists the layers of graphical data contained in the Map Frame. Selecting a data set or data group causes the graphical information to be displayed in the Map Display Frame. For example, selecting 100-year Maximum Significant Wave Height displays a color coded contour map of 100-year Maximum Significant Wave Height. The color legend for the contours will be displayed in the Table of Contents Frame. To avoid a confusing image, only the item of interest should be selected.

Each data set is contained within a specific category or folder. There are four main groups of data within the DOTD Wave Atlas 2014 map. The four groups are Bridge Locations and Recall Numbers, Hydraulic Design Data, Thematic Group Layers and the Basemap group. Each group can either be turned on/off on the Map Display by selecting or deselecting the checkbox to the left of the group. Each main group except for the Bridge Location and Recall Group contain subgroups. For example, the Hydraulic Design Data main group contains two subgroups, the 100-year Maximum Storm Water Level and the 100-year Maximum Significant Wave Height.

The subgroups contain data layers relating to their main group. If the subgroups are not shown, use the plus sign to expand or compress the subgroups. This Group/Subgroup methodology applies to all groups within the Table of Contents such as the Hydraulic Design Data, Thematic Group Layers, and Basemaps.

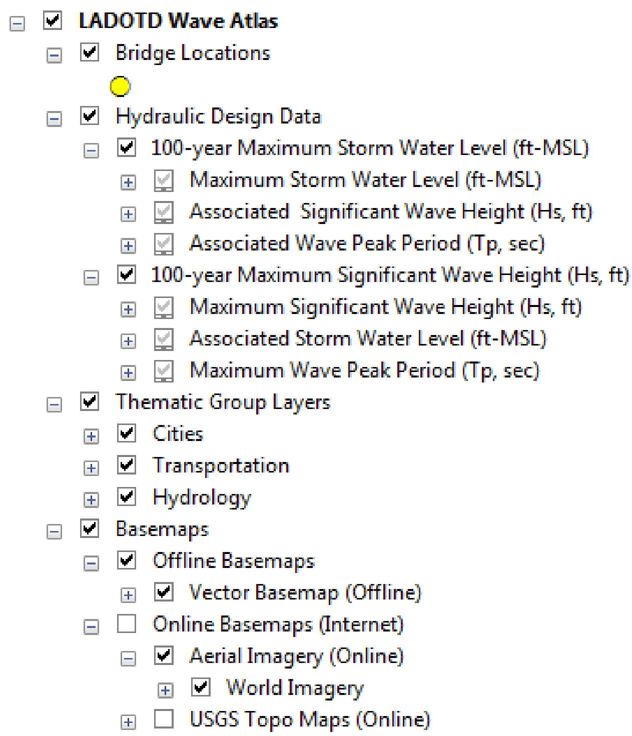


Figure G. 5
ArcGIS reader table of contents

Map Display Frame

The ArcReader 10.1 Map Display contains, or has links to, all of the data in the database. Graphical data can be displayed in this frame by selecting it in the Table of Contents. Information at a specific location in the map can be displayed in tabular form in a superimposed window in the Map Display by specifying the location with the coordinate (XY) or search (binocular) tools and identifying the desired quantity with the identify tool. The location can also be specified by the cursor and a left click of the mouse.

Figure G. 6 displays the default map for the DOTD Storm Surge and Wave Database. The map can be panned and zoomed with the tools in the Data Toolbar. Zooming to a specific area can also occur by selecting a rectangular area with the mouse. Zooming in and out in this frame changes the information that can be displayed, i.e., some information will only be displayed when the map is zoomed in to a certain point. For example, the bridge numbers can only be displayed when the map is zoomed in to a 1:500,000 scale. As an example, the zoomed in image of Lake Pontchartrain shown in Figure G. 7 displays the I-10 Bridge numbers. The bridge recall numbers were not displayed prior to the zoom.

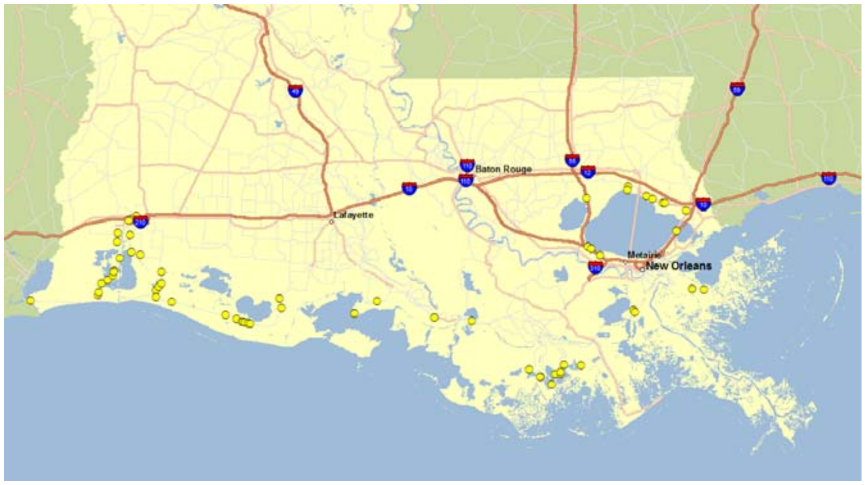


Figure G. 6
ArcGIS Reader 10 default map frame map

Figure G. 7
Zoomed ArcGIS Reader map of Lake Pontchartrain

Navigation Example – Bridge Recall Number 003440

The example below demonstrates how to obtain Hydraulic Values from the DOTD Wave Atlas 2014 GIS Database from start to finish. This example will be used further in Appendix I for calculating the wave forces on a specific bridge structure. This step by step example is for Bridge Recall Number 003440.

STEP 1: OPENING THE DOTD WAVE ATLAS 2014 GIS Database

The ArcReader 10.1 software was designed only for Microsoft Windows operating systems. Initially opening the software requires navigating to the Start Menu Shortcut as displayed in FIGURE G.X. The software will be loaded but will not display any data. Accessing the data is done by opening in the software as shown in Figure G. 8 or by double clicking the DOTD Wave Atlas 2014.pmf file within the windows operating system. ArcReader can only open published map files (.pmf) that have been created and saved within the ArcMap software. The map will now be displayed as shown in Figure G. 9.

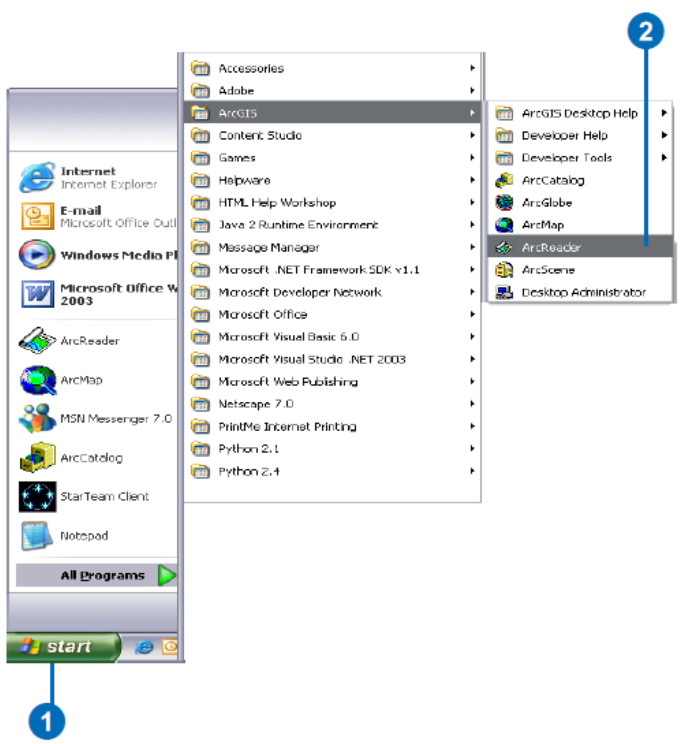


Figure G. 8
Using the Windows Start Menu to open the ArcReader 10.1 software

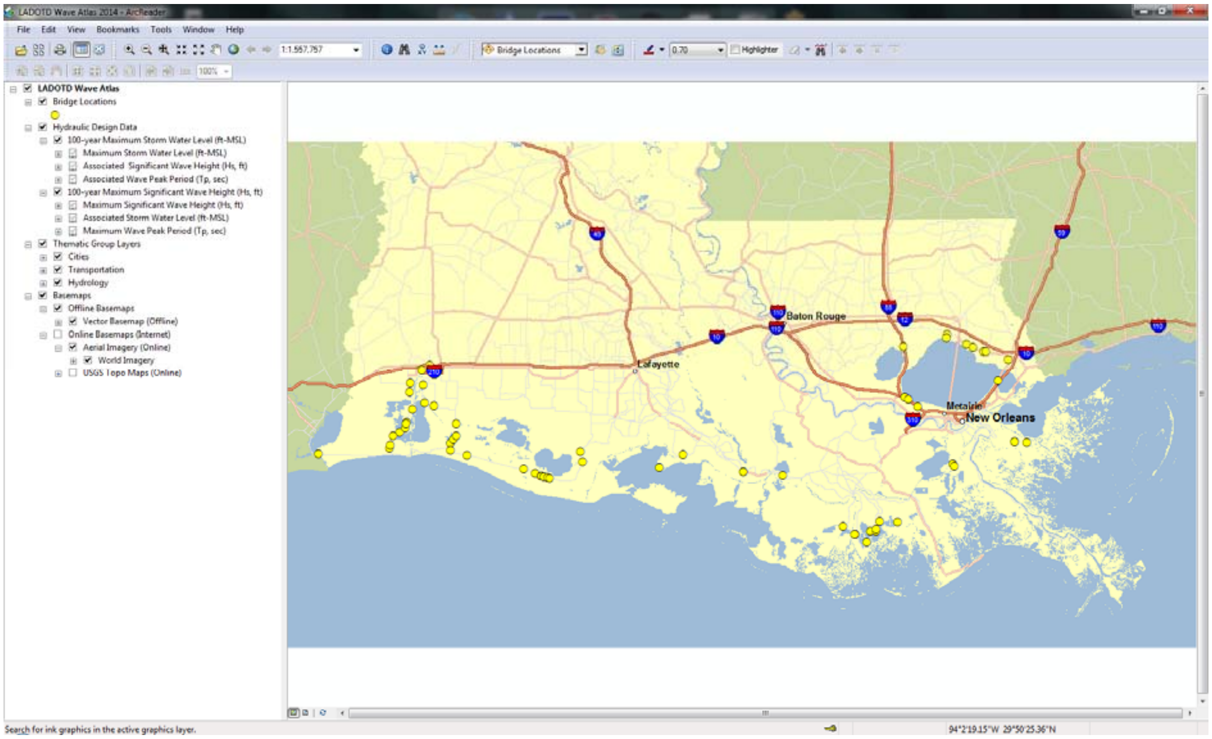


Figure G. 9
DOTD Wave Atlas 2014 GIS Database

STEP 2: SELECTING DISPLAYED DATA

Selecting layers to display on the Display Map Frame is done within the Table of Contents Frame. Turning on and off layers within the Table of Contents Frame is done by checking or unchecking the selection box to the left of the dataset. This example will be looking for the hydraulic data values associated with the 100-year Maximum Storm Water Level. Therefore, the second subgroup under the main Hydraulic Design Data Group, the 100-year Maximum Significant Wave Height, is turned off. Turning this subgroup off can be done in one of two ways. The first way is to turn off the entire subgroup in the Table of Contents. This is done by unchecking the box next to the subgroup heading as displayed in Figure G. 10. The second method is to turn off the subgroups data sets individually as displayed in Figure G. 11. Note, the Hydraulic Design Data Group only displays on the map at a scale of 1:500,000. If the map is at a scale any smaller than that there will not be any change in the Map Display Frame. Regardless, the data sets will remain turned off the check box next to the group, subgroup, or data set layer is turned off.

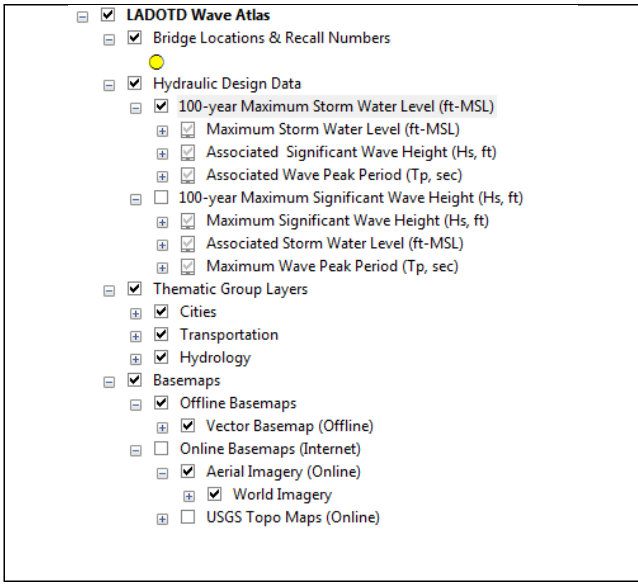


Figure G. 10
Method 1 of Turning off Subgroup Data

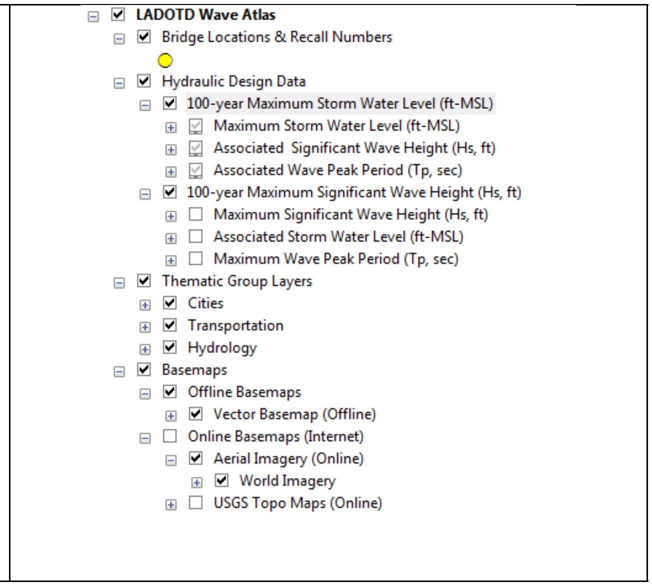


Figure G. 11
Method 2 of Turning off Subgroup data

STEP 3: LOCATING HYDRAULIC DESIGN DATA FOR A LOCATION

A. Locating using the Find Tool

To do this operation, first select the Find Tool located in the Data Toolbar Frame. This tool looks like a pair of binoculars as displayed in Figure G. 12.

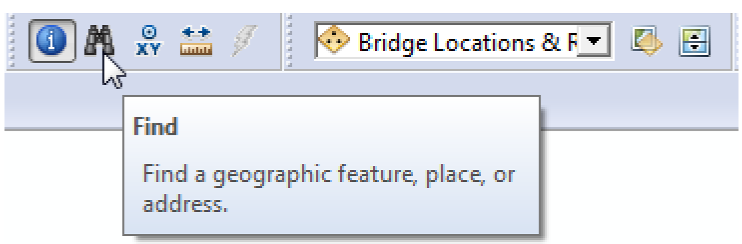


Figure G. 12
Selecting the Find Tool

Once this tool is selected, an information window will appear on the screen with the heading "Find." There are two tabs labeled Features and Locations. The Features Tab locates information found within the database. The Locations Tab locates information through street addresses (internet connection required). For this example, use the Features Tab.

This example is locating Bridge Recall Number 003440, which is located within the Bridge Locations and Recall Numbers layer. To select this layer use the layers dropdown menu and select the appropriate layer as shown in Figure G. 13.

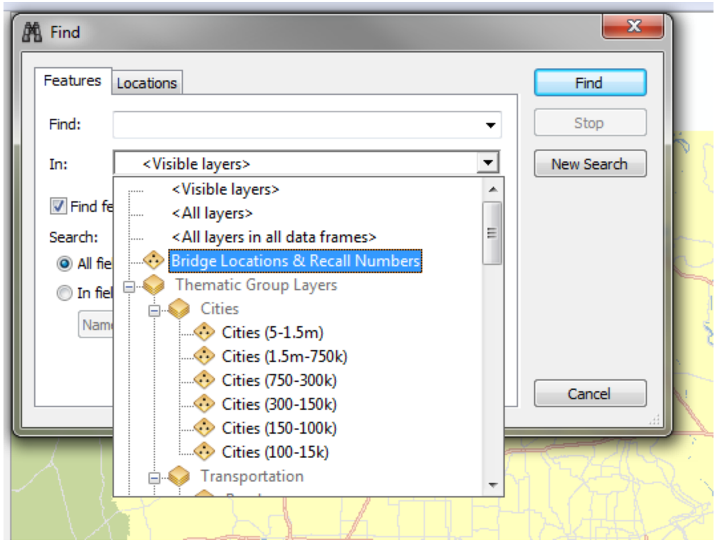


Figure G. 13
Selecting the bridge locations & recall numbers layer

Next, enter the Recall Number in the "Find" box. The box next to "Find Features that are similar to or contain the search string" remains checked. Search the recall number In Field: Name as shown in Figure G.14. The Bridge Recall Number will now be displayed in the menu at the bottom after hitting the Find Button as displayed in Figure G. 15.

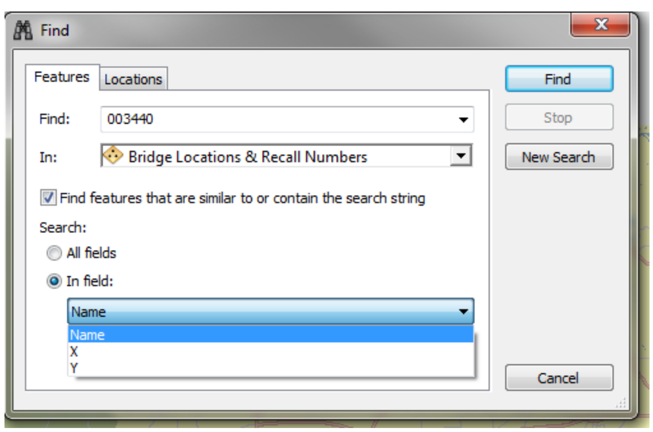


Figure G. 14
Locating Bridge Recall Number 003440 using the Find Tool

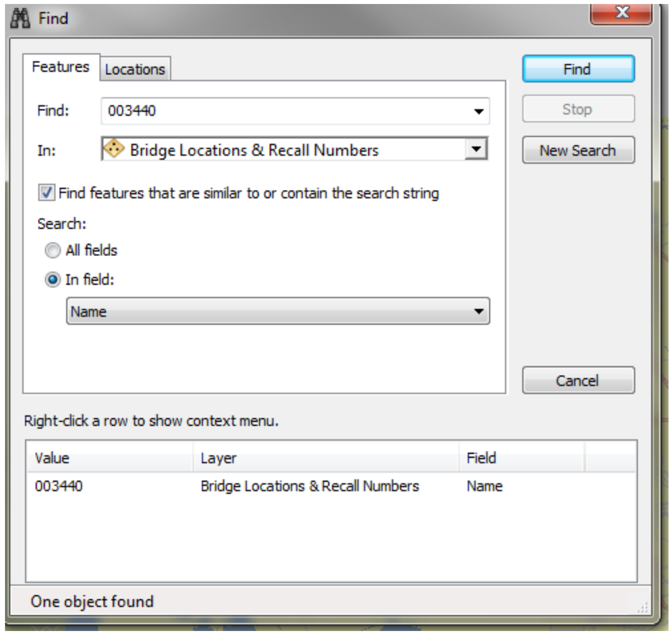


Figure G. 15
Bridge Recall Number Displayed in Find Tool Menu

Right-click the row containing the recall number to display the context menu (Figure G. 16). Within the context menu, Zoom To the feature. This will center the location relating to the Recall Number in the center of the screen as displayed in Figure G. 17.

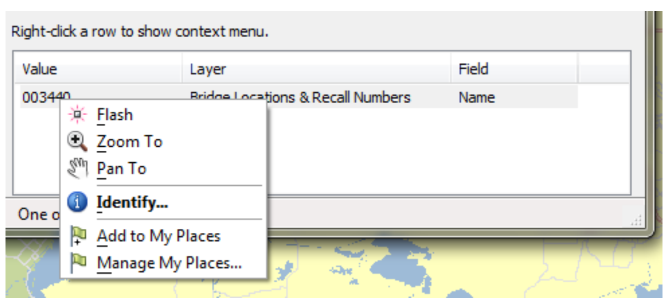


Figure G. 16
Opening the Context Menu

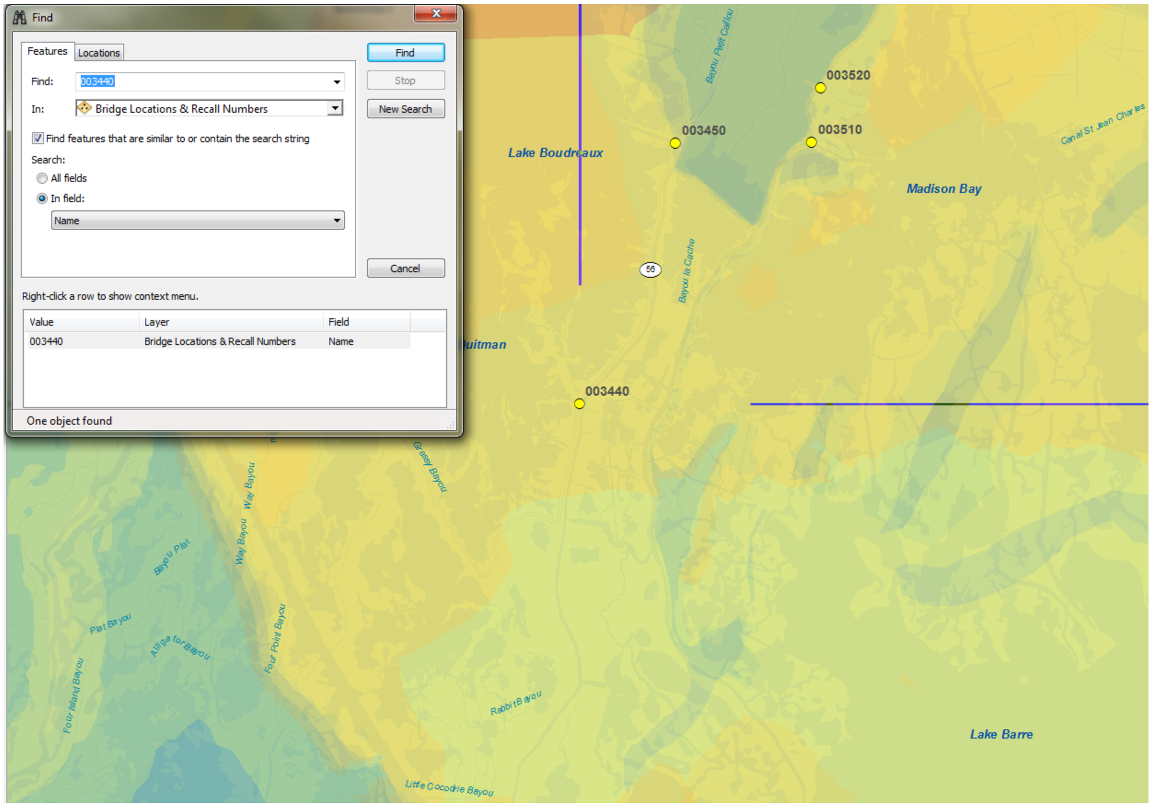


Figure G. 17
Zooming To the Bridge Recall Number

A scale of 1:10,000 or below is used to acquire a more accurate location to identify from. This is accomplished using the Scale Dropdown Menu located in the Data Toolbar. Figure G. 18 presents selecting 1:10,000 scale using the dropdown menu.

