APPENDIX H
RESILIENCE ASSESSMENT REPORT

H.015428

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RESILIENCE ASSESSMENT – SURFACE TRANSPORTATION REPORT
LOWER ST. BERNARD / LOUISIANA TERMINAL ROAD NETWORK STUDY

FEBRUARY 2025

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TRANSPORTATION STUDY
Planning For Future St. Bernard

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I. INTRODUCTION TO SURFACE TRANSPORTATION RESILIENCY

Being resilient means the ability to anticipate, prepare, adapt, respond, and recover from changing conditions. Natural and manmade disasters can quickly bring about change that can impact the transportation network. In response to increasing climate variability and the potential for extreme weather events, ensuring the resilience of roadways and bridges has become paramount. This analysis provides a general overview of various factors to consider during the preliminary design phase of roadways and bridges aimed at enhancing the resilience of the transportation infrastructure. This resilience assessment explores various factors to implement into design in order to mitigate the impact of natural disasters and climate change on roadways and bridges. The factors enhance the safety and functionality of these critical assets during severe weather events. Improving the resilience of the transportation system will provide the capability to effectively adapt to changing conditions. This analysis concentrates on the changing conditions with the highest rate of possible occurrence within the study area.

St. Bernard Parish is a coastal parish built on the delta of the Mississippi River. The Parish has a total area of 2,158 square miles, of which 378 square miles is land and 1,781 square miles is water. This means that an astounding 83% of the Parish is covered by water. The leveed, pumped portions of the Parish are bounded by the

Orleans Parish line, Mississippi River levee and the Southeast Flood Protection Authority – East (SLFPA-E) Back – Protection Levee. See Figure 1 for the St. Bernard Leveed/Pumped Areas.

Although St. Bernard Parish is generally flat, it naturally drains from its southern boundary to its northern boundary. The Mississippi River levees on the southern end are relatively higher than the Back-Protection Levees. Within these levees, rainfall runoff flows through a network of subsurface pipes in the streets into the major canals and then via the pump stations on the northern end of the Back-Protection Levees, where it is pumped into the Central Wetlands. The Central Wetlands area drains toward the north through bayous. It is bounded by the Mississippi River Gulf Outlet (MRGO) and the Gulf Intracoastal Waterway (GIWW). There are control structures at the MRGO on Bayou Bienvenue and Bayou Dupre