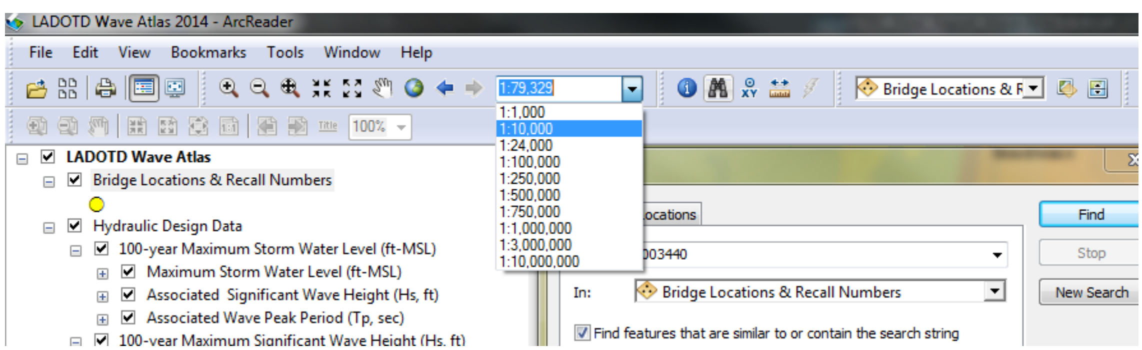


Figure G. 18
Selecting 1:10,000 scale using the Scale Dropdown Menu

B. Locating using the Go To XY Tool

The second method to locate hydraulic values is to use the Go To XY Tool. To do this operation you must first select the Go To XY located in the Data Toolbar Frame. This tool appears as a blue dot with XY underneath as displayed in Figure G. 19.

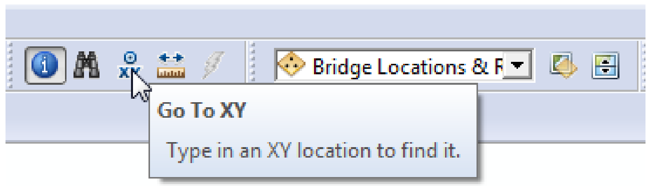


Figure G. 19
Selecting the Go To XY Tool

The Go To XY Tool opens a small input window within the Map Display. The user can choose the search units by using the arrow drop down menu as displayed in Figure G. 20 and Figure G. 21. If the input is in Degrees Minutes Seconds, use a space to differentiate between degrees, minutes and seconds (i.e. 90 45 33.25W, 24 52 46.2N).

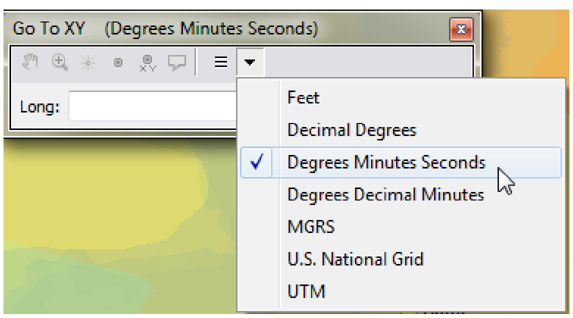


Figure G. 20
Selecting Degrees Minutes Seconds

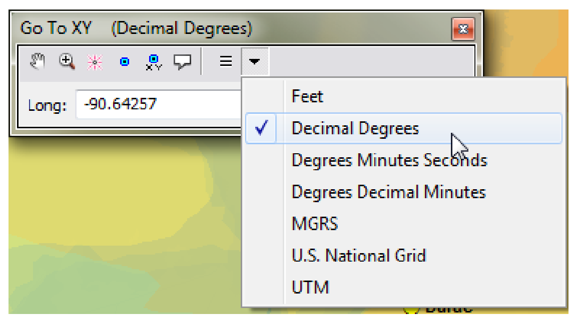


Figure G. 21
Selecting the Decimal Degrees

STEP 4: IDENTIFYING HYDRAULIC DATA

Identifying data is accomplished using the Identify Tool located in the Data Toolbar. This tool is located next to the Find Tool and has an icon, which is a blue circle with a lowercase "i". Selecting the tool opens up the Identify Tool window. In this example, the data will be identified from the Hydraulic Design Data group. This group is selected using the layer dropdown menu as displayed in Figure G. 22. The data being identified should be turned on within the table on contents.

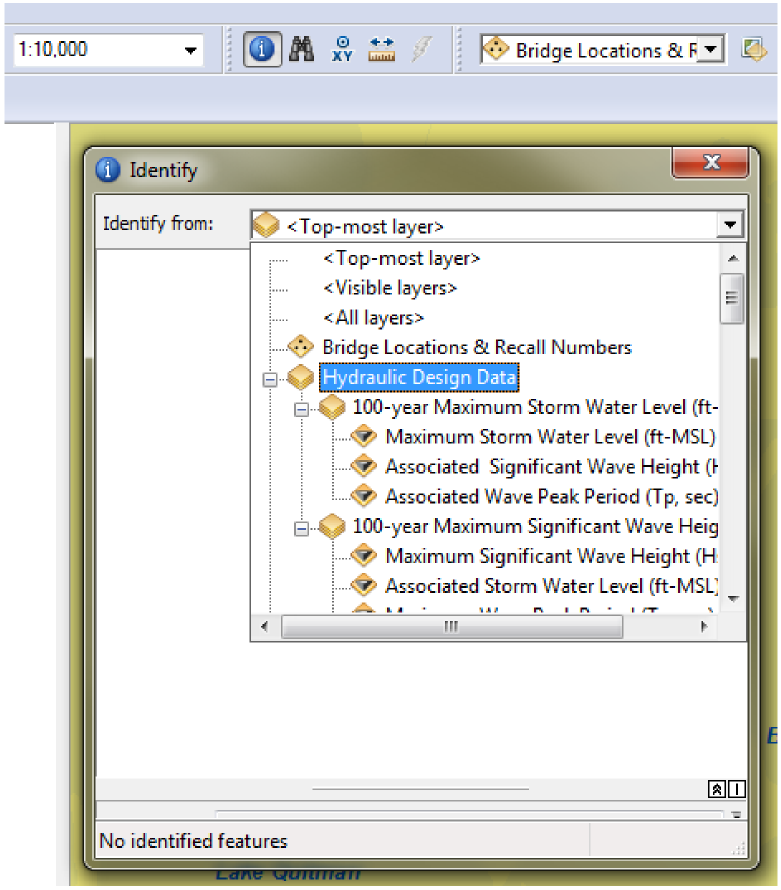


Figure G. 22
Selecting Degrees Minutes Seconds

The cursor is used to identify the hydraulic data by clicking the location of the bridge. This will now display the hydraulic design values within the Identify window. Figure G. 23 displays the screen showing the identified hydraulic values, Table of Contents and the Map Display frame. The identified hydraulic values for Bridge Recall Number 003440 are displayed in Table G. 1. These values will be used in the example in Appendix I.

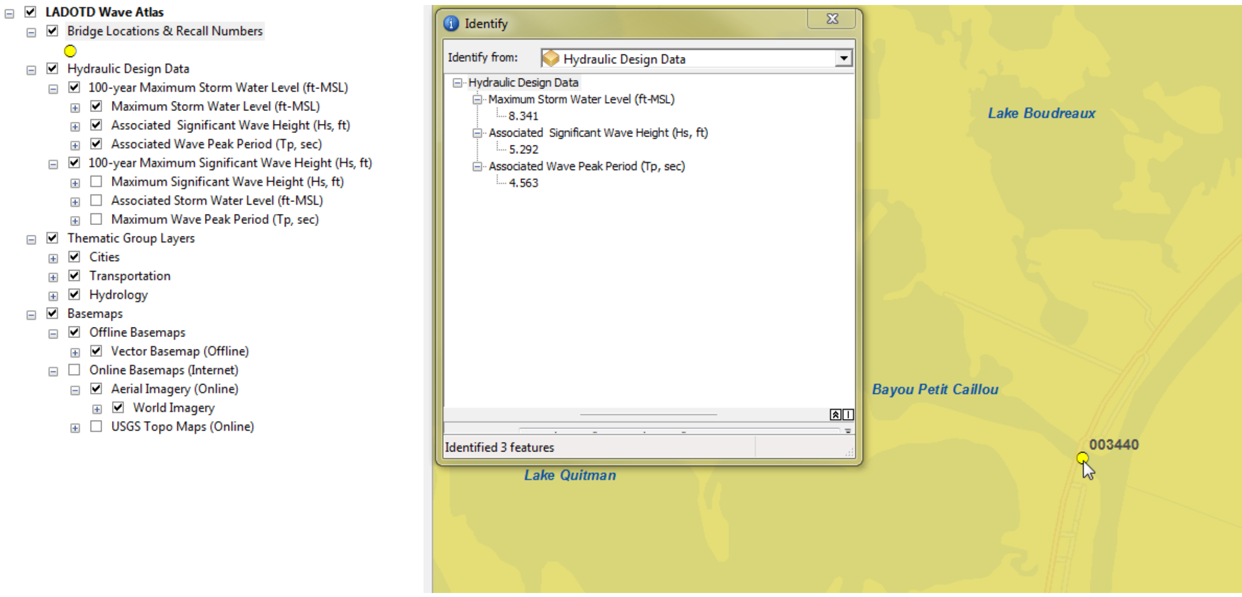


Figure G. 23
Hydraulic Design Data displayed for Bridge Recall Number 003440

Table G. 1
100-Year met/ocean parameters at time of maximum water elevation (from 100-Year Wave and Surge Atlas)

Storm Water Level (ft.)	Associated Significant Wave Height (ft.)	Peak Wave Period (sec.)
8.3	5.3	4.6

Additionally, both the 100-year Maximum Significant Wave Height and Maximum Storm Water Level hydraulic design values and associated values can be displayed in the same Identify Window. Both subgroups must be turned on (checked) in the Table of Contents. Figure G. 24 displays the Table of Contents, Identify Window and Map Display for this scenario.

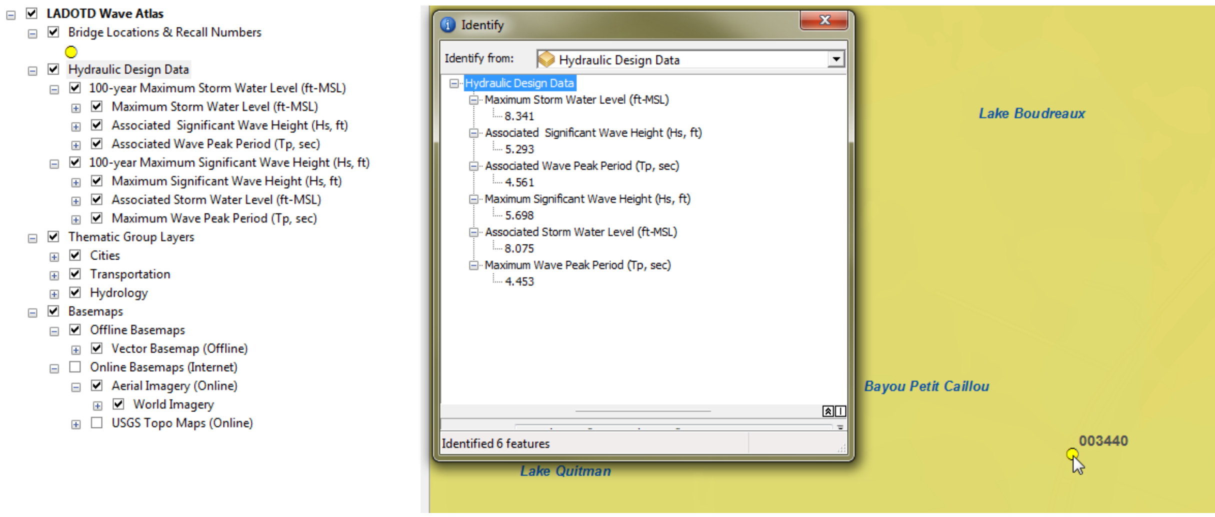


Figure G. 24
All Hydraulic Design Data Subgroups Selected and Identified for Bridge Recall Number 003440

APPENDIX H: PHYSICS BASED MODEL

Storm Surge and Wave Force Equations

The forces exerted on bridge superstructures by waves are composed of drag, inertia, change in added mass, buoyancy (vertical only), and slamming. Of these forces, the first four, referred to as quasi-static forces (due to their relatively low frequency), are addressed directly in the Physics Based Model (PBM). The slamming force has to be analyzed separately via a parametric equation. The definition sketch presented in Figure H. 1, defines the parameters in the equations. The vertical and horizontal quasi-static forces are composed of the following components:

$$F_{Vertical} \equiv F_z = F_{Drag} + F_{Inertia} + F_{CAM} + F_{Buoyancy} \qquad \text{(H-1)}$$

$$F_{Horizontal} \equiv F_x = F_{Drag} + F_{Inertia} + F_{CAM} \qquad \text{(H-2)}$$

$F_{CAM} \equiv$ Change in added mass force

The drag force is a function of the velocity squared and the inertia force a function of the acceleration as illustrated in the following equations.

$$F_z = \frac{d\left(m_{a(z)} V_z\right)}{dt} + \frac{1}{2} \rho \, L \, w \, C_{d(z)} \; V_z \left|V_z\right| + F_{buoyancy} \qquad \text{(H-3)}$$

where,

$$\frac{d\left(m_{a(z)} V_z\right)}{dt} = \frac{dm_{a(z)}}{dt} V_z + m_{a(z)} \frac{dV_z}{dt} \qquad \text{(H-4)}$$

$$m_{a(z)} \equiv \text{Added Mass} = \frac{C_{m(z)} \; \pi \; \rho \; L \; w(t)^2}{4\sqrt{1+\left(\frac{w(t)}{L}\right)^2}} \left(C_1 + C_2 \frac{h(t)}{L} + C_3 \sqrt{\frac{h(t)}{w(t)}} \right) \qquad \text{(H-5)}$$

ρ = density of water

w = wetted span width

L = span length

h = wetted span height

t = time

$m_{a(x)}$ = added mass in horizontal direction

$m_{a(z)}$ = added mass in vertical direction

V_x = added mass in horizontal direction

V_z = added mass in vertical direction

The buoyancy is a function of the submerged volume of the structure and the mass density of the water.

$$F_b = \rho \; g \; L \iint_{wcsa} dA \qquad \text{(H-6)}$$

$F_b \equiv$ buoyancy force
wcsa $\equiv$ wetted cross-sectional area

The slamming force occurs when the air-water interface strikes the structure. While horizontal slamming forces usually occur when a breaking wave strikes the structure, vertical slamming forces are present anytime the low member elevation is above the wave trough elevation and below the wave crest elevation. Vertical slamming forces are included in the analysis for conditions where they exist. Due to their lower probability of occurrence, horizontal slamming forces are not included in the analysis. To evaluate these complex equations, OEA/INTERA developed a computer program called the PBM. This program includes a non-linear wave theory (stream function) solver to compute the wave kinematics (velocities and accelerations) at each time step as the wave propagates past the structure.

The PBM equations include coefficients for drag, inertia, and added mass. The values for these coefficients were determined from wave tank tests conducted in the Coastal Engineering Laboratory at the University of Florida. Bridge failures and survivals during storm surge and wave loading in Florida, Mississippi, and Louisiana during the last decade provide field data to test both the coefficients and the PBM. Two bridges were evaluated; one that failed from wave loading, the I-10 Bridges over Escambia Bay during Hurricane Ivan and one that survived wave loading, the SR-687 Howard Franklin West Approach Bridge over Big Island Gap near Saint Petersburg, Florida during Hurricane Gladys. In both cases, the PBM correctly predicted the bridge's response to the conditions.

The PBM solves the force and moment equations for each element in a grid surrounding the superstructure (Figure H. 2) at each time step of design wave propagation past the structure.

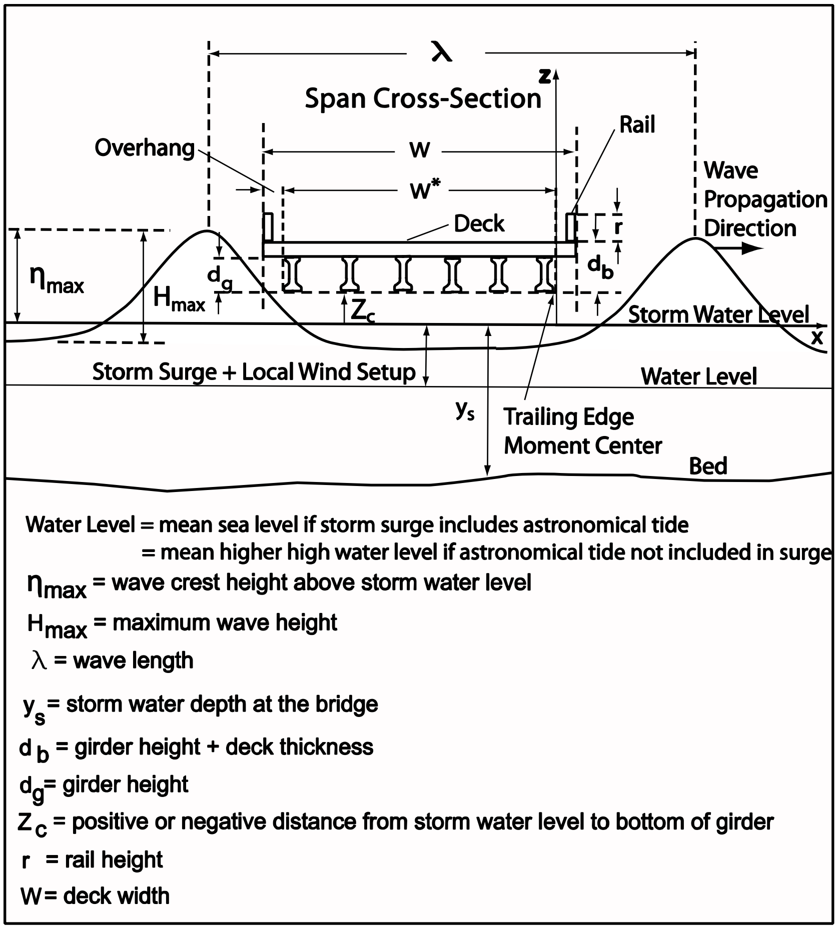


Figure H. 1
Definition sketch for the PBM

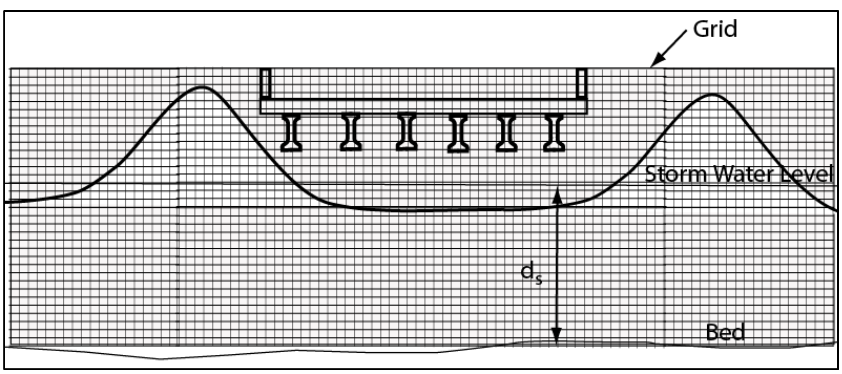


Figure H. 2
Variable resolution grid employed by PBM to compute forces and moments

APPENDIX I: EXAMPLE WAVE FORCE CALCULATIONS

This appendix provides examples of surge/wave force calculations using both the PBM program and the Parametric Equations from the AASHTO code. Two different bridges — a slab span structure and a girder span structure — are evaluated, the first using data from the Wave and Surge Atlas and the second using the same values as the vulnerability analysis. Figure I. 1 shows the locations of the two bridges. For these examples, the forces and moments are only evaluated for the maximum storm water level and associated wave conditions. To obtain the maximum surge/wave loading on the structures, the analysis should be repeated for the maximum wave height and associated storm water level.

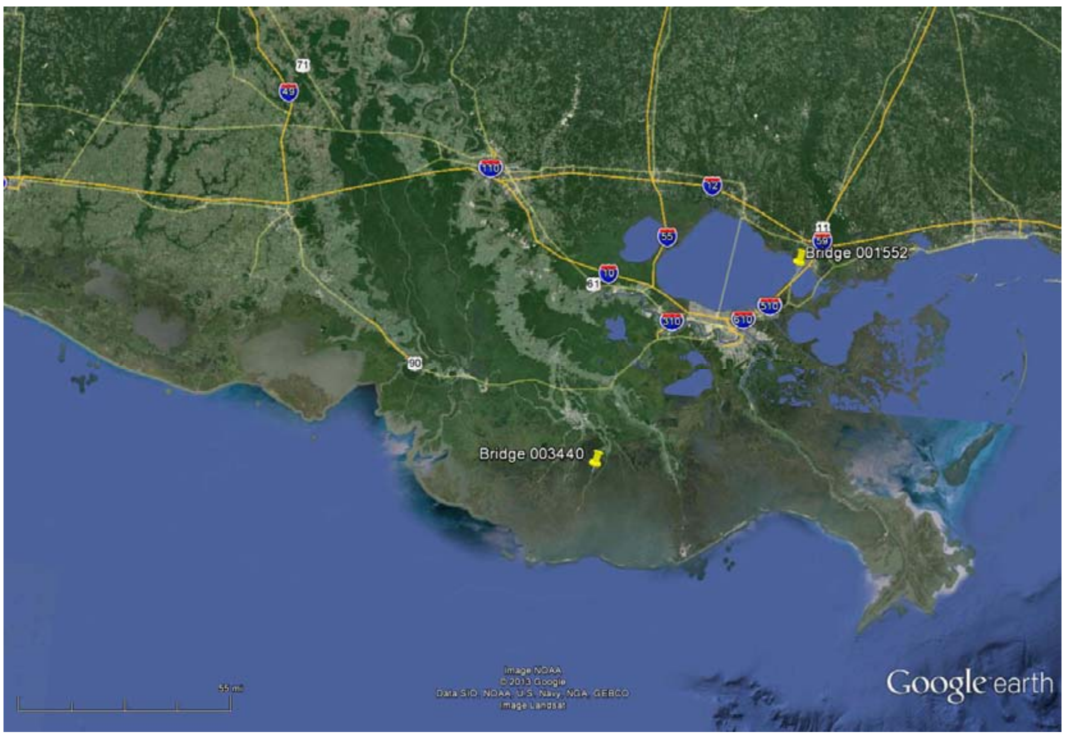


Figure I. 1
Location of example bridges

The first bridge LA 56 (Bridge Recall number 003440), is a slab structure. The initial step is to obtain the 100-year storm water level and associated wave conditions from the 100-year Wave and Surge Atlas. Appendix G details the steps required to extract the storm water level and associated wave conditions for this bridge from the Surge and Wave Atlas and Table I. 1 presents data. Table I. 3 presents the met/ocean input for the force calculations using the parametric equations. In the table, depth is determine using the storm water level and the bed elevation, the maximum wave height using equation 6.2.2.4-8, depth limited wave height using equation 6.2.2.4-9, steepness limited wave height using equation 6.2.2.4-10, wave length (λ) using equation 6.2.2.4-7, and clearance (Z_c) from the storm water level and the low chord elevation. The wave height used in the calculations and in determining η_{max} (using equation 6.2.2.4-11) is 9.5 ft — the smaller of the three wave heights in the table. Notably, the PBM uses non-linear wave theory to calculate wave length, η_{max}, and the velocities and accelerations associated with the wave. Table I. 4 presents the superstructure dimensions provided by the DOTD. Finally, Table I. 5 and Table I. 6 present the wave forces using both methods of computation. As the table illustrates the Parametric Equations provide conservative estimates of the forces. For example, in Table I. 5 the vertical force calculated using the AASHTO Parametric equations is more than 70 percent greater than the values calculated using the PBM. Comparing the moments shows the values computed with are parametric equations exceed those calculated using the PBM by nearly 300 percent.

Table I. 2
100-Year met/ocean parameters at time of maximum water elevation (from 100-Year Wave and Surge Atlas)

Storm Water Level (ft.)	Associated Significant Wave Height (ft.)	Peak Wave Period (sec.)
8.3	5.3	4.6

Table I. 3
Met/ocean parameters used in the force and moment calculations

d_s (ft.)	H_{max} (ft.)	$H_{depthlimited}$ (ft.)	$H_{steepnesslimited}$ (ft.)	Peak Wave Period (sec.)	λ (ft.)	Z_c (ft.)	η_{max} (ft.)
28.3	9.5	18.4	14.9	4.6	104.4	2.2	6.7

Table I. 4
Bridge Recall No. 003440 superstructure data

Bed Elevation (ft.)	Low Chord (ft.)	Span Length (ft.)	Span Width (ft.)	Deck Height (ft.)	Over Hang (ft.)	Beam Height (ft.)	Number of Beams	Rail Height (ft.)
-20	10.5	35	33.5	1.43	1	1.43	0	2.667

Table I. 5
Surge/wave loading at time of maximum vertical force

PBM			Parametric Equations		
Maximum Vertical Force (kips)	Associated Horizontal Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Vertical Force (kips)	Associated Horizontal Force (kips)	Associated Moment about the Trailing Edge (ft-kips)
177	41	1859	314	41	6755

Table I. 6
Surge/wave loading at time of maximum horizontal force

PBM			Parametric Equations		
Maximum Horizontal Force (kips)	Associated Vertical Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Horizontal Force (kips)	Associated Vertical Force (kips)	Associated Moment about the Trailing Edge (ft-kips)
48	96	649	83	131	3869

The second bridge, US 11 (Bridge Recall number 001552), is a girder span structure. This example uses the same maximum storm water levels and associated wave heights as the vulnerability assessment. Table I. 7 presents the maximum storm water level and associated wave data at the 9 locations evaluated.

Table I. 8 presents the met/ocean input parameters for the force calculations. As with the first example, depth is determine using the storm water level and the bed elevation, the maximum wave height using equation 6.2.2.4-8, depth limited wave height using equation 6.2.2.4-9, steepness limited wave height using equation 6.2.2.4-10, wave length (λ) using equation 6.2.2.4-7, and clearance (Z_c) from the storm water level and the low chord elevation. The wave height used in the calculations and in determining η_{max} (using equation 6.2.2.4-11) varies from 5.0 ft. to 9.7 ft. — depending on the smaller of the three wave heights for each case in the table.

Table I. 9 presents the superstructure dimensions provided by the DOTD. Finally, Table I. 10 and Table I. 11 present the surge/wave forces and moments using both methods. As in the previous example, these comparisons further illustrate some of the issues with the parametric equations, especially near the limits of the conditions for which they were developed. For example, a comparison of the maximum vertical force and the associated horizontal force and moment in Table I. 10, shows the conservatism of the parametric equations. While the parametric equations are conservative for most situations, there are a limited number of cases in this study where the parametric equations under predict the PBM values. This usually occurs when the forces and moments are small (see Table I. 11) and thus does not present a problem.

Table I. 7
100-Year met/ocean data for the maximum storm water level (US 11 Bridge Recall No. 001552)

No.	latitude	longitude	Bed Elevation (ft-MSL)	Storm Water Level (ft-MSL)	Storm Water Depth (ft.)	Associated Significant Wave Height (ft.)	Peak Wave Period (sec.)
1	30.1555	-89.8561	-2.5	5.6	8.1	3.5	4.9
2	30.1618	-89.8534	-14.2	5.8	20.0	4.8	4.4
3	30.1665	-89.8514	-12.9	5.8	18.7	5.3	4.5
4	30.1735	-89.8486	-12.4	5.9	18.3	5.4	4.4
5	30.1874	-89.8427	-13.4	6.0	19.4	5.4	4.3
6	30.1972	-89.8387	-13.3	6.1	19.4	5.2	4.2
7	30.2040	-89.8348	-14.6	6.1	20.7	5.0	4.1
8	30.2102	-89.8298	-11.9	6.1	18.0	4.6	4.1
9	30.2174	-89.8240	-1.4	6.2	7.6	3.1	4.6

Table I. 8
Met/ocean input parameter values for the parametric equations (US 11 Bridge Recall No. 001552)

Location	d_s (ft.)	H_{max} (ft.)	$H_{depthlimited}$ (ft.)	$H_{steepnesslimited}$ (ft.)	Peak Wave Period (sec.)	λ (ft.)	Z_c (ft.)	η_{max}(ft.)
1	8.1	6.3	5.3	11.0	4.9	77.0	5.2	4.4
2	20.0	8.6	13.0	13.1	4.4	91.6	5.0	6.0
3	18.7	9.5	12.1	13.4	4.5	93.5	5.0	6.7
4	18.3	9.7	11.9	12.8	4.4	89.9	4.9	6.8
5	19.4	9.7	12.6	12.5	4.3	87.8	4.8	6.8
6	19.4	9.4	12.6	12.1	4.2	84.5	4.7	6.6

Location	d_s (ft.)	H_{max} (ft.)	$H_{depthlimited}$ (ft.)	$H_{steepnesslimited}$ (ft.)	Peak Wave Period (sec.)	λ (ft.)	Z_c (ft.)	η_{max}(ft.)
7	20.7	9.0	13.5	11.7	4.1	82.0	4.7	6.3
8	18.0	8.3	11.7	11.4	4.1	80.1	4.7	5.8
9	7.6	5.6	5.0	10.0	4.6	69.9	4.6	3.9

Table I. 9
US 11 Bridge Recall No. 001552 superstructure data:

Low Chord (ft-MSL)	Span Length (ft.)	Span Width (ft.)	Deck Height (ft.)	Over Hang (ft.)	Beam Height (ft.)	Number of Beams	Rail Height (ft.)
10.8	35	32	0.7	1	2.87	4	3

Table I. 10
Surge/wave loading at time of the maximum vertical force (US 11 Bridge Recall No. 001552)

Location	PBM			Parametric Equations		
	Maximum Vertical Force (kips)	Associated Horizontal Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Vertical Force (kips)	Associated Horizontal Force (kips)	Associated Moment about the Trailing Edge (ft-kips)
1	0	0	0	0	0	0
2	11	0	0	28	8	594
3	36	15	168	43	21	914
4	46	22	447	48	25	1027
5	45	21	329	51	26	1095
6	38	15	241	47	22	1007
7	26	9	73	41	17	886
8	13	3	-73	28	8	597
9	0	0	0	0	0	0

Table I. 11
Surge/wave loading at time of maximum horizontal force (US 11 Bridge Recall No. 001552)

Location	PBM			Parametric Equations		
	Maximum Horizontal Force (kips)	Associated Vertical Force (kips)	Associated Moment about the Trailing Edge (ft-kips)	Maximum Horizontal Force (kips)	Associated Vertical Force (kips)	Associated Moment about the Trailing Edge (ft-kips)
1	0	0	0	0	0	0
2	3	-8	-549	4	-70	-1567
3	21	8	-336	19	-22	177
4	31	15	-73	26	-4	798
5	28	13	-222	29	4	1065
6	21	10	-256	24	-2	778
7	12	5	-242	16	-17	213
8	6	-5	-482	5	-50	-1001
9	0	0	0	0	0	0

APPENDIX J: SELECTION OF BRIDGES

Table J. 1
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
1	'000010'	639	'020258'	1277	'061140'	1915	'800382'	2553	'102215'
2	'000020'	640	'020259'	1278	'061150'	1916	'800388'	2554	'102245'
3	'000030'	641	'020266'	1279	'061160'	1917	'800390'	2555	'102228'
4	'000040'	642	'020267'	1280	'061170'	1918	'800394'	2556	'102208'
5	'000050'	643	'020268'	1281	'061180'	1919	'800396'	2557	'102205'
6	'000060'	644	'020269'	1282	'061195'	1920	'800398'	2558	'102210'
7	'000100'	645	'020273'	1283	'061205'	1921	'500271'	2559	'102232'
8	'000110'	646	'020275'	1284	'061220'	1922	'500259'	2560	'102201'
9	'000132'	647	'020276'	1285	'061230'	1923	'070005'	2561	'102119'
10	'000134'	648	'020280'	1286	'061240'	1924	'070006'	2562	'102135'
11	'000142'	649	'020281'	1287	'061250'	1925	'500036'	2563	'102129'
12	'000152'	650	'020283'	1288	'061360'	1926	'500288'	2564	'102134'
13	'000170'	651	'020284'	1289	'061370'	1927	'070041'	2565	'102138'
14	'000182'	652	'020285'	1290	'061380'	1928	'500275'	2566	'102130'
15	'000192'	653	'020286'	1291	'061390'	1929	'500273'	2567	'102131'
16	'000203'	654	'020287'	1292	'061400'	1930	'500124'	2568	'102117'
17	'000211'	655	'020288'	1293	'061410'	1931	'500122'	2569	'102218'
18	'000212'	656	'020289'	1294	'061420'	1932	'500108'	2570	'102212'
19	'000213'	657	'020290'	1295	'061430'	1933	'070008'	2571	'102203'
20	'000214'	658	'020291'	1296	'061442'	1934	'070010'	2572	'102230'
21	'000215'	659	'020293'	1297	'061450'	1935	'070009'	2573	'102220'
22	'000216'	660	'020294'	1298	'061460'	1936	'500274'	2574	'102206'
23	'000217'	661	'020295'	1299	'061470'	1937	'070040'	2575	'102202'
24	'000221'	662	'020296'	1300	'061480'	1938	'070017'	2576	'102120'
25	'000222'	663	'020297'	1301	'061490'	1939	'500023'	2577	'102139'
26	'000224'	664	'020298'	1302	'061500'	1940	'500297'	2578	'102118'
27	'000225'	665	'020299'	1303	'061510'	1941	'070122'	2579	'001570'
28	'000226'	666	'020300'	1304	'061520'	1942	'500279'	2580	'102149'
29	'000227'	667	'020301'	1305	'061530'	1943	'500162'	2581	'102122'
30	'000228'	668	'020303'	1306	'061600'	1944	'500158'	2582	'102018'
31	'000230'	669	'020304'	1307	'061620'	1945	'500034'	2583	'020234'
32	'000240'	670	'020305'	1308	'061630'	1946	'500033'	2584	'102109'
33	'000245'	671	'020306'	1309	'061640'	1947	'500029'	2585	'102011'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
34	'000246'	672	'020307'	1310	'061650'	1948	'070209'	2586	'102012'
35	'000249'	673	'020308'	1311	'061660'	1949	'500292'	2587	'102013'
36	'000253'	674	'020309'	1312	'061670'	1950	'500021'	2588	'102014'
37	'000260'	675	'020310'	1313	'061690'	1951	'500461'	2589	'102015'
38	'000261'	676	'020311'	1314	'061730'	1952	'500147'	2590	'102252'
39	'000262'	677	'020318'	1315	'061740'	1953	'500298'	2591	'102144'
40	'000263'	678	'020319'	1316	'061742'	1954	'070123'	2592	'020077'
41	'000264'	679	'020339'	1317	'061750'	1955	'500140'	2593	'020233'
42	'000265'	680	'020341'	1318	'061755'	1956	'500283'	2594	'102110'
43	'000266'	681	'020343'	1319	'061760'	1957	'500145'	2595	'102253'
44	'000270'	682	'020344'	1320	'061764'	1958	'500144'	2596	'102150'
45	'000273'	683	'020346'	1321	'061766'	1959	'500139'	2597	'020078'
46	'000274'	684	'020347'	1322	'061770'	1960	'500171'	2598	'102254'
47	'000290'	685	'020348'	1323	'061780'	1961	'070034'	2599	'102151'
48	'000292'	686	'020349'	1324	'061790'	1962	'070033'	2600	'103025'
49	'000330'	687	'020351'	1325	'061800'	1963	'500138'	2601	'020419'
50	'000350'	688	'020352'	1326	'061820'	1964	'070062'	2602	'103027'
51	'000360'	689	'020353'	1327	'061830'	1965	'500189'	2603	'103012'
52	'000371'	690	'020354'	1328	'061840'	1966	'500009'	2604	'103011'
53	'000372'	691	'020355'	1329	'061850'	1967	'500191'	2605	'103002'
54	'000373'	692	'020356'	1330	'061860'	1968	'070015'	2606	'103006'
55	'000374'	693	'020357'	1331	'061870'	1969	'500258'	2607	'103001'
56	'000375'	694	'020358'	1332	'061891'	1970	'500179'	2608	'103005'
57	'000376'	695	'020359'	1333	'061910'	1971	'500136'	2609	'103018'
58	'000380'	696	'020361'	1334	'061920'	1972	'070064'	2610	'103004'
59	'000390'	697	'020362'	1335	'061952'	1973	'500256'	2611	'020051'
60	'000396'	698	'020363'	1336	'061962'	1974	'500254'	2612	'103008'
61	'000398'	699	'020364'	1337	'061970'	1975	'500199'	2613	'103024'
62	'000400'	700	'020365'	1338	'061982'	1976	'500198'	2614	'020143'
63	'000410'	701	'020366'	1339	'061990'	1977	'500196'	2615	'020144'
64	'000430'	702	'020367'	1340	'062010'	1978	'500197'	2616	'020345'
65	'000440'	703	'020368'	1341	'062020'	1979	'500195'	2617	'103026'
66	'000442'	704	'020369'	1342	'062030'	1980	'500194'	2618	'020330'
67	'000444'	705	'020371'	1343	'062040'	1981	'500042'	2619	'020142'
68	'000450'	706	'020372'	1344	'062070'	1982	'070126'	2620	'020141'
69	'000460'	707	'020373'	1345	'062080'	1983	'070042'	2621	'104007'
70	'000470'	708	'020374'	1346	'062090'	1984	'070043'	2622	'104014'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
71	'000472'	709	'020375'	1347	'062100'	1985	'500193'	2623	'104013'
72	'000474'	710	'020376'	1348	'062110'	1986	'500268'	2624	'104012'
73	'000480'	711	'020377'	1349	'062120'	1987	'500047'	2625	'104005'
74	'000482'	712	'020378'	1350	'062180'	1988	'500119'	2626	'104004'
75	'000484'	713	'020381'	1351	'062210'	1989	'500163'	2627	'104011'
76	'000498'	714	'020382'	1352	'062220'	1990	'500074'	2628	'104010'
77	'000500'	715	'020386'	1353	'062222'	1991	'500115'	2629	'020098'
78	'000502'	716	'020388'	1354	'062224'	1992	'500159'	2630	'020099'
79	'000510'	717	'020389'	1355	'062260'	1993	'070014'	2631	'020083'
80	'000530'	718	'020390'	1356	'062300'	1994	'500072'	2632	'104003'
81	'000540'	719	'020391'	1357	'062310'	1995	'500058'	2633	'104001'
82	'000542'	720	'020393'	1358	'062320'	1996	'500071'	2634	'104002'
83	'000544'	721	'020394'	1359	'062330'	1997	'070056'	2635	'104006'
84	'000546'	722	'020395'	1360	'062340'	1998	'500066'	2636	'020002'
85	'000554'	723	'020396'	1361	'062350'	1999	'070059'	2637	'020001'
86	'000556'	724	'020397'	1362	'062372'	2000	'070035'	2638	'105002'
87	'000580'	725	'020398'	1363	'062432'	2001	'500094'	2639	'105001'
88	'000590'	726	'020399'	1364	'062434'	2002	'500086'	2640	'620005'
89	'000600'	727	'020400'	1365	'062436'	2003	'500291'	2641	'200878'
90	'000610'	728	'020401'	1366	'062440'	2004	'070058'	2642	'030178'
91	'000612'	729	'020403'	1367	'062450'	2005	'500085'	2643	'200772'
92	'000620'	730	'020404'	1368	'062452'	2006	'500084'	2644	'030012'
93	'000630'	731	'020405'	1369	'062470'	2007	'500089'	2645	'200880'
94	'000638'	732	'020406'	1370	'062480'	2008	'500088'	2646	'200752'
95	'000810'	733	'020407'	1371	'062490'	2009	'500068'	2647	'200751'
96	'000818'	734	'020408'	1372	'062530'	2010	'070061'	2648	'200756'
97	'000820'	735	'020409'	1373	'062540'	2011	'500087'	2649	'200875'
98	'000831'	736	'020410'	1374	'062570'	2012	'500082'	2650	'200753'
99	'000840'	737	'020411'	1375	'062580'	2013	'500083'	2651	'200884'
100	'000852'	738	'020413'	1376	'062590'	2014	'500065'	2652	'200749'
101	'000862'	739	'020414'	1377	'062620'	2015	'500078'	2653	'200746'
102	'000870'	740	'020415'	1378	'062630'	2016	'500184'	2654	'200743'
103	'000880'	741	'020416'	1379	'062640'	2017	'500182'	2655	'200741'
104	'000890'	742	'020417'	1380	'062650'	2018	'070095'	2656	'200742'
105	'000902'	743	'020418'	1381	'062660'	2019	'070027'	2657	'030013'
106	'000910'	744	'020420'	1382	'062670'	2020	'070012'	2658	'200879'
107	'000920'	745	'020421'	1383	'062680'	2021	'070007'	2659	'200755'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
108	'000930'	746	'020423'	1384	'062690'	2022	'070003'	2660	'200750'
109	'000942'	747	'020424'	1385	'062720'	2023	'070002'	2661	'200876'
110	'000952'	748	'020425'	1386	'062730'	2024	'500284'	2662	'200745'
111	'000966'	749	'020426'	1387	'062740'	2025	'500257'	2663	'200748'
112	'000974'	750	'020427'	1388	'062750'	2026	'500075'	2664	'200877'
113	'000976'	751	'020431'	1389	'062760'	2027	'500253'	2665	'200872'
114	'000980'	752	'020444'	1390	'062772'	2028	'500251'	2666	'200873'
115	'000990'	753	'030115'	1391	'062850'	2029	'500129'	2667	'200885'
116	'001000'	754	'030116'	1392	'062870'	2030	'070029'	2668	'200874'
117	'001010'	755	'030125'	1393	'062880'	2031	'070028'	2669	'200882'
118	'001020'	756	'030126'	1394	'062890'	2032	'500148'	2670	'620121'
119	'001022'	757	'030133'	1395	'062900'	2033	'500041'	2671	'620209'
120	'001030'	758	'030185'	1396	'062911'	2034	'500037'	2672	'620213'
121	'001032'	759	'030189'	1397	'062921'	2035	'500031'	2673	'620211'
122	'001040'	760	'030190'	1398	'062930'	2036	'070054'	2674	'107064'
123	'001052'	761	'030242'	1399	'062940'	2037	'500035'	2675	'107051'
124	'001070'	762	'030262'	1400	'062952'	2038	'500022'	2676	'107052'
125	'001090'	763	'030263'	1401	'062970'	2039	'500293'	2677	'107053'
126	'001100'	764	'030264'	1402	'062990'	2040	'500142'	2678	'620124'
127	'001121'	765	'030265'	1403	'063000'	2041	'500012'	2679	'620123'
128	'001130'	766	'030266'	1404	'063010'	2042	'500137'	2680	'620125'
129	'001142'	767	'030267'	1405	'063020'	2043	'500004'	2681	'620122'
130	'001151'	768	'030271'	1406	'063030'	2044	'500006'	2682	'107047'
131	'001153'	769	'030272'	1407	'063040'	2045	'500255'	2683	'107045'
132	'001160'	770	'030273'	1408	'063050'	2046	'500128'	2684	'620083'
133	'001165'	771	'030274'	1409	'063060'	2047	'500278'	2685	'107076'
134	'001211'	772	'030278'	1410	'063070'	2048	'500276'	2686	'107062'
135	'001212'	773	'030279'	1411	'063082'	2049	'500172'	2687	'620157'
136	'001280'	774	'030285'	1412	'063100'	2050	'500261'	2688	'107043'
137	'001292'	775	'030286'	1413	'063122'	2051	'500260'	2689	'107037'
138	'001304'	776	'030288'	1414	'063142'	2052	'500049'	2690	'107058'
139	'001306'	777	'030291'	1415	'063160'	2053	'070055'	2691	'107057'
140	'001312'	778	'030294'	1416	'063170'	2054	'500059'	2692	'107033'
141	'001340'	779	'030295'	1417	'063180'	2055	'500103'	2693	'107068'
142	'001342'	780	'030297'	1418	'063200'	2056	'500101'	2694	'107041'
143	'001344'	781	'030298'	1419	'063210'	2057	'500169'	2695	'107059'
144	'001346'	782	'030305'	1420	'063220'	2058	'500063'	2696	'107060'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
145	'001350'	783	'030306'	1421	'063230'	2059	'500092'	2697	'620192'
146	'001360'	784	'030308'	1422	'063260'	2060	'500077'	2698	'620027'
147	'001381'	785	'030309'	1423	'063300'	2061	'070011'	2699	'620185'
148	'001390'	786	'030312'	1424	'063310'	2062	'070001'	2700	'107066'
149	'001411'	787	'030327'	1425	'063320'	2063	'070004'	2701	'107031'
150	'001421'	788	'030329'	1426	'063330'	2064	'500178'	2702	'620184'
151	'001422'	789	'030331'	1427	'063350'	2065	'500176'	2703	'107044'
152	'001423'	790	'030332'	1428	'063360'	2066	'070053'	2704	'620028'
153	'001440'	791	'030333'	1429	'063370'	2067	'500161'	2705	'107077'
154	'001470'	792	'030334'	1430	'063380'	2068	'070112'	2706	'107027'
155	'001480'	793	'030338'	1431	'063390'	2069	'500110'	2707	'107078'
156	'001525'	794	'030339'	1432	'063400'	2070	'070113'	2708	'107083'
157	'001545'	795	'030351'	1433	'063410'	2071	'500067'	2709	'107082'
158	'001552'	796	'030363'	1434	'063420'	2072	'500130'	2710	'107081'
159	'001560'	797	'030365'	1435	'063430'	2073	'070114'	2711	'059290'
160	'001580'	798	'030369'	1436	'063440'	2074	'500157'	2712	'620219'
161	'001590'	799	'030381'	1437	'063450'	2075	'500154'	2713	'107087'
162	'001600'	800	'030382'	1438	'063460'	2076	'500252'	2714	'107086'
163	'001610'	801	'030383'	1439	'070030'	2077	'500028'	2715	'107085'
164	'001621'	802	'030393'	1440	'070050'	2078	'070092'	2716	'107089'
165	'001630'	803	'030394'	1441	'070051'	2079	'070111'	2717	'107088'
166	'001670'	804	'031330'	1442	'070063'	2080	'500153'	2718	'107090'
167	'001671'	805	'031340'	1443	'070076'	2081	'500024'	2719	'107092'
168	'001672'	806	'031350'	1444	'070078'	2082	'500025'	2720	'107091'
169	'001677'	807	'031360'	1445	'070096'	2083	'070115'	2721	'107093'
170	'001679'	808	'031370'	1446	'070097'	2084	'070060'	2722	'620076'
171	'001710'	809	'031380'	1447	'070098'	2085	'500149'	2723	'107071'
172	'001715'	810	'031390'	1448	'070099'	2086	'070107'	2724	'107072'
173	'001716'	811	'031400'	1449	'070104'	2087	'500285'	2725	'620108'
174	'001730'	812	'031410'	1450	'070119'	2088	'500286'	2726	'107017'
175	'001755'	813	'031420'	1451	'070120'	2089	'500015'	2727	'620026'
176	'001757'	814	'031430'	1452	'070132'	2090	'500014'	2728	'107003'
177	'001780'	815	'031432'	1453	'070133'	2091	'500013'	2729	'107007'
178	'001790'	816	'031442'	1454	'070134'	2092	'070109'	2730	'620214'
179	'001842'	817	'031450'	1455	'070135'	2093	'500005'	2731	'107018'
180	'001850'	818	'031470'	1456	'070137'	2094	'070110'	2732	'107065'
181	'001852'	819	'031480'	1457	'070141'	2095	'500133'	2733	'107061'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
182	'001855'	820	'031490'	1458	'070142'	2096	'070052'	2734	'620111'
183	'001862'	821	'031510'	1459	'070143'	2097	'500003'	2735	'620112'
184	'001870'	822	'031520'	1460	'070144'	2098	'500001'	2736	'620212'
185	'001900'	823	'031530'	1461	'070145'	2099	'500277'	2737	'107034'
186	'001901'	824	'031540'	1462	'070146'	2100	'500043'	2738	'107067'
187	'001906'	825	'031550'	1463	'070150'	2101	'500044'	2739	'107056'
188	'001908'	826	'031560'	1464	'070152'	2102	'500125'	2740	'107032'
189	'001931'	827	'031570'	1465	'070154'	2103	'500269'	2741	'107040'
190	'001932'	828	'031580'	1466	'070158'	2104	'070108'	2742	'107030'
191	'001933'	829	'031590'	1467	'070166'	2105	'500117'	2743	'107025'
192	'001934'	830	'031600'	1468	'070167'	2106	'500120'	2744	'107012'
193	'001937'	831	'031610'	1469	'070172'	2107	'500052'	2745	'620154'
194	'001938'	832	'031620'	1470	'070173'	2108	'500051'	2746	'107001'
195	'001946'	833	'031630'	1471	'070205'	2109	'500055'	2747	'620042'
196	'001948'	834	'031640'	1472	'070207'	2110	'500111'	2748	'620001'
197	'001954'	835	'031650'	1473	'070208'	2111	'500073'	2749	'620029'
198	'001956'	836	'031660'	1474	'073820'	2112	'500098'	2750	'107016'
199	'001958'	837	'031670'	1475	'073830'	2113	'500097'	2751	'107005'
200	'001963'	838	'031680'	1476	'104015'	2114	'500096'	2752	'107096'
201	'001965'	839	'031690'	1477	'200010'	2115	'070057'	2753	'107008'
202	'001967'	840	'031700'	1478	'200020'	2116	'500081'	2754	'107002'
203	'001969'	841	'031712'	1479	'200030'	2117	'500185'	2755	'107055'
204	'001972'	842	'031720'	1480	'200040'	2118	'500186'	2756	'620084'
205	'001976'	843	'031730'	1481	'200050'	2119	'500183'	2757	'620113'
206	'001983'	844	'031732'	1482	'200060'	2120	'070065'	2758	'107015'
207	'001985'	845	'031734'	1483	'200070'	2121	'070044'	2759	'107014'
208	'001987'	846	'031736'	1484	'200080'	2122	'070093'	2760	'620114'
209	'001989'	847	'031751'	1485	'200110'	2123	'500076'	2761	'620082'
210	'002007'	848	'031752'	1486	'200120'	2124	'500212'	2762	'107073'
211	'002008'	849	'031755'	1487	'200130'	2125	'500208'	2763	'107013'
212	'002013'	850	'031760'	1488	'200140'	2126	'500220'	2764	'107004'
213	'002014'	851	'031762'	1489	'200150'	2127	'500226'	2765	'107009'
214	'002060'	852	'031780'	1490	'200160'	2128	'500202'	2766	'203832'
215	'002070'	853	'031790'	1491	'200170'	2129	'500207'	2767	'203830'
216	'002100'	854	'031802'	1492	'200180'	2130	'500221'	2768	'620156'
217	'002101'	855	'031812'	1493	'200190'	2131	'500222'	2769	'620218'
218	'002103'	856	'031820'	1494	'200220'	2132	'500225'	2770	'620109'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
219	'002106'	857	'031860'	1495	'200320'	2133	'500214'	2771	'060220'
220	'002107'	858	'031900'	1496	'200470'	2134	'500213'	2772	'107080'
221	'002110'	859	'031910'	1497	'200500'	2135	'500223'	2773	'107074'
222	'002111'	860	'031930'	1498	'200580'	2136	'500206'	2774	'107079'
223	'002112'	861	'031950'	1499	'200600'	2137	'500205'	2775	'107075'
224	'002113'	862	'031960'	1500	'200630'	2138	'500204'	2776	'620155'
225	'002114'	863	'031970'	1501	'200710'	2139	'500203'	2777	'107084'
226	'002115'	864	'031980'	1502	'200757'	2140	'500215'	2778	'620006'
227	'002116'	865	'031990'	1503	'200762'	2141	'500216'	2779	'108100'
228	'002117'	866	'032000'	1504	'200774'	2142	'500218'	2780	'108031'
229	'002120'	867	'032010'	1505	'200782'	2143	'500219'	2781	'108143'
230	'002130'	868	'032020'	1506	'200783'	2144	'500201'	2782	'108137'
231	'002132'	869	'032030'	1507	'200784'	2145	'200725'	2783	'108070'
232	'002134'	870	'032040'	1508	'200785'	2146	'200727'	2784	'108077'
233	'002136'	871	'032050'	1509	'200786'	2147	'200717'	2785	'108119'
234	'002138'	872	'032062'	1510	'200787'	2148	'200709'	2786	'108121'
235	'002142'	873	'032090'	1511	'200790'	2149	'030134'	2787	'108073'
236	'002144'	874	'032102'	1512	'200820'	2150	'200718'	2788	'108080'
237	'002160'	875	'032110'	1513	'200830'	2151	'200719'	2789	'108068'
238	'002170'	876	'032120'	1514	'200850'	2152	'200731'	2790	'108089'
239	'002172'	877	'032130'	1515	'200902'	2153	'200721'	2791	'108125'
240	'002174'	878	'032140'	1516	'200910'	2154	'200704'	2792	'108114'
241	'002190'	879	'032150'	1517	'200920'	2155	'200729'	2793	'108095'
242	'002191'	880	'032160'	1518	'200940'	2156	'200703'	2794	'108115'
243	'002210'	881	'032170'	1519	'200950'	2157	'200735'	2795	'108108'
244	'002220'	882	'032182'	1520	'200960'	2158	'200714'	2796	'108051'
245	'002230'	883	'032190'	1521	'200970'	2159	'200732'	2797	'620007'
246	'002250'	884	'032202'	1522	'201620'	2160	'200734'	2798	'620008'
247	'002254'	885	'032210'	1523	'201810'	2161	'200722'	2799	'108105'
248	'002260'	886	'032223'	1524	'201840'	2162	'200754'	2800	'108106'
249	'002270'	887	'032231'	1525	'201845'	2163	'200723'	2801	'108045'
250	'002290'	888	'032242'	1526	'203810'	2164	'030135'	2802	'108065'
251	'002300'	889	'032250'	1527	'203820'	2165	'200739'	2803	'108101'
252	'002310'	890	'032254'	1528	'203848'	2166	'200730'	2804	'108061'
253	'002320'	891	'032256'	1529	'203850'	2167	'030057'	2805	'108007'
254	'002330'	892	'032261'	1530	'203860'	2168	'200736'	2806	'108010'
255	'002352'	893	'032263'	1531	'203870'	2169	'200737'	2807	'108008'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
256	'002354'	894	'032266'	1532	'203873'	2170	'200724'	2808	'108030'
257	'002380'	895	'032280'	1533	'203880'	2171	'200715'	2809	'108032'
258	'002400'	896	'032310'	1534	'203890'	2172	'030043'	2810	'620228'
259	'002403'	897	'032320'	1535	'203900'	2173	'200738'	2811	'108033'
260	'002405'	898	'032340'	1536	'203910'	2174	'200705'	2812	'108041'
261	'002406'	899	'032350'	1537	'203920'	2175	'200706'	2813	'108039'
262	'002408'	900	'032360'	1538	'203930'	2176	'200726'	2814	'108017'
263	'002411'	901	'032370'	1539	'203940'	2177	'200701'	2815	'108155'
264	'002437'	902	'032372'	1540	'203950'	2178	'200700'	2816	'108126'
265	'002438'	903	'032380'	1541	'203960'	2179	'200707'	2817	'108145'
266	'002439'	904	'032383'	1542	'203970'	2180	'200712'	2818	'108150'
267	'002480'	905	'032410'	1543	'203980'	2181	'200713'	2819	'108135'
268	'002490'	906	'032420'	1544	'203990'	2182	'200711'	2820	'108206'
269	'002500'	907	'032430'	1545	'204000'	2183	'200716'	2821	'108169'
270	'002510'	908	'032435'	1546	'204010'	2184	'200702'	2822	'108138'
271	'002520'	909	'032440'	1547	'204020'	2185	'200698'	2823	'620117'
272	'002530'	910	'032460'	1548	'204030'	2186	'200699'	2824	'620115'
273	'002562'	911	'032470'	1549	'204040'	2187	'200694'	2825	'108136'
274	'002564'	912	'032480'	1550	'204050'	2188	'200692'	2826	'620116'
275	'002566'	913	'032490'	1551	'204060'	2189	'200900'	2827	'108168'
276	'002572'	914	'032495'	1552	'204070'	2190	'006120'	2828	'108165'
277	'002592'	915	'032510'	1553	'204100'	2191	'006110'	2829	'108167'
278	'002600'	916	'032520'	1554	'204110'	2192	'006100'	2830	'108173'
279	'002620'	917	'032530'	1555	'204120'	2193	'030033'	2831	'108175'
280	'002624'	918	'032550'	1556	'204130'	2194	'200883'	2832	'108190'
281	'002631'	919	'032560'	1557	'204140'	2195	'200901'	2833	'108198'
282	'002632'	920	'032565'	1558	'204150'	2196	'200903'	2834	'108201'
283	'002640'	921	'032600'	1559	'204162'	2197	'200708'	2835	'108170'
284	'002650'	922	'032630'	1560	'204164'	2198	'030229'	2836	'108203'
285	'002660'	923	'032640'	1561	'204172'	2199	'006140'	2837	'108117'
286	'002670'	924	'032680'	1562	'204176'	2200	'006142'	2838	'108205'
287	'002690'	925	'032690'	1563	'204182'	2201	'006150'	2839	'108097'
288	'002700'	926	'032710'	1564	'204192'	2202	'100010'	2840	'108111'
289	'002710'	927	'032731'	1565	'204196'	2203	'100008'	2841	'063250'
290	'002720'	928	'032742'	1566	'204212'	2204	'100137'	2842	'108052'
291	'002730'	929	'032770'	1567	'204216'	2205	'100101'	2843	'108011'
292	'002740'	930	'032780'	1568	'204230'	2206	'100012'	2844	'108006'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
293	'002750'	931	'032790'	1569	'204240'	2207	'100146'	2845	'108180'
294	'002760'	932	'032800'	1570	'204250'	2208	'100102'	2846	'108075'
295	'002770'	933	'032810'	1571	'204260'	2209	'100022'	2847	'108112'
296	'002780'	934	'032820'	1572	'204262'	2210	'020325'	2848	'108013'
297	'002790'	935	'032830'	1573	'204270'	2211	'020037'	2849	'620138'
298	'002819'	936	'032840'	1574	'204272'	2212	'020135'	2850	'108019'
299	'002820'	937	'032860'	1575	'204280'	2213	'100021'	2851	'108129'
300	'002830'	938	'032870'	1576	'204282'	2214	'020134'	2852	'108151'
301	'002840'	939	'032880'	1577	'204290'	2215	'020069'	2853	'108153'
302	'002849'	940	'032890'	1578	'204292'	2216	'100232'	2854	'108140'
303	'002860'	941	'032900'	1579	'204300'	2217	'020133'	2855	'108163'
304	'002870'	942	'032910'	1580	'204310'	2218	'100023'	2856	'108196'
305	'002874'	943	'032920'	1581	'204320'	2219	'020093'	2857	'620052'
306	'002880'	944	'032930'	1582	'204330'	2220	'020091'	2858	'620186'
307	'002890'	945	'032938'	1583	'204340'	2221	'020155'	2859	'108058'
308	'002892'	946	'032940'	1584	'204344'	2222	'100006'	2860	'108093'
309	'002894'	947	'032950'	1585	'204345'	2223	'100052'	2861	'620195'
310	'003068'	948	'032960'	1586	'204346'	2224	'020379'	2862	'108049'
311	'003074'	949	'033000'	1587	'204347'	2225	'100226'	2863	'108009'
312	'003115'	950	'033010'	1588	'204348'	2226	'020089'	2864	'108014'
313	'003116'	951	'033040'	1589	'204349'	2227	'020023'	2865	'620043'
314	'003117'	952	'033050'	1590	'204350'	2228	'020024'	2866	'108042'
315	'003118'	953	'033070'	1591	'204351'	2229	'020025'	2867	'108040'
316	'003119'	954	'033080'	1592	'204352'	2230	'100220'	2868	'108021'
317	'003130'	955	'033090'	1593	'204353'	2231	'020154'	2869	'108024'
318	'003140'	956	'033110'	1594	'204354'	2232	'020074'	2870	'620118'
319	'003150'	957	'033120'	1595	'204355'	2233	'020256'	2871	'108023'
320	'003160'	958	'033130'	1596	'204356'	2234	'100204'	2872	'108016'
321	'003180'	959	'033140'	1597	'205186'	2235	'020132'	2873	'620196'
322	'003190'	960	'033150'	1598	'205202'	2236	'100217'	2874	'108142'
323	'003210'	961	'033160'	1599	'205206'	2237	'020177'	2875	'108139'
324	'003220'	962	'033190'	1600	'205502'	2238	'020315'	2876	'620087'
325	'003230'	963	'033200'	1601	'205510'	2239	'100131'	2877	'108182'
326	'003240'	964	'033202'	1602	'205520'	2240	'020020'	2878	'620075'
327	'003255'	965	'033204'	1603	'205530'	2241	'020090'	2879	'108185'
328	'003260'	966	'033210'	1604	'205540'	2242	'100129'	2880	'620047'
329	'003270'	967	'033220'	1605	'205550'	2243	'100128'	2881	'620059'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
330	'003280'	968	'033230'	1606	'205560'	2244	'020263'	2882	'108154'
331	'003290'	969	'033240'	1607	'205561'	2245	'100127'	2883	'620194'
332	'003312'	970	'033250'	1608	'205562'	2246	'020264'	2884	'108166'
333	'003322'	971	'033260'	1609	'205563'	2247	'020316'	2885	'108090'
334	'003332'	972	'033270'	1610	'205564'	2248	'100120'	2886	'108076'
335	'003362'	973	'033280'	1611	'205565'	2249	'100122'	2887	'620044'
336	'003381'	974	'033282'	1612	'205566'	2250	'100114'	2888	'108120'
337	'003384'	975	'033284'	1613	'205567'	2251	'100118'	2889	'108118'
338	'003390'	976	'033286'	1614	'205568'	2252	'100119'	2890	'108122'
339	'003412'	977	'033288'	1615	'206000'	2253	'100104'	2891	'108088'
340	'003432'	978	'033290'	1616	'206010'	2254	'100106'	2892	'108084'
341	'003440'	979	'033292'	1617	'206020'	2255	'100135'	2893	'108086'
342	'003450'	980	'033294'	1618	'300420'	2256	'100113'	2894	'108085'
343	'003470'	981	'033296'	1619	'300430'	2257	'020030'	2895	'108116'
344	'003480'	982	'033298'	1620	'300440'	2258	'020151'	2896	'108067'
345	'003490'	983	'033300'	1621	'300450'	2259	'100111'	2897	'620233'
346	'003500'	984	'033302'	1622	'300460'	2260	'020044'	2898	'108056'
347	'003510'	985	'033304'	1623	'300470'	2261	'020019'	2899	'108071'
348	'003520'	986	'033306'	1624	'300480'	2262	'020010'	2900	'620058'
349	'003540'	987	'033308'	1625	'300490'	2263	'020015'	2901	'108124'
350	'003550'	988	'033310'	1626	'300610'	2264	'020011'	2902	'108092'
351	'003570'	989	'033312'	1627	'300620'	2265	'020017'	2903	'108091'
352	'003580'	990	'033314'	1628	'300630'	2266	'020014'	2904	'108113'
353	'003590'	991	'033316'	1629	'300640'	2267	'020016'	2905	'108066'
354	'003600'	992	'033318'	1630	'300650'	2268	'020018'	2906	'108094'
355	'003610'	993	'033322'	1631	'300660'	2269	'100231'	2907	'108104'
356	'003620'	994	'033324'	1632	'300670'	2270	'020067'	2908	'108103'
357	'003641'	995	'033326'	1633	'300680'	2271	'020065'	2909	'108048'
358	'003660'	996	'033328'	1634	'301030'	2272	'100032'	2910	'108029'
359	'003670'	997	'033332'	1635	'301040'	2273	'100224'	2911	'108044'
360	'003690'	998	'033334'	1636	'301050'	2274	'100221'	2912	'108069'
361	'003700'	999	'033336'	1637	'301060'	2275	'100030'	2913	'108046'
362	'003702'	1000	'033338'	1638	'301070'	2276	'100031'	2914	'108110'
363	'005680'	1001	'033339'	1639	'302000'	2277	'100040'	2915	'620234'
364	'005700'	1002	'033340'	1640	'302010'	2278	'100039'	2916	'108001'
365	'005712'	1003	'033341'	1641	'302020'	2279	'100029'	2917	'108026'
366	'005714'	1004	'033342'	1642	'302030'	2280	'100024'	2918	'108012'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
367	'005722'	1005	'033343'	1643	'302040'	2281	'100214'	2919	'108037'
368	'005724'	1006	'033344'	1644	'302050'	2282	'100215'	2920	'108003'
369	'005730'	1007	'033345'	1645	'302060'	2283	'100216'	2921	'108109'
370	'005731'	1008	'033346'	1646	'302070'	2284	'100034'	2922	'108004'
371	'005736'	1009	'033347'	1647	'302080'	2285	'100218'	2923	'108018'
372	'005740'	1010	'033348'	1648	'302090'	2286	'100205'	2924	'108022'
373	'005750'	1011	'033349'	1649	'302110'	2287	'020086'	2925	'108020'
374	'005760'	1012	'033350'	1650	'302130'	2288	'100206'	2926	'108038'
375	'005770'	1013	'033351'	1651	'302140'	2289	'100225'	2927	'108128'
376	'005780'	1014	'033353'	1652	'302150'	2290	'020087'	2928	'108131'
377	'005790'	1015	'033354'	1653	'302160'	2291	'020088'	2929	'108148'
378	'005800'	1016	'033370'	1654	'302170'	2292	'100213'	2930	'108144'
379	'005830'	1017	'033372'	1655	'302180'	2293	'020053'	2931	'108159'
380	'005840'	1018	'033374'	1656	'302190'	2294	'020313'	2932	'108171'
381	'005850'	1019	'033376'	1657	'302200'	2295	'100130'	2933	'108132'
382	'005860'	1020	'033390'	1658	'302230'	2296	'100132'	2934	'108164'
383	'005868'	1021	'033398'	1659	'302240'	2297	'100133'	2935	'108184'
384	'005870'	1022	'033400'	1660	'302250'	2298	'100136'	2936	'108174'
385	'005900'	1023	'033402'	1661	'302252'	2299	'100125'	2937	'108183'
386	'005904'	1024	'033410'	1662	'302254'	2300	'100123'	2938	'108181'
387	'005910'	1025	'033420'	1663	'302260'	2301	'100124'	2939	'108178'
388	'005920'	1026	'033430'	1664	'302270'	2302	'100126'	2940	'108179'
389	'005930'	1027	'033440'	1665	'302280'	2303	'100112'	2941	'108191'
390	'005940'	1028	'033450'	1666	'302290'	2304	'020085'	2942	'108189'
391	'005950'	1029	'033455'	1667	'302300'	2305	'100107'	2943	'108186'
392	'005980'	1030	'033460'	1668	'302310'	2306	'100121'	2944	'108188'
393	'005990'	1031	'033470'	1669	'302500'	2307	'020072'	2945	'108187'
394	'006000'	1032	'033480'	1670	'302510'	2308	'020038'	2946	'108204'
395	'006010'	1033	'033490'	1671	'302520'	2309	'020063'	2947	'620004'
396	'006020'	1034	'033492'	1672	'302530'	2310	'100020'	2948	'108193'
397	'006030'	1035	'033500'	1673	'302540'	2311	'100019'	2949	'620092'
398	'006040'	1036	'033502'	1674	'302550'	2312	'020041'	2950	'108192'
399	'006050'	1037	'033510'	1675	'302560'	2313	'020174'	2951	'108202'
400	'006080'	1038	'033590'	1676	'302570'	2314	'100028'	2952	'108199'
401	'006082'	1039	'033602'	1677	'302580'	2315	'100228'	2953	'108200'
402	'006090'	1040	'033610'	1678	'302590'	2316	'100044'	2954	'200802'
403	'006130'	1041	'033620'	1679	'302600'	2317	'020039'	2955	'020161'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
404	'006160'	1042	'033630'	1680	'302610'	2318	'020152'	2956	'020159'
405	'006170'	1043	'033650'	1681	'302620'	2319	'020005'	2957	'200809'
406	'006180'	1044	'033660'	1682	'303000'	2320	'100026'	2958	'020120'
407	'006190'	1045	'033672'	1683	'303004'	2321	'100043'	2959	'200851'
408	'006200'	1046	'033681'	1684	'303010'	2322	'020176'	2960	'200781'
409	'006210'	1047	'033690'	1685	'303014'	2323	'100002'	2961	'020338'
410	'006222'	1048	'033698'	1686	'303015'	2324	'100001'	2962	'020337'
411	'006230'	1049	'033700'	1687	'303016'	2325	'100004'	2963	'200815'
412	'006250'	1050	'033730'	1688	'303017'	2326	'100207'	2964	'200814'
413	'006258'	1051	'033742'	1689	'303018'	2327	'100211'	2965	'200807'
414	'006262'	1052	'033750'	1690	'303020'	2328	'100049'	2966	'200800'
415	'006270'	1053	'033760'	1691	'303030'	2329	'020068'	2967	'200810'
416	'006280'	1054	'033770'	1692	'303034'	2330	'100203'	2968	'200806'
417	'006290'	1055	'033780'	1693	'303036'	2331	'020056'	2969	'200811'
418	'006300'	1056	'033790'	1694	'303038'	2332	'100145'	2970	'200808'
419	'006302'	1057	'033800'	1695	'303039'	2333	'100142'	2971	'200792'
420	'006306'	1058	'033804'	1696	'303040'	2334	'020175'	2972	'200793'
421	'008958'	1059	'033811'	1697	'303042'	2335	'020079'	2973	'200805'
422	'008960'	1060	'057151'	1698	'303043'	2336	'020101'	2974	'200854'
423	'008970'	1061	'057152'	1699	'303045'	2337	'020102'	2975	'200791'
424	'008990'	1062	'058710'	1700	'303046'	2338	'020103'	2976	'200848'
425	'009000'	1063	'058720'	1701	'303048'	2339	'020029'	2977	'200840'
426	'009020'	1064	'058730'	1702	'303050'	2340	'100110'	2978	'020164'
427	'009030'	1065	'058740'	1703	'303062'	2341	'020064'	2979	'020165'
428	'009060'	1066	'058750'	1704	'303070'	2342	'020046'	2980	'200795'
429	'009070'	1067	'058760'	1705	'303080'	2343	'020129'	2981	'020158'
430	'009080'	1068	'058770'	1706	'303090'	2344	'020128'	2982	'020121'
431	'009090'	1069	'058780'	1707	'303105'	2345	'020326'	2983	'020125'
432	'009110'	1070	'058790'	1708	'303110'	2346	'100229'	2984	'020163'
433	'009130'	1071	'058800'	1709	'303120'	2347	'100045'	2985	'200768'
434	'009142'	1072	'058810'	1710	'303130'	2348	'100025'	2986	'200780'
435	'009160'	1073	'058820'	1711	'303140'	2349	'020071'	2987	'200776'
436	'009170'	1074	'058830'	1712	'303150'	2350	'020173'	2988	'020162'
437	'009180'	1075	'058858'	1713	'303290'	2351	'020097'	2989	'200847'
438	'009190'	1076	'058861'	1714	'303300'	2352	'100141'	2990	'020317'
439	'009198'	1077	'058862'	1715	'303310'	2353	'100147'	2991	'020255'
440	'009202'	1078	'058890'	1716	'303320'	2354	'100143'	2992	'200779'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
441	'009210'	1079	'058900'	1717	'303330'	2355	'100144'	2993	'200846'
442	'009212'	1080	'058910'	1718	'303340'	2356	'020080'	2994	'200778'
443	'009220'	1081	'058920'	1719	'303350'	2357	'100134'	2995	'020166'
444	'009222'	1082	'058930'	1720	'303360'	2358	'100138'	2996	'200771'
445	'009230'	1083	'058940'	1721	'303370'	2359	'100109'	2997	'200770'
446	'009232'	1084	'058950'	1722	'500046'	2360	'020032'	2998	'200796'
447	'009240'	1085	'058960'	1723	'610088'	2361	'020156'	2999	'200773'
448	'009242'	1086	'058970'	1724	'620061'	2362	'020131'	3000	'200788'
449	'009250'	1087	'058990'	1725	'620073'	2363	'100016'	3001	'200766'
450	'009260'	1088	'059000'	1726	'620078'	2364	'100017'	3002	'020169'
451	'009272'	1089	'059011'	1727	'620079'	2365	'100210'	3003	'020123'
452	'009280'	1090	'059030'	1728	'620081'	2366	'100014'	3004	'020124'
453	'009292'	1091	'059040'	1729	'620085'	2367	'100011'	3005	'200767'
454	'009300'	1092	'059060'	1730	'620086'	2368	'100051'	3006	'200803'
455	'009310'	1093	'059070'	1731	'620088'	2369	'100108'	3007	'200769'
456	'009320'	1094	'059075'	1732	'620091'	2370	'020062'	3008	'200889'
457	'009330'	1095	'059080'	1733	'620093'	2371	'020153'	3009	'020265'
458	'009340'	1096	'059090'	1734	'620094'	2372	'102305'	3010	'200777'
459	'009350'	1097	'059100'	1735	'620096'	2373	'100050'	3011	'200789'
460	'009360'	1098	'059110'	1736	'620097'	2374	'102019'	3012	'030001'
461	'009370'	1099	'059120'	1737	'620101'	2375	'100148'	3013	'200849'
462	'009380'	1100	'059140'	1738	'620105'	2376	'102306'	3014	'200871'
463	'009390'	1101	'059160'	1739	'620106'	2377	'100149'	3015	'200865'
464	'009400'	1102	'059170'	1740	'620119'	2378	'020327'	3016	'200869'
465	'009410'	1103	'059192'	1741	'620128'	2379	'020385'	3017	'200868'
466	'009420'	1104	'059194'	1742	'620129'	2380	'100046'	3018	'200852'
467	'009430'	1105	'059202'	1743	'620131'	2381	'100202'	3019	'200856'
468	'009450'	1106	'059204'	1744	'620132'	2382	'100201'	3020	'200859'
469	'009460'	1107	'059212'	1745	'620148'	2383	'100035'	3021	'200858'
470	'009470'	1108	'059214'	1746	'620149'	2384	'100018'	3022	'200765'
471	'009480'	1109	'059240'	1747	'620159'	2385	'020043'	3023	'020336'
472	'009490'	1110	'059250'	1748	'620166'	2386	'100237'	3024	'020260'
473	'009500'	1111	'059270'	1749	'620167'	2387	'100235'	3025	'200864'
474	'009510'	1112	'059300'	1750	'620168'	2388	'020008'	3026	'200857'
475	'009522'	1113	'059312'	1751	'620171'	2389	'020094'	3027	'200855'
476	'009532'	1114	'059315'	1752	'620172'	2390	'100139'	3028	'020127'
477	'009540'	1115	'059318'	1753	'620173'	2391	'100117'	3029	'200870'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
478	'009542'	1116	'059320'	1754	'620174'	2392	'020033'	3030	'200853'
479	'009550'	1117	'059322'	1755	'620198'	2393	'020105'	3031	'200764'
480	'009552'	1118	'059324'	1756	'620204'	2394	'100027'	3032	'200246'
481	'009554'	1119	'059330'	1757	'620207'	2395	'020387'	3033	'200188'
482	'009570'	1120	'059340'	1758	'620208'	2396	'020066'	3034	'200295'
483	'009580'	1121	'059350'	1759	'620217'	2397	'020073'	3035	'200290'
484	'009590'	1122	'059360'	1760	'620221'	2398	'020084'	3036	'200291'
485	'009600'	1123	'059372'	1761	'620222'	2399	'100038'	3037	'200255'
486	'009610'	1124	'059390'	1762	'620223'	2400	'020314'	3038	'200292'
487	'009620'	1125	'059398'	1763	'620224'	2401	'100238'	3039	'200241'
488	'009630'	1126	'059400'	1764	'620225'	2402	'020045'	3040	'200248'
489	'009640'	1127	'059410'	1765	'620229'	2403	'100047'	3041	'200281'
490	'009650'	1128	'059420'	1766	'620231'	2404	'020323'	3042	'030387'
491	'009680'	1129	'059430'	1767	'620232'	2405	'020321'	3043	'200326'
492	'009690'	1130	'059440'	1768	'620235'	2406	'020324'	3044	'200249'
493	'009700'	1131	'059450'	1769	'620239'	2407	'100013'	3045	'200254'
494	'009710'	1132	'059460'	1770	'620240'	2408	'200835'	3046	'200250'
495	'009722'	1133	'059470'	1771	'620241'	2409	'020146'	3047	'200327'
496	'009726'	1134	'059482'	1772	'620242'	2410	'200888'	3048	'200257'
497	'009728'	1135	'059490'	1773	'620243'	2411	'200828'	3049	'200253'
498	'009729'	1136	'059500'	1774	'620244'	2412	'200834'	3050	'200311'
499	'009730'	1137	'059510'	1775	'620246'	2413	'200822'	3051	'200312'
500	'009750'	1138	'059520'	1776	'620247'	2414	'200812'	3052	'200641'
501	'009770'	1139	'059530'	1777	'620248'	2415	'200823'	3053	'030361'
502	'009790'	1140	'059542'	1778	'620249'	2416	'200819'	3054	'200285'
503	'009810'	1141	'059552'	1779	'620252'	2417	'200818'	3055	'200325'
504	'009812'	1142	'059562'	1780	'620253'	2418	'200831'	3056	'200378'
505	'009820'	1143	'059572'	1781	'620254'	2419	'200824'	3057	'200189'
506	'009830'	1144	'059582'	1782	'620255'	2420	'020167'	3058	'200240'
507	'009840'	1145	'059592'	1783	'620260'	2421	'200825'	3059	'200203'
508	'009850'	1146	'059602'	1784	'620330'	2422	'020383'	3060	'200261'
509	'009860'	1147	'059612'	1785	'620340'	2423	'020168'	3061	'200328'
510	'009870'	1148	'059632'	1786	'620350'	2424	'020181'	3062	'200276'
511	'009880'	1149	'059644'	1787	'620360'	2425	'020179'	3063	'200208'
512	'009900'	1150	'059650'	1788	'620370'	2426	'200804'	3064	'200216'
513	'009902'	1151	'059660'	1789	'620380'	2427	'200841'	3065	'200277'
514	'009910'	1152	'059680'	1790	'620382'	2428	'200821'	3066	'200252'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
515	'009920'	1153	'059690'	1791	'620400'	2429	'020183'	3067	'200238'
516	'009930'	1154	'059710'	1792	'620409'	2430	'200829'	3068	'200204'
517	'009938'	1155	'059720'	1793	'620410'	2431	'200827'	3069	'200219'
518	'009940'	1156	'059730'	1794	'620411'	2432	'200817'	3070	'300037'
519	'009942'	1157	'059740'	1795	'620412'	2433	'200816'	3071	'200244'
520	'009950'	1158	'059748'	1796	'620413'	2434	'200833'	3072	'300036'
521	'009960'	1159	'059750'	1797	'620418'	2435	'200826'	3073	'200362'
522	'009970'	1160	'059760'	1798	'620422'	2436	'020182'	3074	'200335'
523	'009982'	1161	'059770'	1799	'620423'	2437	'020178'	3075	'200356'
524	'009984'	1162	'059780'	1800	'620425'	2438	'200799'	3076	'030372'
525	'009990'	1163	'059792'	1801	'620426'	2439	'200798'	3077	'200372'
526	'010003'	1164	'059801'	1802	'620427'	2440	'200797'	3078	'200357'
527	'010004'	1165	'059842'	1803	'620428'	2441	'200886'	3079	'200333'
528	'010006'	1166	'059870'	1804	'620429'	2442	'200866'	3080	'200340'
529	'010008'	1167	'059880'	1805	'620430'	2443	'200863'	3081	'200364'
530	'010010'	1168	'059890'	1806	'620440'	2444	'200839'	3082	'200349'
531	'010020'	1169	'059900'	1807	'620460'	2445	'020232'	3083	'200377'
532	'010030'	1170	'059910'	1808	'620470'	2446	'200860'	3084	'200350'
533	'010040'	1171	'059920'	1809	'620480'	2447	'020384'	3085	'200332'
534	'010050'	1172	'059950'	1810	'620490'	2448	'020145'	3086	'200361'
535	'010090'	1173	'059960'	1811	'620500'	2449	'200842'	3087	'200339'
536	'010100'	1174	'059970'	1812	'620510'	2450	'200836'	3088	'200758'
537	'010110'	1175	'059980'	1813	'620520'	2451	'102145'	3089	'200354'
538	'010120'	1176	'059990'	1814	'620530'	2452	'202920'	3090	'200336'
539	'010130'	1177	'060000'	1815	'620540'	2453	'020342'	3091	'200324'
540	'010160'	1178	'060020'	1816	'620550'	2454	'102111'	3092	'200363'
541	'010181'	1179	'060070'	1817	'620590'	2455	'202550'	3093	'200642'
542	'010184'	1180	'060080'	1818	'620600'	2456	'020076'	3094	'200243'
543	'010192'	1181	'060090'	1819	'620610'	2457	'020136'	3095	'200609'
544	'010220'	1182	'060100'	1820	'620620'	2458	'020434'	3096	'200610'
545	'010234'	1183	'060110'	1821	'620630'	2459	'102304'	3097	'200337'
546	'010258'	1184	'060120'	1822	'620730'	2460	'102103'	3098	'200376'
547	'010262'	1185	'060130'	1823	'620780'	2461	'102104'	3099	'200367'
548	'010270'	1186	'060140'	1824	'620798'	2462	'102152'	3100	'200347'
549	'010280'	1187	'060150'	1825	'620822'	2463	'020058'	3101	'200608'
550	'010290'	1188	'060160'	1826	'620890'	2464	'102243'	3102	'200334'
551	'010300'	1189	'060170'	1827	'621030'	2465	'102256'	3103	'200191'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
552	'010312'	1190	'060180'	1828	'621142'	2466	'102137'	3104	'200369'
553	'010320'	1191	'060190'	1829	'621150'	2467	'102101'	3105	'200366'
554	'010330'	1192	'060200'	1830	'621160'	2468	'202960'	3106	'200351'
555	'010340'	1193	'060210'	1831	'621180'	2469	'020184'	3107	'200330'
556	'010348'	1194	'060230'	1832	'621190'	2470	'102112'	3108	'200605'
557	'010350'	1195	'060240'	1833	'621200'	2471	'102136'	3109	'200338'
558	'010352'	1196	'060244'	1834	'621212'	2472	'102146'	3110	'200346'
559	'010362'	1197	'060250'	1835	'621220'	2473	'102121'	3111	'200352'
560	'020012'	1198	'060260'	1836	'621225'	2474	'102125'	3112	'200260'
561	'020013'	1199	'060270'	1837	'621230'	2475	'102123'	3113	'200375'
562	'020106'	1200	'060280'	1838	'621240'	2476	'102133'	3114	'200348'
563	'020107'	1201	'060290'	1839	'621250'	2477	'020059'	3115	'200305'
564	'020108'	1202	'060300'	1840	'621260'	2478	'102244'	3116	'200615'
565	'020109'	1203	'060310'	1841	'621280'	2479	'102102'	3117	'200374'
566	'020111'	1204	'060338'	1842	'621290'	2480	'102147'	3118	'200237'
567	'020112'	1205	'060340'	1843	'621300'	2481	'102126'	3119	'200371'
568	'020113'	1206	'060360'	1844	'621310'	2482	'102124'	3120	'200316'
569	'020114'	1207	'060370'	1845	'621320'	2483	'020060'	3121	'200268'
570	'020115'	1208	'060380'	1846	'621332'	2484	'020277'	3122	'030176'
571	'020116'	1209	'060390'	1847	'621340'	2485	'020270'	3123	'200289'
572	'020117'	1210	'060412'	1848	'621350'	2486	'020278'	3124	'200293'
573	'020118'	1211	'060420'	1849	'621360'	2487	'020279'	3125	'030174'
574	'020119'	1212	'060442'	1850	'621370'	2488	'020271'	3126	'030362'
575	'020157'	1213	'060445'	1851	'621380'	2489	'020026'	3127	'200294'
576	'020171'	1214	'060450'	1852	'621390'	2490	'020027'	3128	'200315'
577	'020172'	1215	'060452'	1853	'621400'	2491	'020028'	3129	'200274'
578	'020185'	1216	'060460'	1854	'621410'	2492	'102302'	3130	'200310'
579	'020186'	1217	'060470'	1855	'621420'	2493	'020429'	3131	'200273'
580	'020187'	1218	'060480'	1856	'621430'	2494	'102204'	3132	'200899'
581	'020188'	1219	'060490'	1857	'621440'	2495	'102241'	3133	'200280'
582	'020189'	1220	'060500'	1858	'621450'	2496	'020430'	3134	'200271'
583	'020191'	1221	'060510'	1859	'621460'	2497	'102227'	3135	'200267'
584	'020192'	1222	'060520'	1860	'621462'	2498	'102226'	3136	'200272'
585	'020193'	1223	'060530'	1861	'621464'	2499	'102234'	3137	'200251'
586	'020194'	1224	'060540'	1862	'621470'	2500	'102233'	3138	'200265'
587	'020195'	1225	'060560'	1863	'621480'	2501	'102235'	3139	'200321'
588	'020196'	1226	'060562'	1864	'621490'	2502	'102236'	3140	'030359'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
589	'020197'	1227	'060570'	1865	'621500'	2503	'102237'	3141	'030358'
590	'020198'	1228	'060580'	1866	'621510'	2504	'102115'	3142	'030106'
591	'020199'	1229	'060590'	1867	'621520'	2505	'102114'	3143	'200279'
592	'020200'	1230	'060620'	1868	'621530'	2506	'102113'	3144	'200313'
593	'020201'	1231	'060630'	1869	'621540'	2507	'020436'	3145	'200314'
594	'020202'	1232	'060640'	1870	'621550'	2508	'102010'	3146	'200242'
595	'020203'	1233	'060650'	1871	'621800'	2509	'102007'	3147	'200616'
596	'020204'	1234	'060660'	1872	'621810'	2510	'102003'	3148	'200266'
597	'020205'	1235	'060670'	1873	'621820'	2511	'102001'	3149	'030180'
598	'020206'	1236	'060675'	1874	'621830'	2512	'102004'	3150	'200380'
599	'020207'	1237	'060690'	1875	'621840'	2513	'102002'	3151	'200383'
600	'020208'	1238	'060700'	1876	'621850'	2514	'102225'	3152	'200258'
601	'020209'	1239	'060710'	1877	'621860'	2515	'102223'	3153	'200559'
602	'020210'	1240	'060720'	1878	'621870'	2516	'102022'	3154	'200282'
603	'020211'	1241	'060730'	1879	'621880'	2517	'102221'	3155	'200236'
604	'020213'	1242	'060740'	1880	'621881'	2518	'102301'	3156	'200185'
605	'020214'	1243	'060750'	1881	'621882'	2519	'102213'	3157	'200247'
606	'020215'	1244	'060760'	1882	'621890'	2520	'020137'	3158	'200211'
607	'020216'	1245	'060770'	1883	'621900'	2521	'020139'	3159	'200264'
608	'020217'	1246	'060780'	1884	'621910'	2522	'020261'	3160	'200278'
609	'020218'	1247	'060790'	1885	'621920'	2523	'020435'	3161	'200270'
610	'020219'	1248	'060800'	1886	'621930'	2524	'020050'	3162	'200215'
611	'020220'	1249	'060810'	1887	'621940'	2525	'102216'	3163	'200207'
612	'020221'	1250	'060820'	1888	'621950'	2526	'102214'	3164	'200201'
613	'020223'	1251	'060830'	1889	'621960'	2527	'102209'	3165	'200192'
614	'020224'	1252	'060840'	1890	'621970'	2528	'020138'	3166	'030182'
615	'020226'	1253	'060850'	1891	'621980'	2529	'020147'	3167	'200269'
616	'020227'	1254	'060860'	1892	'621990'	2530	'020225'	3168	'200217'
617	'020229'	1255	'060870'	1893	'622000'	2531	'102005'	3169	'200218'
618	'020230'	1256	'060880'	1894	'623020'	2532	'102242'	3170	'200275'
619	'020231'	1257	'060890'	1895	'623030'	2533	'102143'	3171	'030073'
620	'020235'	1258	'060900'	1896	'623040'	2534	'102116'	3172	'030074'
621	'020236'	1259	'060910'	1897	'623050'	2535	'020328'	3173	'200210'
622	'020237'	1260	'060920'	1898	'623060'	2536	'102128'	3174	'030072'
623	'020238'	1261	'060930'	1899	'623070'	2537	'102127'	3175	'200209'
624	'020239'	1262	'060940'	1900	'623080'	2538	'102132'	3176	'200759'
625	'020241'	1263	'060950'	1901	'623090'	2539	'020095'	3177	'200239'

Table J. 1 (cont.)
Original 3177 bridges from Coastal Parishes

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
626	'020242'	1264	'060960'	1902	'623100'	2540	'020334'		
627	'020243'	1265	'060970'	1903	'623110'	2541	'020332'		
628	'020244'	1266	'060980'	1904	'623120'	2542	'020331'		
629	'020245'	1267	'061002'	1905	'623130'	2543	'020096'		
630	'020246'	1268	'061060'	1906	'700170'	2544	'020329'		
631	'020247'	1269	'061070'	1907	'800360'	2545	'020333'		
632	'020248'	1270	'061075'	1908	'800362'	2546	'020335'		
633	'020249'	1271	'061082'	1909	'800364'	2547	'102217'		
634	'020251'	1272	'061092'	1910	'800366'	2548	'102211'		
635	'020252'	1273	'061100'	1911	'800368'	2549	'102207'		
636	'020253'	1274	'061110'	1912	'800372'	2550	'102021'		
637	'020254'	1275	'061120'	1913	'800374'	2551	'102229'		
638	'020257'	1276	'061130'	1914	'800380'	2552	'102219'		

Table J. 2
471 Bridges Sent to Districts

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
1	'000170'	96	'003190'	191	'009310'	286	'020238'	381	'033742'
2	'000182'	97	'003210'	192	'009340'	287	'020239'	382	'033750'
3	'000203'	98	'003220'	193	'009350'	288	'020241'	383	'033770'
4	'000212'	99	'003230'	194	'009370'	289	'020242'	384	'033780'
5	'000216'	100	'003240'	195	'009380'	290	'020243'	385	'033790'
6	'000222'	101	'003255'	196	'009400'	291	'020244'	386	'058710'
7	'000230'	102	'003260'	197	'009420'	292	'020245'	387	'058720'
8	'000240'	103	'003270'	198	'009430'	293	'020247'	388	'058730'
9	'000810'	104	'003312'	199	'009450'	294	'020248'	389	'058740'
10	'000840'	105	'003322'	200	'009460'	295	'020249'	390	'058750'
11	'000852'	106	'003332'	201	'009500'	296	'020257'	391	'058858'
12	'000862'	107	'003362'	202	'009510'	297	'020266'	392	'058910'
13	'000870'	108	'003381'	203	'009570'	298	'020267'	393	'058920'
14	'000880'	109	'003384'	204	'009580'	299	'020269'	394	'058930'
15	'000890'	110	'003390'	205	'009590'	300	'020289'	395	'058940'
16	'000902'	111	'003412'	206	'009600'	301	'020291'	396	'058970'
17	'000910'	112	'003432'	207	'009610'	302	'020294'	397	'058990'
18	'000920'	113	'003440'	208	'009620'	303	'020303'	398	'059011'
19	'000930'	114	'003450'	209	'009630'	304	'020304'	399	'059030'
20	'000942'	115	'003470'	210	'009640'	305	'020305'	400	'059040'
21	'000952'	116	'003480'	211	'009650'	306	'020306'	401	'059070'
22	'000966'	117	'003490'	212	'009680'	307	'020307'	402	'059075'
23	'000974'	118	'003500'	213	'009690'	308	'020309'	403	'059140'
24	'000976'	119	'003510'	214	'009700'	309	'020310'	404	'059372'
25	'000980'	120	'003520'	215	'009710'	310	'020311'	405	'059482'
26	'000990'	121	'003540'	216	'009722'	311	'020319'	406	'059748'
27	'001000'	122	'003550'	217	'009726'	312	'020346'	407	'059880'
28	'001010'	123	'003580'	218	'009728'	313	'020352'	408	'059900'
29	'001020'	124	'003590'	219	'009729'	314	'020353'	409	'059920'
30	'001022'	125	'003600'	220	'009730'	315	'020354'	410	'060360'
31	'001030'	126	'003610'	221	'009750'	316	'020356'	411	'060412'
32	'001032'	127	'003620'	222	'009810'	317	'020357'	412	'060450'
33	'001040'	128	'003641'	223	'009812'	318	'020361'	413	'061070'
34	'001052'	129	'003660'	224	'009820'	319	'020362'	414	'062090'
35	'001070'	130	'003670'	225	'009900'	320	'020366'	415	'062100'
36	'001090'	131	'003690'	226	'009902'	321	'020367'	416	'063440'

Table J. 2 (cont.)
471 Bridges Sent to Districts

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
37	'001100'	132	'003700'	227	'009910'	322	'020374'	417	'070030'
38	'001121'	133	'003702'	228	'009920'	323	'020386'	418	'070076'
39	'001130'	134	'005680'	229	'009930'	324	'020389'	419	'070096'
40	'001142'	135	'005714'	230	'009938'	325	'020413'	420	'070097'
41	'001151'	136	'005724'	231	'009940'	326	'020415'	421	'070119'
42	'001153'	137	'005731'	232	'009942'	327	'020416'	422	'070137'
43	'001165'	138	'005740'	233	'010010'	328	'020417'	423	'070141'
44	'001211'	139	'005750'	234	'010020'	329	'020423'	424	'070142'
45	'001212'	140	'005780'	235	'010030'	330	'020426'	425	'070143'
46	'001280'	141	'005790'	236	'010040'	331	'020431'	426	'070144'
47	'001292'	142	'005800'	237	'010050'	332	'030133'	427	'070166'
48	'001304'	143	'005830'	238	'010090'	333	'030185'	428	'000214'
49	'001306'	144	'005840'	239	'010100'	334	'030190'	429	'001160'
50	'001312'	145	'005850'	240	'010110'	335	'030242'	430	'002190'
51	'001342'	146	'005860'	241	'010130'	336	'030262'	431	'002220'
52	'001344'	147	'005868'	242	'010160'	337	'030263'	432	'002260'
53	'001346'	148	'005870'	243	'010181'	338	'030264'	433	'002300'
54	'001390'	149	'005900'	244	'010184'	339	'030265'	434	'002352'
55	'001525'	150	'005940'	245	'010192'	340	'030266'	435	'002631'
56	'001545'	151	'005980'	246	'010234'	341	'030267'	436	'002690'
57	'001552'	152	'005990'	247	'010258'	342	'030271'	437	'002720'
58	'002191'	153	'006040'	248	'010262'	343	'030273'	438	'002740'
59	'002210'	154	'006050'	249	'010270'	344	'030286'	439	'002819'
60	'002230'	155	'006130'	250	'010290'	345	'030288'	440	'002892'
61	'002250'	156	'006160'	251	'010300'	346	'030291'	441	'005712'
62	'002270'	157	'006170'	252	'010312'	347	'030294'	442	'005722'
63	'002290'	158	'006180'	253	'010320'	348	'030295'	443	'005730'
64	'002310'	159	'006190'	254	'010330'	349	'030309'	444	'005930'
65	'002320'	160	'006200'	255	'010340'	350	'030312'	445	'005980'
66	'002330'	161	'006210'	256	'010348'	351	'030339'	446	'006040'
67	'002354'	162	'006222'	257	'010362'	352	'030351'	447	'009250'
68	'002411'	163	'006230'	258	'020171'	353	'030365'	448	'009410'
69	'002562'	164	'006250'	259	'020185'	354	'030381'	449	'020192'
70	'002564'	165	'006258'	260	'020186'	355	'030382'	450	'020196'
71	'002566'	166	'006270'	261	'020193'	356	'030383'	451	'020210'
72	'002632'	167	'006280'	262	'020194'	357	'030394'	452	'020172'

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
73	'002640'	168	'006290'	263	'020195'	358	'031755'	453	'020209'
74	'002650'	169	'006300'	264	'020197'	359	'032120'	454	'020290'
75	'002660'	170	'006302'	265	'020198'	360	'032190'	455	'020301'
76	'002670'	171	'006306'	266	'020199'	361	'032266'	456	'020359'
77	'002700'	172	'008970'	267	'020200'	362	'032640'	457	'020365'
78	'002730'	173	'008990'	268	'020201'	363	'032690'	458	'020358'
79	'002750'	174	'009000'	269	'020202'	364	'032780'	459	'030115'
80	'002820'	175	'009020'	270	'020211'	365	'033210'	460	'030189'
81	'002830'	176	'009030'	271	'020213'	366	'033280'	461	'030285'
82	'002840'	177	'009060'	272	'020214'	367	'033290'	462	'030308'
83	'002860'	178	'009070'	273	'020215'	368	'033354'	463	'030393'
84	'002870'	179	'009130'	274	'020216'	369	'033402'	464	'032630'
85	'002874'	180	'009142'	275	'020217'	370	'033470'	465	'032680'
86	'002880'	181	'009160'	276	'020218'	371	'033480'	466	'033270'
87	'002890'	182	'009170'	277	'020219'	372	'033590'	467	'033400'
88	'002894'	183	'009180'	278	'020220'	373	'033602'	468	'059870'
89	'003068'	184	'009190'	279	'020221'	374	'033650'	469	'059890'
90	'003074'	185	'009198'	280	'020223'	375	'033660'	470	'059910'
91	'003130'	186	'009260'	281	'020224'	376	'033672'	471	'033502'
92	'003140'	187	'009272'	282	'020226'	377	'033681'		
93	'003150'	188	'009280'	283	'020235'	378	'033698'		
94	'003160'	189	'009292'	284	'020236'	379	'033700'		
95	'003180'	190	'009300'	285	'020237'	380	'033730'		

Exhibit J. 1
Letter to and Response from District 02

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

INTRADEPARTMENTAL CORRESPONDENCE

IN REPLY REFER TO
FILE NO.

October 18, 2011
(225) 379-1321

REFERRED TO

____ REFERRED FOR ACTION
____ ANSWER FOR MY SIGNATURE
____ FOR FILE
____ FOR YOUR INFORMATION
____ FOR SIGNATURE
____ RETURN TO ME
____ PLEASE SEE ME
____ PLEASE TELEPHONE ME
____ FOR APPROVAL
____ PLEASE ADVISE ME

BY ____ DATE ____
BY ____ DATE ____
BY ____ DATE ____

MEMORANDUM

TO: **MICHAEL STACK, P.E.**
DISTRICT 02 ADMINISTRATOR

FROM: **ZHENGZHENG "JENNY" FU, P.E.**
ASSISTANT BRIDGE DESIGN ADMINISTRATOR

SUBJECT: **COASTAL BRIDGE SELECTION REQUEST FOR VULNERABILITY STUDY**

Included herewith is a list of bridges in your district that may be included in a LTRC research project which will determine the vulnerability of Louisiana's coastal bridges to storm surge wave loading. The attached bridge list began with all on and off-system structures found in the STRM database located in coastal parishes. Bridges meeting the following criteria were then eliminated and divided into districts:

1. Bridge locations that were not actually bridges (e.g. culverts, ferry docks).
2. Bridges that were protected by a levee system.
3. Bridges located at high ground elevations and away from large water bodies and bridges away from FEMA V zones.
4. Bridges with short local wind setup and wave fetches (due to geography and/or vegetation) limiting wave heights.
5. Bridges that could be identified as having high, low-cord elevations from GoogleEarth images.

Please review the attached list of 228 bridges in your district and select any structure whose closure may have a significant impact on the community, may be the only access to/from a populated coastal area, or you deem to be of concern and can benefit from this project. Add any bridge that may be of concern that may not be on the provided list. Do not select bridges that may be replaced soon, were recently constructed and designed for wave forces, or are minor structures that will not be retrofitted if found to be vulnerable. Please provide your list of selected bridges no later than Tuesday, November 22, 2011. Your assistance in this effort is greatly appreciated.

Please contact me if you have any questions or need additional information.

ZZF/ssc

Attachments
CC: Mr. Hossein Ghara
Mrs. Stephanie Cavalier
Mr. Walid Alaywan (LTRC)
Mr. Huseyin Demir (OEA, Inc.)
Dr. Max Sheppard (OEA, Inc.)

RECOMMENDED FOR APPROVAL ____ DATE ____

RECOMMENDED FOR APPROVAL ____ DATE ____

APPROVED ____ DATE ____

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
1	02	26	000170	02260640106571	CODEKG	LA0001	CAMINADA BAY
2	02	26	000182	02260640109291	COSLAB	LA0001	BAYOU THUNDER OVERFLOW
3	02	26	000203	02262490112531	COPCSS	LA0301	PRIEST CANAL
4	02	26	000212	02264290207501	COMWEL	LA3134	LA45;LA303;ICWW
5	02	26	000216	02264290209102	COSLAB	LA3134	B.DES FAMILLIES
6	02	26	000222	02262499002681	COSLAB	LA0045	FLEMINGS CANAL
7	02	26	000230	02262499006621	CNTIBM	LA0045	GOOSE BAYOU
8	02	26	000240	02262499008331	COPCSS	LA0045	DRAIN CANAL
9	02	26	000810	02268263900071	LOSWNG	LA0302	BAYOU BARATARIA
10	02	29	000840	02290050600681	COSLAB	LA0182	HOLLYWOOD CANAL
11	02	29	000852	02290050604961	COSLAB	LA0182	MCMAHON CANAL
12	02	29	000862	02290050605631	COSLAB	LA0182	BAYOU FOLSE
13	02	29	000870	02290050606241	COSLAB	LA0182	40 ARPENT CANAL
14	02	29	000880	02290050700011	STVERT	LA0182	BAYOU LAFOURCHE
15	02	29	000890	02290050700831	CIBTCF	LA0182	DRAIN CANAL
16	02	29	000902	02290640200001	COSLAB	LA0001	BAYOU THUNDER
17	02	29	000910	02290640200501	COSLAB	LA0001	BAYOU FERBLANC
18	02	29	000920	02290640503281	STVERT	LA0001	INTRACOASTAL CANL
19	02	29	000930	02290640601401	STVERT	LA0001	CO CANAL LOCKPORT
20	02	29	000942	02290640703331	COSLAB	LA0001	THERIOT CANAL
21	02	29	000952	02290640710371	STPLGR	S.P.RR	LA 1
22	02	29	000966	02290650100101	CODEKG	LA0024	DRESSER CANAL
23	02	29	000974	02290650102131	COSLAB	LA0024	PIPELINE CROSSING
24	02	29	000976	02290650102201	COSLAB	LA0024	BAYOU BLUE
25	02	29	000980	02290650600001	CORIBM	LA0020	BAYOU LAFOURCHE
26	02	29	000990	02290650603201	COPCSS	LA0020	40 ARPENT CANAL
27	02	29	001000	02290650604241	COPCSS	LA0020	DRAINAGE CANAL
28	02	29	001010	02290650605001	COPCSS	LA0020	DRAINAGE CANAL
29	02	29	001020	02290650605201	COPCSS	LA0020	DRAINAGE CANAL
30	02	29	001022	02290650607621	COPCSS	LA0020	GRAND BAYOU
31	02	29	001030	02294070100001	STVERT	LA0308	BAYOU LAFOURCHE
32	02	29	001032	02294070106161	COPCSS	LA0308	LEBRETON CANAL
33	02	29	001040	02294070111941	CIBTCF	LA0308	SCULLY CANAL
34	02	29	001052	02294079003501	STCPLG	LA0308	LA657-ICWW-STR@LAROSE
35	02	29	001070	02294079007761	COPCSS	LA0308	DRAINAGE CANAL
36	02	29	001090	02294079009361	COPCSS	LA0308	VALENTINE CANAL
37	02	29	001100	02294079014381	COPCSS	LA0308	DRAINAGE CANAL
38	02	29	001121	02294070300001	COSLAB	LA0308	COMPANY CANAL
39	02	29	001130	02294070306491	COPCSS	LA0308	DRAINAGE CANAL
40	02	29	001142	02294070403131	COSLAB	LA0308	THERIOT CANAL
41	02	29	001151	02294070410761	STHITR	LA0308	SRRR LAFOURCHE XING
42	02	29	001153	02294070412521	COPCSS	LA0308	L VALLEY CANAL
43	02	29	001165	02298292804102	COSLAB	LA3087	HOLLYWOOD CANAL
44	02	29	001211	02298290405721	COSLAB	LA0304	BAYOU L'ONION
45	02	29	001212	02298292900621	COPCSS	LA0648	DRAIN CANAL
46	02	29	001280	02298291203701	TTTRES	LA0653	BAYOU DUMAR
47	02	29	001292	02298291204601	CPGCCD	LA0653	LA 653 OVER US 90
48	02	29	001304	02298291400791	PGSWNG	LA0655	BAYOU LAFOURCHE
49	02	29	001306	02298291504801	COPCSS	LA0307	BAYOU ROND POMPON
50	02	29	001312	02298291510171	STVERT	LA0307	BAYOU BOEUF
51	02	29	001342	02298292200401	COPCSS	LA3107	DRAINAGE CANAL

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
103	02	55	003322	02552440101691	COSLAB	LA0020	TIGER BAYOU
104	02	55	003332	02552440102151	COSLAB	LA0020	DONNER CANAL
105	02	55	003362	02552440107231	COSLAB	LA0020	DRAINAGE CANAL
106	02	55	003381	02552440109431	COSLAB	LA0020	DRAINAGE CANAL
107	02	55	003384	02550650404699	COSLAB	LA0024	TERREBONNE BAYOU
108	02	55	003390	02552450207341	PGSWNG	LA0315	FALGOUT CANAL
109	02	55	003412	02552459009801	PGBASC	LA0315	BAYOU DULARGE
110	02	55	003432	02552460117211	PGSWNG	LA0057	BAYOU DULAC
111	02	55	003440	02552470106421	COSLAB	LA0056	ROBINSON CANAL
112	02	55	003450	02552470204101	PGSWNG	LA0056	BOUDREAUX CANAL
113	02	55	003470	02552470305961	COSLAB	LA0056	ST LOUIS CANAL
114	02	55	003480	02552473000011	STVERT	LA0058	PETIT CAILLOU
115	02	55	003490	02552473000361	COPCSS	LA0058	DRAINAGE CANAL
116	02	55	003500	02552473001581	STVERT	LA0058	BAYOU TERREBONNE
117	02	55	003510	02552480200001	COSLAB	LA0055	MADISON CANAL
118	02	55	003520	02552480200801	COSLAB	LA0055	LAPEYROUSE CANAL
119	02	55	003540	02552480304841	COSLAB	LA0055	ST LOUIS CANAL
120	02	55	003550	02554120400561	COSLAB	LA0316	ST.LOUIS CANAL
121	02	55	003580	02550650400881	COPCSS	LA0024	STIVOUIS CANAL
122	02	55	003590	02558550700021	COPCSS	LA0660	BAYOU TERREBONNE
123	02	55	003600	02558550703031	COSLAB	LA0660	ST LOUIS CANAL
124	02	55	003610	02558550800001	PGSWNG	LA0661	NAVIGATION CANAL
125	02	55	003620	02558550800481	STVERT	LA0661	BAYOU LACARPE
126	02	55	003641	02558550908511	COSLAB	LA0655	ISLE JEAN CHARLES CANAL
127	02	55	003660	02550650410809	COPCSS	LA0024	BAYOU TERREBONNE
128	02	55	003670	02558551200011	CONIBM	LA0664	BAYOU TERREBONNE
129	02	55	003690	02558551300021	TTTRES	LA3011	DRAINAGE CANAL
130	02	55	003700	02558551400011	STVERT	LA3087	BAYOU TERREBONNE
131	02	55	003702	02558551400331	STCPLG	LA3087	INTRACOASTAL WW
132	02	45	020171	02454503600005	CPGCCD	I0310	SWAMP
133	02	45	020185	02454501401459	COPSGR	I0010	LAKE PONTCHARTRAIN X-OVER
134	02	45	020186	02454501405609	COPSGR	I0010	SWAMP (EMERGENCY X-OVER)
135	02	36	020193	02364504300241	CPGCCD	LOC RD	I-510
136	02	36	020194	02364504300581	CPGCCD	I0510	RR/US 90(CHEF HWY)
137	02	36	020195	02364504300552	CPGCCD	I0510	RR/US 90(CHEF HWY)
138	02	36	020197	02364504301402	CPGCCD	I0510	CITY STREETS
139	02	36	020198	02364504301851	CPGCCD	I0510	CITY STREETS
140	02	36	020199	02364504301832	CPGCCD	I0510	CITY STREETS
141	02	36	020200	02364504300757	COPSGR	I0510	R/R
142	02	36	020201	02364504302205	CPGCCD	I0510	GROUND
143	02	36	020202	02364504302278	CPGCCD	I0510	GROUND
144	02	45	020211	02454503605982	COPSGR	I0310	PIPELINE
145	02	45	020213	02454503600408	CPGCCD	I0310	I-10/I-310/SWAMP
146	02	45	020214	02454503600418	CPGCCD	I0310	GROUND
147	02	45	020215	02454503600425	CPGCCD	I0310	I-310 RAMP OVER I-10
148	02	45	020216	02454503602456	CPGCCD	I0310	RAMPS/US 61
149	02	45	020217	02454503602567	COPSGR	I0310	RAMPS/US 61
150	02	45	020218	02454503602646	CPGCCD	I0310	SWAMP
151	02	45	020219	02454503602777	CPGCCD	I0310	SWAMP
152	02	45	020220	02454503603158	COPSGR	I0310	RR/CANAL
153	02	45	020221	02454503603325	CPGCCD	I0310	RR/CANAL

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
154	02	45	020223	02454503603388	STCUGR	I0310	RAMPS/RR/CANAL/US 61
155	02	45	020224	02454503603505	CPGCCD	I0310	RAMPS/RR/CANAL/US 61
156	02	55	020226	02550050300001	COSLAB	LA0182	BORROW CANAL
157	02	36	020235	02367210600001	COMWEL	CCCFERRY	LOWER ALGIERS FERRY FAC.
158	02	36	020236	02364504300706	COPSGR	I0510	RAILROAD
159	02	36	020237	02367210400001	COMWEL	CCCFERRY	MISS RIVER RAMP ALGIERS
160	02	36	020238	02367210300001	COMWEL	CCCFERRY	CANAL ST.FERRY RAMP
161	02	36	020239	02367210100001	COMWEL	CCCFERRY	JACKSON AVE.FERRY RAMP
162	02	36	020241	02367210200001	COMWEL	CCCFERRY	JACKSON AVE.FERRY RAMP
163	02	55	020242	02554240706315	COPSGR	US0090	LA 20, SP RR DRAIN CANAL
164	02	55	020243	02554240706406	COPSGR	US0090	SWAMP
165	02	55	020244	02554240706351	COPSGR	US0090	SWAMP, LOCAL RD., TIGER B
166	02	55	020245	02554240706308	COPSGR	LA3052	LA 20, SP RR, DRAIN CANAL
167	02	29	020247	02294130403071	COSLAB	LA0309	PHILLIPS CANAL
168	02	55	020248	02554240706007	COPSGR	US0090	LA 20, SP RR, DRAIN CANAL
169	02	55	020249	02554240706332	COPSGR	US0090	SWAMP, LOCAL RD. TIGER B.
170	02	29	020257	02294130401571	COSLAB	LA0309	BUBBLING BAYOU
171	02	26	020266	02268264804061	COPCSS	LA3257	PAILET CANAL
172	02	29	020267	02298291800001	PGSWNG	LA0649	BAYOU LAFOURCHE
173	02	36	020269	02364504301026	COPSGR	I0510	GROUND
174	02	36	020289	02362830802075	CNTWEL	US0090B	CITY STREETS
175	02	36	020291	02362830802325	STCUGR	US0090B	CITY STREETS,TRANSIT RAMP
176	02	36	020294	02362830802318	STCUGR	US0090B	CITY STREETS
177	02	55	020303	02554240708362	COPSGR	US0090	DRAINAGE CANALS,LA 20,RR
178	02	55	020304	02554240709018	COPSGR	US0090	SWAMP
179	02	55	020305	02554240709117	COPSGR	US0090	SWAMP
180	02	55	020306	02554240709366	COPSGR	US0902	SWAMP
181	02	55	020307	02554240709415	COPSGR	US0090	SWAMP
182	02	55	020309	02558550400031	STCPLG	LA0659	INTERCOASTAL WATERWAY
183	02	55	020310	02550659108701	STCPLG	LA024	INTRACOASTAL WATERWAY
184	02	36	020311	02364501702701	COPSGR	I0010	LAKE PONTCHARTRAIN
185	02	55	020319	02552480204001	PGSWNG	LA0055	HUMBLE CANAL
186	02	29	020346	02298291204251	COSLAB	LA0653	DRAINAGE CANAL
187	02	29	020352	02298291000001	STVERT	LA0654	BAYOU LAFOURCHE
188	02	45	020353	02450050904651	COPSGR	US0090	DAVIS POND DIVERSION
189	02	55	020354	02558550802451	STVERT	LA0661	BAYOU TERREBONNE
190	02	55	020356	02550050508191	COSLAB	LA0182	ST. LOUIS CANAL
191	02	55	020357	02554240700052	COPSGR	US0090	LA 662, BAYOU L'OURSE
192	02	55	020361	02554240700051	COPSGR	US0090	LA662, BAYOU L'OURSE
193	02	55	020362	02554240701351	COPSGR	US0090	DRAINAGE CANAL
194	02	55	020366	02554240703951	COVSLB	US0090	TIGER BAYOU
195	02	55	020367	02554240703351	COPSGR	US0090	CHACAHOULA BAYOU
196	02	55	020374	02552460100021	STVERT	LA0057	BAYOU TERREBONNE
197	02	36	020386	02360060600001	COPSGR	US0090	RIGOLETS PASS
198	02	29	020389	02298291300321	COPCSS	LA0652	LA 652 @ 40 ARPENT CANAL
199	02	26	020413	02262490108371	COSLAB	LA0045	DRAIN DITCH
200	02	29	020415	02290640212601	IBMWEL	LA0001	BAYOU LAFOURCHE
201	02	29	020416	02290640211901	COPSGR	LA0001	MARSH
202	02	29	020417	02290649001001	COPSGR	LA0001	MARSH
203	02	55	020423	02558550706471	COPCSS	LA0660	DRAIN CANAL
204	02	55	020426	02550659109101	COSLAB	CITY STR	BAYOU TERREBONNE

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
205	02	45	020431	02450050904652	COPSGR	US0090	DAVIS POND DIVERSION
206	02	26	000214	02264290209101	COSLAB	LA3134	B.DES FAMILLIES
207	02	29	001160	02298292804101	COSLAB	LA3087	HOLLYWOOD CANAL
208	02	36	002190	02364504305342	CNTWEL	I0510	I-510(PARIS RD) OVER I-10
209	02	36	002220	02364509018131	COPSGR	I0010	DRAIN CANAL
210	02	36	002260	02364509019581	COPSGR	I0010	DRAIN CANAL
211	02	36	002300	02364509021241	COPSGR	I0010	DRAIN CANAL
212	02	36	002352	02364501700001	COMWEL	I0010	LAKE PONTCHARTRAIN
213	02	44	002631	02442840107751	COSLAB	LA0046	BAYOU LALOUTRE
214	02	45	002690	02450050800001	COMWEL	US0090	B DESALLEMANDS
215	02	45	002720	02450050905861	CODEKG	US0090	DRAIN CANAL
216	02	45	002740	02450050907151	CODEKG	US0090	SELLERS CANAL
217	02	45	002819	02450070309181	CPGCCD	US0061	BONNET CARRE SPILLWAY
218	02	45	002892	02454501400001	COMWEL	I0010	BONNET CARRE SPILLWAY
219	02	36	020192	02364504300242	CPGCCD	LOC RD	I-510
220	02	36	020196	02364504301401	CPGCCD	I0510	CITY STREETS
221	02	45	020210	02454503605981	COPSGR	I0310	PIPELINE
222	02	45	020172	02454503600401	COPSGR	I0310	US 61/RR/SWAMP/LA 626
223	02	45	020209	02454503600412	COPSGR	I0310	US 61/RR/SWAMP/LA 626
224	02	36	020290	02362830802314	STCUGR	US0090B	CITY STREETS
225	02	55	020301	02554240708361	COPSGR	US0090	DRAIN CANALS,LA.20,RR
226	02	55	020359	02554240701352	COPSGR	US0090	DRAINAGE CANAL
227	02	55	020365	02554240703952	COVSLB	US0090	TIGER BAYOU
228	02	55	020358	02554240703352	COPSGR	US0090	CHACAHOULA BAYOU

From: John Guidry
Sent: Thursday, December 15, 2011 3:54 PM
To: Buzzy Wegener
Subject: RE: Coastal bridge selection request for vulnerability study

ID	Recall	Name
High Risk or Larger unprotected Structures		
57	001552	US 11
72	002632	Bayou La loutre
74	002650	Bayou La Loutre (Yscloskey Draw)
88	002894	I-10 Bonnet Carre Spillway
133	020185	I-10 lake Pontchartrain x over
134	020186	I-10 Swamp x over
218	002892	I-10 Bonnet Carre Spillway
213	002631	Bayou La Loutre
Mississippi River Ferry Ramps		
157	020235	CCC Ferry Ramp
159	020237	CCC Ferry Ramp
160	020238	CCC Ferry Ramp
161	020239	CCC Ferry Ramp
162	020241	CCC Ferry Ramp
Smaller canal crossings that are at risk and would isolate if taken out.		
171	020266	Pailet Canal
185	020319	Humble Canal
108	003390	Falgout Canal
110	003432	Bayou Dulac
111	003440	Robinson Canal
112	003480	Boudreax Canal
117	003510	Madison Canal
118	003520	Lapeyrouse Canal
126	003641	Isle Jean Charles Canal
129	003690	Drainage Canal

Exhibit J. 2
Letter to and Response from District 03

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

INTRADEPARTMENTAL CORRESPONDENCE

IN REPLY REFER TO
FILE NO.

REFERRED TO

____ REFERRED FOR ACTION
____ ANSWER FOR MY SIGNATURE
____ FOR FILE
____ FOR YOUR INFORMATION
____ FOR SIGNATURE
____ RETURN TO ME
____ PLEASE SEE ME
____ PLEASE TELEPHONE ME
____ FOR APPROVAL
____ PLEASE ADVISE ME

BY ____ DATE ____
BY ____ DATE ____
BY ____ DATE ____

October 18, 2011
(225) 379-1321

MEMORANDUM

TO: **MICHAEL MOSS, P.E.**
DISTRICT 03 ADMINISTRATOR

FROM: **ZHENGZHENG "JENNY" FU, P.E.**
ASSISTANT BRIDGE DESIGN ADMINISTRATOR

SUBJECT: **COASTAL BRIDGE SELECTION REQUEST FOR VULNERABILITY STUDY**

Included herewith is a list of bridges in your district that may be included in a LTRC research project which will determine the vulnerability of Louisiana's coastal bridges to storm surge wave loading. The attached bridge list began with all on and off-system structures found in the STRM database located in coastal parishes. Bridges meeting the following criteria were then eliminated and divided into districts:

1. Bridge locations that were not actually bridges (e.g. culverts, ferry docks).
2. Bridges that were protected by a levee system.
3. Bridges located at high ground elevations and away from large water bodies and bridges away from FEMA V zones.
4. Bridges with short local wind setup and wave fetches (due to geography and/or vegetation) limiting wave heights.
5. Bridges that could be identified as having high, low-cord elevations from GoogleEarth images.

Please review the attached list of 163 bridges in your district and select any structure whose closure may have a significant impact on the community, may be the only access to/from a populated coastal area, or you deem to be of concern and can benefit from this project. Add any bridge that may be of concern that may not be on the provided list. Do not select bridges that may be replaced soon, were recently constructed and designed for wave forces, or are minor structures that will not be retrofitted if found to be vulnerable. Please provide your list of selected bridges no later than Tuesday, November 22, 2011. Your assistance in this effort is greatly appreciated.

Please contact me if you have any questions or need additional information.

ZZF/ssc

Attachments
CC: Mr. Hossein Ghara
Mrs. Stephanie Cavalier
Mr. Walid Alaywan (LTRC)
Mr. Huseyin Demir (OEA, Inc.)
Dr. Max Sheppard (OEA, Inc.)

RECOMMENDED FOR APPROVAL ____ DATE ____
RECOMMENDED FOR APPROVAL ____ DATE ____
APPROVED ____ DATE ____

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
1	03	23	005680	03230040506771	CIBTCF	LA0182	SANDAGER CANAL
2	03	23	005714	03230550704152	COSLAB	LA0014	POUFETTE CANAL
3	03	23	005724	03230550705262	COSLAB	LA0014	BAYOU PETITE ANSE
4	03	23	005731	03230550707862	COSLAB	LA0014	ARMENCO CANAL
5	03	23	005740	03232350100101	CODEKG	LA0329	RODERE CANAL
6	03	23	005750	03232360101131	CONIBM	LA0083	COMMMERICAL CANAL
7	03	23	005780	03232360202041	TTTRES	LA0085	PATOUT CANAL
8	03	23	005790	03232360206641	COPCSS	LA0085	DRAIN
9	03	23	005800	03232370100141	PGBASC	LA0086	BAYOU TECHE/DUPERIOR ST
10	03	23	005830	03232400302221	LOSWNG	LA0083	BAYOU PATOUT-WEEKS ISLAND
11	03	23	005840	03232400303491	CIBTTM	LA0083	STUMPY BAYOU
12	03	23	005850	03232400305941	TTTRES	LA0083	BAYOU BLUE
13	03	23	005860	03232410100161	LOSWNG	LA0671	BAYOU TECHE JEAN
14	03	23	005868	03233970501931	TTTRES	LA0089	CREEK
15	03	23	005870	03233970503171	TTTRES	LA0089	PARC PEROU BAYOU
16	03	23	005900	03234003100241	PGSWNG	LA0086	B TECHE DASPIT
17	03	23	005940	03234240404702	COSLAB	US0090	SEGURA BRANCH
18	03	23	005980	03234240406661	COSLAB	US0090	ARMENCO CANAL
19	03	23	005990	03234240406662	COSLAB	US0090	ARMENCO CANAL
20	03	23	006040	03234240409161	COSLAB	US0090	RODERE CANAL
21	03	23	006050	03234240409162	COSLAB	US0090	RODERE CANAL
22	03	23	006130	03238230208181	COSLAB	LA0675	ARMENCO CANAL
23	03	23	006160	03238230701181	TTTRES	LA0676	DEBLANC COULEE
24	03	23	006170	03238230702011	COPCSS	LA0676	CREEK
25	03	23	006180	03238231200171	PGSWNG	LA0320	B TECHE (OLIVER)
26	03	23	006190	03238231201361	COPCSS	LA0320	TELE BAYOU
27	03	23	006200	03238231400251	PGSWNG	LA0344	B TECHE MORBIHAN
28	03	23	006210	03238231406331	STVERT	LA0344	TECHE BAYOU @ LOREAUVILLE
29	03	23	006222	03238232000171	COPCSS	LA0673	DRAINAGE CANAL
30	03	23	006230	03238232603471	TTTRES	LA0087	CREEK
31	03	23	006250	03238232800551	COSLAB	LA0668	DELAHOUSSAYE CNL
32	03	23	006258	03238232907581	COSLAB	LA0674	COMMERCIAL CANAL
33	03	23	006270	03238233400391	TTTCOF	LA0682	CREEK
34	03	23	006280	03238233400841	TTTCOF	LA0682	NORRIS CANAL
35	03	23	006290	03238233401811	TTTCOF	LA0682	CREEK
36	03	23	006300	03238234100461	COSLAB	LA0089	ROMERO CANAL
37	03	23	006302	03238234200081	LOSWNG	LA3156	BAYOU TECHE
38	03	23	006306	03238234300081	PGSWNG	LA3182	BAYOU TECHE
39	03	51	008970	03510040609371	STHITR	LA0182	CHARENTON
40	03	51	008990	03510040702071	CIBTCF	LA0182	HANSON CANAL
41	03	51	009000	03510050100001	STHITR	LA0182	ATCHAF.R/BERWICK BAY
42	03	51	009020	03510050105491	CODEKG	US0090	RAMOS BAYOU
43	03	51	009030	03512390100491	TTTRES	LA0319	CYPREMORT POINT
44	03	51	009060	03512390202651	COSLAB	LA0083	IVANHOE CANAL
45	03	51	009070	03512390204501	COSLAB	LA0083	BELLIVUE CANAL
46	03	51	009130	03512410209141	LOSWNG	LA0324	BAYOU TECHE
47	03	51	009142	03512430200001	STPLGR	LA0317	ICWW @ BAYOU SALE
48	03	51	009160	03512430206521	CONIBM	LA0317	YELLOW BAYOU
49	03	51	009170	03514080203871	TTTRES	LA0087	CREEK
50	03	51	009180	03514083000201	LOSWNG	LA0323	B TECHE OAKLAWN
51	03	51	009190	03514083100091	PGSWNG	LA0322	B TECHE STERLING

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
52	03	51	009198	03514240522602	CPGCCD	US0090	WAX LAKE OUTLET
53	03	51	009260	03514240531742	COSLAB	US0090	LITTLE BAYOUBLACK
54	03	51	009272	03518510400171	LOSWNG	LA0670	BAYOU TECHE
55	03	51	009280	03518510900241	PGSWNG	LA3069	B TECHE FRANKLIN
56	03	57	009292	03570550100001	SUSPLG	LA0014	MERMENTAU RIVER
57	03	57	009300	03570550303081	COSLAB	LA0014	BIG FOUR CANAL
58	03	57	009310	03570550304131	COSLAB	LA0014	ELLIOT DITCH
59	03	57	009340	03570550401241	CODEKG	LA0014	AVRICO CANAL
60	03	57	009350	03570550402881	CODEKG	LA0014	MARE MICHELE
61	03	57	009370	03570550412681	COSLAB	LA0014	VINCENT CANAL
62	03	57	009380	03570550503131	COSLAB	LA0014	ISLE MARRON CANAL
63	03	57	009400	03570550503651	COSLAB	LA0014	COULEE BAYOU
64	03	57	009420	03570550509462	COSLAB	LA0014	COULEE KENNY BRIDGE
65	03	57	009430	03570550600131	STVERT	LA0014	VERMILION R/ABBEVILLE
66	03	57	009450	03570550606411	COSLAB	LA0014	BAYOU TIGRE
67	03	57	009460	03570553001081	STVERT	LA0014BY	VERMILION R/ABBEVILLE
68	03	57	009500	03570570103361	CODEKG	LA0013	COULEE DES ISES
69	03	57	009510	03570570105841	CODEKG	LA0013	B GRAND MARAIS
70	03	57	009570	03571940300911	COPCSS	LA0082	LONG DITCH
71	03	57	009580	03571940303141	COPCSS	LA0082	TURF BAYOU
72	03	57	009590	03571940303401	COPCSS	LA0082	WEST RELIEF
73	03	57	009600	03571940304111	COPCSS	LA0082	MARSH DITCH
74	03	57	009610	03571940304321	COPCSS	LA0082	MIDDLE CANAL
75	03	57	009620	03571940305421	COPCSS	LA0082	MILLER CANAL
76	03	57	009630	03571940306211	COPCSS	LA0082	EAST RELEIF
77	03	57	009640	03571940700031	TTTRES	LA0082	DRAIN
78	03	57	009650	03571940701791	TTTRES	LA0082	LITTLE BAYOU
79	03	57	009680	03571940707511	STVERT	LA0082	VERMILION R PERRY
80	03	57	009690	03572070106671	PGSWNG	LA0082	OLD ICC L PRAIRE
81	03	57	009700	03572070106771	COSLAB	LA0082	DRAINAGE CANAL
82	03	57	009710	03572070110481	COSLAB	LA0082	WARREN CANAL
83	03	57	009722	03572070114121	STCPLG	LA0082	INTRACOASTAL WATERWAY
84	03	57	009726	03572070201341	TTTRES	LA0035	CREEK
85	03	57	009728	03572070204011	TTTRES	LA0035	CREEK
86	03	57	009729	03572070206851	TTTRES	LA0035	CREEK
87	03	57	009730	03572070209041	TTTRES	LA0035	COULEE DEJON
88	03	57	009750	03572070211261	TTTRES	LA0035	SLEDGE CANAL
89	03	57	009810	03572120102981	TTTRES	LA0091	SPENCER CANAL
90	03	57	009812	03572120104501	TTTRES	LA0091	CREEK
91	03	57	009820	03572120105611	TTTRES	LA0091	MARE MICHELE
92	03	57	009900	03572150100291	TTTCOF	LA0082	TOUCHETS CANAL
93	03	57	009902	03572150102031	TTTCOF	LA0082	CREEK
94	03	57	009910	03572150103221	TTTCOF	LA0082	CANAL
95	03	57	009920	03572150104351	TTTCOF	LA0082	SEVENTH WARD CANAL
96	03	57	009930	03572150105921	TTTCOF	LA0082	HERBERT CANAL
97	03	57	009938	03572160100651	TTTRES	LA0339	CREEK
98	03	57	009940	03572160101501	TTTRES	LA0339	CANAL
99	03	57	009942	03572160105521	TTTRES	LA0339	CREEK
100	03	57	010010	03573960200071	TTTRES	LA0335	ROBINS CANAL
101	03	57	010020	03573960202111	TTTRES	LA0335	SLEDGE CANAL
102	03	57	010030	03573960205161	TTTRES	LA0335	CREEK

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
154	03	23	005930	03234240404701	COSLAB	US0090	SEGURA BRANCH
155	03	23	005980	03234240406661	COSLAB	US0090	ARMENCO CANAL
156	03	23	006040	03234240409161	COSLAB	US0090	RODERE CANAL
157	03	51	009250	03514240531741	COSLAB	US0090	LITTLE BAYOU BLAC
158	03	57	009410	03570550509461	COSLAB	LA0014	COULEE KINNEY
159	03	51	030115	03514240536941	COPSGR	US0090	BAYOU RAMOS/LOC RD
160	03	51	030189	03514240537191	COSLAB	US0090	TEXAS GAS PIPELINE
161	03	51	030285	03514240510601	COPSGR	US0090	US 90 OVER LA 3211
162	03	51	030308	03514240537202	COSLAB	US0090	CREEK
163	03	23	030393	03234240404704	COSLAB	US0090	SEGURA BRANCH CANAL

From: Kevin Leleux
Sent: Monday, December 12, 2011 8:48 AM
To: Stephanie Cavalier
Cc: Murphy Ledoux
Subject: RE: Coastal Bridge Selection Request for Vulnerability Study

Ms. Cavalier

Please find attached document with highlighted structures.

Let me know if you need anything else.

Thanks

>-->-->--> ----^ ---- V--V ----^ ---- <--<--<--<

Kevin P. Leleux
LA DOTD Dist. 03
(Bridge Maint; Insp. & Ops. Supv.)
Office: 337-262-6128
Mobile: 337-280-3918

>-->-->--> ----^ ---- V--V ----^ ---- <--<--<--<

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
1	03	23	005680	03230040506771	CIBTCF	LA0182	SANDAGER CANAL
2	03	23	005714	03230550704152	COSLAB	LA0014	POUFETTE CANAL
3	03	23	005724	03230550705262	COSLAB	LA0014	BAYOU PETITE ANSE
4	03	23	005731	03230550707862	COSLAB	LA0014	ARMENCO CANAL
5	03	23	005740	03232350100101	CODEKG	LA0329	RODERE CANAL
6	03	23	005750	03232360101131	CONIBM	LA0083	COMMMERICAL CANAL
7	03	23	005780	03232360202041	TTTRES	LA0085	PATOUT CANAL
8	03	23	005790	03232360206641	COPCSS	LA0085	DRAIN
9	03	23	005800	03232370100141	PGBASC	LA0086	BAYOU TECHE/DUPERIOR ST
10	03	23	005830	03232400302221	LOSWNG	LA0083	BAYOU PATOUT-WEEKS ISLAND
11	03	23	005840	03232400303491	CIBTTM	LA0083	STUMPY BAYOU
12	03	23	005850	03232400305941	TTTRES	LA0083	BAYOU BLUE
13	03	23	005860	03232410100161	LOSWNG	LA0671	BAYOU TECHE JEAN.
14	03	23	005868	03233970501931	TTTRES	LA0089	CREEK
15	03	23	005870	03233970503171	TTTRES	LA0089	PARC PEROU BAYOU
16	03	23	005900	03234003100241	PGSWNG	LA0086	B TECHE DASPIT
17	03	23	005940	03234240404702	COSLAB	US0090	SEGURA BRANCH
18	03	23	005980	03234240406661	COSLAB	US0090	ARMENCO CANAL
19	03	23	005990	03234240406662	COSLAB	US0090	ARMENCO CANAL
20	03	23	006040	03234240409161	COSLAB	US0090	RODERE CANAL
21	03	23	006050	03234240409162	COSLAB	US0090	RODERE CANAL
22	03	23	006130	03238230208181	COSLAB	LA0675	ARMENCO CANAL
23	03	23	006160	03238230701181	TTTRES	LA0676	DEBLANC COULEE
24	03	23	006170	03238230702011	COPCSS	LA0676	CREEK
25	03	23	006180	03238231200171	PGSWNG	LA0320	B TECHE (OLIVER)
26	03	23	006190	03238231201361	COPCSS	LA0320	TELE BAYOU
27	03	23	006200	03238231400251	PGSWNG	LA0344	B TECHE MORBIHAN
28	03	23	006210	03238231406331	STVERT	LA0344	TECHE BAYOU @ LOREAUVILLE
29	03	23	006222	03238232000171	COPCSS	LA0673	DRAINAGE CANAL
30	03	23	006230	03238232603471	TTTRES	LA0087	CREEK
31	03	23	006250	03238232800551	COSLAB	LA0668	DELAHOUSSAYE CNL
32	03	23	006258	03238232907581	COSLAB	LA0674	COMMERCIAL CANAL
33	03	23	006270	03238233400391	TTTCOF	LA0682	CREEK
34	03	23	006280	03238233400841	TTTCOF	LA0682	NORRIS CANAL
35	03	23	006290	03238233401811	TTTCOF	LA0682	CREEK
36	03	23	006300	03238234100461	COSLAB	LA0089	ROMERO CANAL
37	03	23	006302	03238234200081	LOSWNG	LA3156	BAYOU TECHE
38	03	23	006306	03238234300081	PGSWNG	LA3182	BAYOU TECHE
39	03	51	008970	03510040609371	STHITR	LA0182	CHARENTON
40	03	51	008990	03510040702071	CIBTCF	LA0182	HANSON CANAL
41	03	51	009000	03510050100001	STHITR	LA0182	ATCHAF.R/BERWICK BAY
42	03	51	009020	03510050105491	CODEKG	US0090	RAMOS BAYOU
43	03	51	009030	03512390100491	TTTRES	LA0319	CYPREMORT POINT
44	03	51	009060	03512390202651	COSLAB	LA0083	IVANHOE CANAL
45	03	51	009070	03512390204501	COSLAB	LA0083	BELLIVUE CANAL
46	03	51	009130	03512410209141	LOSWNG	LA0324	BAYOU TECHE
47	03	51	009142	03512430200001	STPLGR	LA0317	ICWW @ BAYOU SALE
48	03	51	009160	03512430206521	CONIBM	LA0317	YELLOW BAYOU
49	03	51	009170	03514080203871	TTTRES	LA0087	CREEK
50	03	51	009180	03514083000201	LOSWNG	LA0323	B TECHE OAKLAWN
51	03	51	009190	03514083100091	PGSWNG	LA0322	B TECHE STERLING

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
52	03	51	009198	03514240522602	CPGCCD	US0090	WAX LAKE OUTLET
53	03	51	009260	03514240531742	COSLAB	US0090	LITTLE BAYOUBLACK
54	03	51	009272	03518510400171	LOSWNG	LA0670	BAYOU TECHE
55	03	51	009280	03518510900241	PGSWNG	LA3069	B TECHE FRANKLIN
56	03	57	009292	03570550100001	SUSPLG	LA0014	MERMENTAU RIVER
57	03	57	009300	03570550303081	COSLAB	LA0014	BIG FOUR CANAL
58	03	57	009310	03570550304131	COSLAB	LA0014	ELLIOT DITCH
59	03	57	009340	03570550401241	CODEKG	LA0014	AVRICO CANAL
60	03	57	009350	03570550402881	CODEKG	LA0014	MARE MICHELE
61	03	57	009370	03570550412681	COSLAB	LA0014	VINCENT CANAL
62	03	57	009380	03570550503131	COSLAB	LA0014	ISLE MARRON CANAL
63	03	57	009400	03570550503651	COSLAB	LA0014	COULEE BAYOU
64	03	57	009420	03570550509462	COSLAB	LA0014	COULEE KENNY BRIDGE
65	03	57	009430	03570550600131	STVERT	LA0014	VERMILION R/ABBEVILLE
66	03	57	009450	03570550606411	COSLAB	LA0014	BAYOU TIGRE
67	03	57	009460	03570553001081	STVERT	LA0014BY	VERMILION R/ABBEVILLE
68	03	57	009500	03570570103361	CODEKG	LA0013	COULEE DES ISES
69	03	57	009510	03570570105841	CODEKG	LA0013	B GRAND MARAIS
70	03	57	009570	03571940300911	COPCSS	LA0082	LONG DITCH
71	03	57	009580	03571940303141	COPCSS	LA0082	TURF BAYOU
72	03	57	009590	03571940303401	COPCSS	LA0082	WEST RELIEF
73	03	57	009600	03571940304111	COPCSS	LA0082	MARSH DITCH
74	03	57	009610	03571940304321	COPCSS	LA0082	MIDDLE CANAL
75	03	57	009620	03571940305421	COPCSS	LA0082	MILLER CANAL
76	03	57	009630	03571940306211	COPCSS	LA0082	EAST RELEIF
77	03	57	009640	03571940700031	TTTRES	LA0082	DRAIN
78	03	57	009650	03571940701791	TTTRES	LA0082	LITTLE BAYOU
79	03	57	009680	03571940707511	STVERT	LA0082	VERMILION R PERRY
80	03	57	009690	03572070106671	PGSWNG	LA0082	OLD ICC L PRAIRE
81	03	57	009700	03572070106771	COSLAB	LA0082	DRAINAGE CANAL
82	03	57	009710	03572070110481	COSLAB	LA0082	WARREN CANAL
83	03	57	009722	03572070114121	STCPLG	LA0082	INTRACOASTAL WATERWAY
84	03	57	009726	03572070201341	TTTRES	LA0035	CREEK
85	03	57	009728	03572070204011	TTTRES	LA0035	CREEK
86	03	57	009729	03572070206851	TTTRES	LA0035	CREEK
87	03	57	009730	03572070209041	TTTRES	LA0035	COULEE DEJON
88	03	57	009750	03572070211261	TTTRES	LA0035	SLEDGE CANAL
89	03	57	009810	03572120102981	TTTRES	LA0091	SPENCER CANAL
90	03	57	009812	03572120104501	TTTRES	LA0091	CREEK
91	03	57	009820	03572120105611	TTTRES	LA0091	MARE MICHELE
92	03	57	009900	03572150100291	TTTCOF	LA0082	TOUCHETS CANAL
93	03	57	009902	03572150102031	TTTCOF	LA0082	CREEK
94	03	57	009910	03572150103221	TTTCOF	LA0082	CANAL
95	03	57	009920	03572150104351	TTTCOF	LA0082	SEVENTH WARD CANAL
96	03	57	009930	03572150105921	TTTCOF	LA0082	HERBERT CANAL
97	03	57	009938	03572160100651	TTTRES	LA0339	CREEK
98	03	57	009940	03572160101501	TTTRES	LA0339	CANAL
99	03	57	009942	03572160105521	TTTRES	LA0339	CREEK
100	03	57	010010	03573960200071	TTTRES	LA0335	ROBINS CANAL
101	03	57	010020	03573960202111	TTTRES	LA0335	SLEDGE CANAL
102	03	57	010030	03573960205161	TTTRES	LA0335	CREEK

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
103	03	57	010040	03573960205721	TTTRES	LA0335	CREEK
104	03	57	010050	03573960206951	TTTRES	LA0335	IL MELROSE CANAL
105	03	57	010090	03573963001841	COSLAB	LA0335	COULEE KINNEY
106	03	57	010100	03573970103751	COSLAB	LA0330	YOUNGS COULEE
107	03	57	010110	03573970104581	COSLAB	LA0330	RAMSEY CANAL
108	03	57	010130	03573970304251	HISWNG	LA0330	BAYOU TIGRE
109	03	57	010160	03578570201731	TTTRES	LA0332	CREEK
110	03	57	010181	03578570604101	COPCSS	LA0697	STREAM
111	03	57	010184	03578570605001	COPCSS	LA0697	STREAM
112	03	57	010192	03578570606201	COPCSS	LA0697	COULEE KENNYS
113	03	57	010234	03578571201261	COPCSS	LA0708	SLEDGE CANAL
114	03	57	010258	03578572202311	COPCSS	LA0690	BANKER CANAL
115	03	57	010262	03578576703701	COPCSS	LA0690	CREEK
116	03	57	010270	03578572507821	COSLAB	LA0696	COULEE KENNY
117	03	57	010290	03578573300781	COSLAB	LA0685	BAYOU TIGRE
118	03	57	010300	03578573600801	TTTRES	LA0688	CANAL
119	03	57	010312	03578573700551	COPCSS	LA0331	BAYOU TIGRE
120	03	57	010320	03578573701411	TTTRES	LA0331	CREEK
121	03	57	010330	03578573702141	TTTRES	LA0331	CREEK
122	03	57	010340	03578573705181	TTTRES	LA0331	CREEK
123	03	57	010348	03578576301971	TTTRES	LA0082	CREEK
124	03	57	010362	03578576502601	TTTRES	LA3143	WARREN CANAL
125	03	51	030133	03510050103901	COPSGR	US0090W	SOUTHERN PACIFIC RAILROAD
126	03	51	030185	03514240536942	COPSGR	US0090	BAYOU RAMOS
127	03	51	030190	03514240537192	COSLAB	US0090	TEXAS GAS PIPELINE
128	03	51	030242	03514240522601	COPSGR	US0090	WAX LAKE OUTLET
129	03	23	030262	03234240409163	COSLAB	US0090	RODERE COULEE
130	03	23	030263	03234240409164	COSLAB	US0090	RODERE CANAL
131	03	23	030264	03234240409827	COSLAB	US0090	COMMERCIAL CANAL
132	03	23	030265	03234240409826	COSLAB	US0090	COMMERCIAL CANAL
133	03	23	030266	03234240409823	COSLAB	US0090	COMMERCIAL CANAL
134	03	51	030267	03512410208871	COPSGR	LA0087	CHARENTON CANAL
135	03	57	030271	03570553101501	COSLAB	LA0014	COULEE
136	03	57	030273	03570553101041	COSLAB	LA0014	BAYOU TIGRE
137	03	51	030286	03514240510602	COPSGR	US0090	US 90 OVER LA 3211
138	03	51	030288	03510040612081	COSLAB	LA0182	YOKELY BAYOU
139	03	57	030291	03571940703191	TTTRES	LA0082	BANKER CANAL
140	03	57	030294	03573960303731	COSLAB	LA0335	BILL CANAL
141	03	57	030295	03573960301601	COSLAB	LA0335	COULEE BATON
142	03	51	030309	03514240537201	COSLAB	US0090	CREEK
143	03	23	030312	03230550700321	STVERT	LA0014	DELCHAMBRE CANAL
144	03	23	030339	03234240406664	COSLAB	US 90	ARMENCO CANAL
145	03	51	030351	03512390106491	PGBASC	LA0319	INTRACOASTAL CANAL
146	03	23	030365	03238234400781	CONRCH	00003195	TETE BAYOU
147	03	23	030381	03234240405901	CPGCCD	US0090	US 90 OVER LA 675
148	03	23	030382	03234240405902	CPGCCD	US0090	US 90 OVER LA 675
149	03	57	030383	03578576803221	COPCSS	LA3267	YOUNGS NORTH COULEE
150	03	23	030394	03234240404703	COSLAB	US0090	SEGURA BRANCH CANAL
151	03	23	005712	03230550704151	COSLAB	LA0014	POUFETTE CANAL
152	03	23	005722	03230550705261	COSLAB	LA0014	BAYOU PETITE ANSE
153	03	23	005730	03230550707861	COSLAB	LA0014	ARMANCO CANAL

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
154	03	23	005930	03234240404701	COSLAB	US0090	SEGURA BRANCH
155	03	23	005980	03234240406661	COSLAB	US0090	ARMENCO CANAL
156	03	23	006040	03234240409161	COSLAB	US0090	RODERE CANAL
157	03	51	009250	03514240531741	COSLAB	US0090	LITTLE BAYOU BLAC
158	03	57	009410	03570550509461	COSLAB	LA0014	COULEE KINNEY
159	03	51	030115	03514240536941	COPSGR	US0090	BAYOU RAMOS/LOC RD
160	03	51	030189	03514240537191	COSLAB	US0090	TEXAS GAS PIPELINE
161	03	51	030285	03514240510601	COPSGR	US0090	US 90 OVER LA 3211
162	03	51	030308	03514240537202	COSLAB	US0090	CREEK
163	03	23	030393	03234240404704	COSLAB	US0090	SEGURA BRANCH CANAL

Exhibit J. 3
Letter to and Response from District 07

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

INTRADEPARTMENTAL CORRESPONDENCE

REFERRED TO

____ REFERRED FOR ACTION
____ ANSWER FOR MY SIGNATURE
____ FOR FILE
____ FOR YOUR INFORMATION
____ FOR SIGNATURE
____ RETURN TO ME
____ PLEASE SEE ME
____ PLEASE TELEPHONE ME
____ FOR APPROVAL
____ PLEASE ADVISE ME

BY ______ DATE ______
BY ______ DATE ______
BY ______ DATE ______

IN REPLY REFER TO
FILE NO.

October 18, 2011
(225) 379-1321

MEMORANDUM

TO: STEVEN JILES, P.E.
DISTRICT 07 ADMINISTRATOR

FROM: ZHENGZHENG "JENNY" FU, P.E.
ASSISTANT BRIDGE DESIGN ADMINISTRATOR

SUBJECT: COASTAL BRIDGE SELECTION REQUEST FOR VULNERABILITY STUDY

Included herewith is a list of bridges in your district that may be included in a LTRC research project which will determine the vulnerability of Louisiana's coastal bridges to storm surge wave loading. The attached bridge list began with all on and off-system structures found in the STRM database located in coastal parishes. Bridges meeting the following criteria were then eliminated and divided into districts:

1. Bridge locations that were not actually bridges (e.g. culverts, ferry docks).
2. Bridges that were protected by a levee system.
3. Bridges located at high ground elevations and away from large water bodies and bridges away from FEMA V zones.
4. Bridges with short local wind setup and wave fetches (due to geography and/or vegetation) limiting wave heights.
5. Bridges that could be identified as having high, low-cord elevations from GoogleEarth images.

Please review the attached list of 44 bridges in your district and select any structure whose closure may have a significant impact on the community, may be the only access to/from a populated coastal area, or you deem to be of concern and can benefit from this project. Add any bridge that may be of concern that may not be on the provided list. Do not select bridges that may be replaced soon, were recently constructed and designed for wave forces, or are minor structures that will not be retrofitted if found to be vulnerable. Please provide your list of selected bridges no later than Tuesday, November 22, 2011. Your assistance in this effort is greatly appreciated.

Please contact me if you have any questions or need additional information.

ZZF/ssc

Attachments
CC: Mr. Hossein Ghara
Mrs. Stephanie Cavalier
Mr. Walid Alaywan (LTRC)
Mr. Huseyin Demir (OEA, Inc.)
Dr. Max Sheppard (OEA, Inc.)

RECOMMENDED FOR APPROVAL ______ DATE ______

RECOMMENDED FOR APPROVAL ______ DATE ______

APPROVED ______ DATE ______

AN EQUAL OPPORTUNITY EMPLOYER
A DRUG FREE WORKPLACE

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
1	07	10	031755	07100310403151	COPSGR	LA0027	CHOUPIQUE BAYOU
2	07	10	032120	07101950403261	CODEKG	LA0385	COULEE
3	07	10	032190	07101960109201	COPCSS	LA0014	BAYOU
4	07	12	032266	07123840100001	LOSWNG	LA0082	SABINE LAKE CAUSEWAY
5	07	10	032640	07104509121522	COSLAB	I0010	BAYOU DIENDE
6	07	10	032690	07104509123662	COSLAB	I0010	MAPLE FORK BAYOU
7	07	10	032780	07104509127691	STCANT	I0010	CALCASIEU RIVER, RR, STS.
8	07	10	033210	07104503001411	STPLGR	I0210	PRIEN LAKE
9	07	10	033280	07104503004992	STCPLG	I0210	CONTRABAND BAYOU
10	07	10	033290	07108100602691	CONIBM	LA11382	BAYOU CONTRABAND
11	07	10	033354	07108101200301	COPSGR	LA0378	BAYOU
12	07	10	033402	07108101904251	COPSGR	LA0108	BAYOU D'INDE
13	07	10	033470	07108102700741	COPCSS	LA3077	BAYOU D'INDE
14	07	10	033480	07108102701211	COPCSS	LA3077	LITTLE D'INDE
15	07	12	033590	07120310214721	COSLAB	LA0027	KAYOU BAYOU
16	07	12	033602	07120310303551	PGSWNG	LA0027	KELSO BAYOU/HACKBERRY
17	07	12	033650	07121930201211	COSLAB	LA0027	CANAL
18	07	12	033660	07121930203061	COSLAB	LA0027	CANAL
19	07	12	033672	07121930204581	COPCSS	LA0027	CANAL
20	07	12	033681	07121930208531	STPLGR	LA0027	ICWW GIBBSTOWN
21	07	12	033698	07121940101201	COPCSS	LA0082	BAYOU
22	07	12	033700	07121940200001	LOSWNG	LA0082	MERMENTAU R./G.CHENIER
23	07	12	033730	07121940221101	LOSWNG	LA0082	SUPERIOR CANAL
24	07	12	033742	07121950100701	COPCSS	LA0384	CANAL
25	07	12	033750	07121950201021	COSLAB	LA0385	S FORK BLACK BAYOU
26	07	12	033770	07128120101451	COSLAB	LA0717	KLONDIKE CANAL
27	07	12	033780	07128120105611	COPCSS	LA0717	KLONDIKE CANAL
28	07	12	033790	07128120107491	COPCSS	LA0717	BAYOU
29	07	10	070030	07108102702453	COSLAB	LA3077	BAYOU DINDE
30	07	10	070076	07102090100771	COPCSS	LA0101	BAYOU
31	07	12	070096	07120310202251	COSLAB	LA0027	BAYOU
32	07	10	070097	07103820405941	COPCSS	LA0384	GUY BAYOU
33	07	10	070119	07108101800741	COPCSS	LA1133	CANAL
34	07	12	070137	07120310203631	COSLAB	LA0027	BAYOU
35	07	12	070141	07120310209821	COSLAB	LA0027	LITTLE CROSS CREEK
36	07	12	070142	07120310207161	COSLAB	LA0027	BIG CROSS CREEK BRIDGE
37	07	12	070143	07120310212781	COSLAB	LA0027	HOG ISLAND GULLY
38	07	12	070144	07120310214241	COSLAB	LA0027	LONG POINT BAYOU
39	07	12	070166	07123820303031	COPCSS	LA0384	DRAIN
40	07	10	032630	07104509121521	COSLAB	I0010	BAYOU DIENDE
41	07	10	032680	07104509123661	COSLAB	I0010	MAPLE FORK BAYOU
42	07	10	033270	07104503004991	STCPLG	I0210	CONTRABAND BAYOU
43	07	10	033400	07108101904252	CODEKG	LA0108	BAYOU D'INDE
44	07	10	033502	07108102702451	COSLAB	LA0027	BAYOU DINDE

From: Steve Jiles
Sent: Tuesday, January 31, 2012 11:32 AM
To: Stephanie Cavalier
Cc: ZhengZheng Fu; Steven Young; Jerome Carter
Subject: RE: Responses from districts

District 07 believes that all 44 bridges in Calcasieu and Cameron Parishes which were identified in the attachment should remain on the listing of critical bridges.

Please advise me if further information is needed.

Thanks.

From: Haylye Brown
Sent: Tuesday, April 03, 2012 3:22 PM
To: Stephanie Cavalier
Subject: RE: LTRC 10-4ST: Coastal Bridges

Stephanie,

I've looked over the lists that each district submitted. District 07 included all 44 bridges but after going through it I've selected 29* bridges that seem to be most vulnerable in the event of a storm surge. I've listed the ID and Recall from the list. I went over District 02's final list and there aren't any that we want to add since the ones we had in mind were eliminated based on the criteria provided. Thanks. Again this is just our recommendation.

ID	Recall	ID	Recall
1	031755	24	033742
3	032190	25	033750
4	032266	26	033770
7	032780	27	033780
8	033210	28	033790
9	033280	31	070096
15	033590	32	070097
16	033602	33	070119
17	033650	34	070137
18	033660	35	070141
19	033672	36	070142
20	033681	37	070143
21	033698	38	070144
22	033700	39	070166
23	033730	42	033270

*(OEA/INTERA) Note that The body of the email says 29 bridges were selected, but there are actually 30 bridges in the list

Exhibit J. 4
Letter to and Response from District 62

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

INTRADEPARTMENTAL CORRESPONDENCE

REFERRED TO

___ REFERRED FOR ACTION
___ ANSWER FOR MY SIGNATURE
___ FOR FILE
___ FOR YOUR INFORMATION
___ FOR SIGNATURE
___ RETURN TO ME
___ PLEASE SEE ME
___ PLEASE TELEPHONE ME
___ FOR APPROVAL
___ PLEASE ADVISE ME

BY ___ DATE ___
BY ___ DATE ___
BY ___ DATE ___

IN REPLY REFER TO
FILE NO.

October 18, 2011
(225) 379-1321

MEMORANDUM

TO: **CONNIE STANDIGE, P.E.**
DISTRICT 62 ADMINISTRATOR

FROM: **ZHENGZHENG "JENNY" FU, P.E.**
ASSISTANT BRIDGE DESIGN ADMINISTRATOR

SUBJECT: **COASTAL BRIDGE SELECTION REQUEST FOR VULNERABILITY STUDY**

Included herewith is a list of bridges in your district that may be included in a LTRC research project which will determine the vulnerability of Louisiana's coastal bridges to storm surge wave loading. The attached bridge list began with all on and off-system structures found in the STRM database located in coastal parishes. Bridges meeting the following criteria were then eliminated and divided into districts:

1. Bridge locations that were not actually bridges (e.g. culverts, ferry docks).
2. Bridges that were protected by a levee system.
3. Bridges located at high ground elevations and away from large water bodies and bridges away from FEMA V zones.
4. Bridges with short local wind setup and wave fetches (due to geography and/or vegetation) limiting wave heights.
5. Bridges that could be identified as having high, low-cord elevations from GoogleEarth images.

Please review the attached list of 34 bridges in your district and select any structure whose closure may have a significant impact on the community, may be the only access to/from a populated coastal area, or you deem to be of concern and can benefit from this project. Add any bridge that may be of concern that may not be on the provided list. Do not select bridges that may be replaced soon, were recently constructed and designed for wave forces, or are minor structures that will not be retrofitted if found to be vulnerable. Please provide your list of selected bridges no later than Tuesday, November 22, 2011. Your assistance in this effort is greatly appreciated.

Please contact me if you have any questions or need additional information.

ZZF/ssc

Attachments
CC: Mr. Hossein Ghara
Mrs. Stephanie Cavalier
Mr. Walid Alaywan (LTRC)
Mr. Huseyin Demir (OEA, Inc.)
Dr. Max Sheppard (OEA, Inc.)

RECOMMENDED FOR APPROVAL ___ DATE ___

RECOMMENDED FOR APPROVAL ___ DATE ___

APPROVED ___ DATE ___

AN EQUAL OPPORTUNITY EMPLOYER
A DRUG FREE WORKPLACE

ID	DISTRICT	PARISH	RECALL	STRUCTURE NO.	TYPE	ROUTE	NAME
1	62	52	058710	62520060705291	STVERT	US0090	WEST PEARL RIVER
2	62	52	058720	62520060706701	STLOTR	US0090	WEST MIDDLE RIVER
3	62	52	058730	62520060707111	STLOTR	US0090	MIDDLE MIDDLE PEARL RIVER
4	62	52	058740	62520060707701	STLOTR	US0090	E MIDDLE PEARL RIVER
5	62	52	058750	62520060800001	HISWNG	US0090	EAST PEARL RIVER
6	62	52	058858	62520131105821	COPSGR	US0190	LA 22
7	62	52	058910	62520131204111	CODEKG	US0190	BAYOU CASTINE
8	62	52	058920	62520131206411	CODEKG	US0190	CANE BAYOU
9	62	52	058930	62520131210841	PGSWNG	US0190	BAYOU LACOMBE
10	62	52	058940	62520131211661	CODEKG	US0190	BIG BRANCH
11	62	52	058970	62520131217421	CODEKG	US0190	BAYOU LIBERTY
12	62	52	058990	62520131220001	CODEKG	US0190	BAYOU BONFOUCA
13	62	52	059011	62520131300721	COSLAB	US0190B	DRAIN CANAL
14	62	52	059030	62520131303691	CIBTCF	US0190B	FRENCH BRANCH
15	62	52	059040	62520131307571	CIBTCF	US0190	DRAIN
16	62	52	059070	62520180304811	COSLAB	US0011	BAYOU POTASSAY
17	62	52	059075	62524501801001	COPSGR	I0010	EDEN ISLES OVER I-10
18	62	52	059140	62520183002361	COSLAB	LA0433	SALT BAYOU
19	62	52	059372	62520590100771	COSLAB	LA0021	BAYOU DEZEIRE
20	62	52	059482	62522610600001	PGSWNG	LA0022	TCHEFUNCTE R/MADISONVILLE
21	62	52	059748	62522810302121	COPCSS	LA0059	DRAIN
22	62	52	059880	62524501801082	COSLAB	I0010	CANAL
23	62	52	059900	62524501803102	COMWEL	I0010	I-10 OVER LA 433
24	62	52	059920	62524501804202	COSLAB	I0010	DRAINAGE CANAL
25	62	52	060360	62528521300731	TTTRES	LA1077	BLACK BAYOU
26	62	52	060412	62528522106161	IBSWNG	LA0433	BAYOU BONFOUCA
27	62	52	060450	62528522600771	COSLAB	US0190	FRENCH BRANCH
28	62	53	061070	62532610300001	CONIBM	LA0022	NATALBANY RIVER
29	62	53	062090	62534529001903	COSLAB	US0051	NORTH PASS
30	62	53	062100	62534529004243	COSLAB	US0051	OWL BAYOU
31	62	53	063440	62538533600501	CONIBM	US0051B	US 51B OVER I-55
32	62	52	059870	62524501801081	COSLAB	I0010	CANAL
33	62	52	059890	62524501803101	COMWEL	I0010	I-10 OVER LA 433
34	62	52	059910	62524501804201	COSLAB	I0010	CANAL

From: Conrad Luper
Sent: Thursday, November 10, 2011 12:02 PM
To: ZhengZheng Fu
Cc: Roland Maurin; Connie Standige; Philip Graves; William Murray
Subject: FW: Coastal Bridge Selection Request for Vulnerability Study (DISTRICT 62)

ID	ACTION	ID	ACTION
1.	REMOVE	18.	REMOVE
2.	REMOVE	19.	STUDY
3.	REMOVE	20.	STUDY
4.	REMOVE	21.	REMOVE
5.	REMOVE	22.	STUDY
6.	REMOVE	23.	STUDY
7.	STUDY	24.	STUDY
8.	STUDY	25.	STUDY
9.	STUDY	26.	STUDY
10.	STUDY	27.	STUDY
11.	STUDY	28.	STUDY
12.	STUDY	29.	REMOVE
13.	REMOVE	30.	STUDY
14.	REMOVE	31.	REMOVE
15.	REMOVE	32.	STUDY
16.	REMOVE	33.	STUDY
17.	STUDY	34.	STUDY

Table J. 3
100 Bridges selected by the Districts

No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number	No.	Recall Number
1	'000810'	21	'009030'	41	'010100'	61	'033660'	81	'059870'
2	'001552'	22	'009060'	42	'010110'	62	'033672'	82	'059880'
3	'002631'	23	'009070'	43	'010290'	63	'033681'	83	'059890'
4	'002632'	24	'009198'	44	'020185'	64	'033698'	84	'059900'
5	'002650'	25	'009570'	45	'020186'	65	'033700'	85	'059910'
6	'002892'	26	'009580'	46	'020266'	66	'033730'	86	'059920'
7	'002894'	27	'009590'	47	'020319'	67	'033742'	87	'060360'
8	'003390'	28	'009600'	48	'030242'	68	'033750'	88	'060412'
9	'003432'	29	'009610'	49	'030271'	69	'033770'	89	'060450'
10	'003440'	30	'009620'	50	'030273'	70	'033780'	90	'061070'
11	'003450'*	31	'009630'	51	'031755'	71	'033790'	91	'062100'
12	'003510'	32	'009640'	52	'032190'	72	'058910'	92	'070096'
13	'003520'	33	'009650'	53	'032266'	73	'058920'	93	'070097'
14	'003641'	34	'009700'	54	'032780'	74	'058930'	94	'070119'
15	'003690'	35	'009710'	55	'033210'	75	'058940'	95	'070137'
16	'005712'	36	'009900'	56	'033270'	76	'058970'	96	'070141'
17	'005722'	37	'009902'	57	'033280'	77	'058990'	97	'070142'
18	'005730'	38	'009910'	58	'033590'	78	'059075'	98	'070143'
19	'005740'	39	'009920'	59	'033602'	79	'059372'	99	'070144'
20	'009020'	40	'009930'	60	'033650'	80	'059482'	100	'070166'

***Bridge 003450 was erroneously selected for 003480. The analysis of both bridges is included in this report.j**

Table J. 4
36 Bridges removed from consideration

No.	Bridge Recall Number	Bridge	Reason for Removal
1	005712	LA0014 over POUFETTE CANAL	Narrow inland waterway with heavy tree canopy
2	005722	LA0014 over BAYOU PETITE ANSE	Narrow inland waterway with heavy tree canopy
3	005730	LA0014 over ARMANCO CANAL	Narrow inland waterway with heavy tree canopy
4	005740	LA0329 over RODERE CANAL	Narrow inland waterway with tree canopy and a short (less than 200ft)fetch
5	009070	LA0083 over BELLIVUE CANAL	Thick vegetation and tree canopy
6	009640	LA0082 over DRAIN	Narrow inland waterway with heavy tree canopy and no (less than 30ft) fetch
7	009650	LA0082 over LITTLE BAYOU	Narrow inland waterway with tree canopy
8	009900	LA0082 over TOUCHETS CANAL	Narrow inland waterway with tree canopy
9	009902	LA0082 over CREEK	Narrow inland waterway with tree canopy
10	009910	LA0082 over CANAL	Narrow inland waterway with tree canopy and short (less than 500ft) fetch
11	009920	LA0082 over SEVENTH WARD CANAL	Narrow inland waterway with tree canopy
12	009930	LA0082 over HERBERT CANAL	Narrow inland waterway with a minimal (less than 350ft) fetch
13	010100	LA0330 over YOUNGS COULEE	Narrow inland waterway with tree canopy and short (less than 400ft) fetch
14	010110	LA0330 over RAMSEY CANAL	Narrow inland waterway with tree canopy
15	010290	LA0685 over BAYOU TIGRE	Narrow inland waterway with tree canopy
16	030271	LA0014 over COULEE	Narrow inland waterway with tree canopy and a short (less than 200ft)fetch

No.	Bridge Recall Number	Bridge	Reason for Removal
17	030273	LA0014 over BAYOU TIGRE	Narrow inland waterway with tree canopy and a short (less than 300ft)fetch
18	032190	LA0014 over BAYOU	Narrow, heavily vegetated inland waterway
19	033270	I0210 over CONTRABAND BAYOU	High (approaches above 20ft) inland bridge with a short fetch (less than 800 ft)
20	033280	I0210 over CONTRABAND BAYOU	High (approaches above 20ft) inland bridge with a short fetch (less than 800 ft)
21	033742	LA0384 over CANAL	Narrow inland cannal with limited connectivity to open water
22	033770	LA0717 over KLONDIKE CANAL	Narrow waterway with minimal (less than 300ft) fetch.
23	033780	LA0717 over KLONDIKE CANAL	Narrow inland waterway with an extensive tree canopy
24	033790	LA0717 over BAYOU	Narrow inland waterway with an extensive tree canopy
25	058970	US0190 over BAYOU LIBERTY	Heavy tree canopy and short fetch (less than 400 ft.)
26	058990	US0190 over BAYOU BONFOUCA	Heavy tree canopy and short fetch (less than 100 ft.)
27	059075	I0010 over EDEN ISLES OVER I-10	High bridge over a narrow drainage canal with limited (culvert) connectivity to Lake Ponchartrain, +11ft-NGVD approaches, and a short fetch (less than 1500ft)
28	059372	LA0021 over BAYOU DEZEIRE	Narrow inland waterway with tree canopy
29	059870	I0010 over CANAL	Narrow drainage canal with limited (culvert) connectivity to Lake Ponchartrain, +11ft-NGVD approaches, and a short fetch (less than 250ft)
30	059880	I0010 over CANAL	Narrow drainage canal with limited (culvert) connectivity to Lake Ponchartrain, +11ft-NGVD approaches, and a short fetch (less than 250ft)
31	059890	I0010 over I-10 OVER LA 433	Overpass, does not cross a waterway. Approach elevations are +25ft-NGVD.
32	059900	I0010 over I-10 OVER LA 433	Overpass, does not cross a waterway. Approach elevations are +25ft-NGVD.
33	059910	I0010 over CANAL	Narrow drainage canal with tree canopy and +14ft-NGVD approaches
34	059920	I0010 over DRAINAGE CANAL	Narrow drainage canal with tree canopy and +14ft-NGVD approaches

No.	Bridge Recall Number	Bridge	Reason for Removal
35	060450	US0190 over FRENCH BRANCH	Narrow, heavily canopied waterway
36	061070	LA0022 over NATALBANY RIVER	Heavy tree canopy and short fetch (less than 400 ft.)

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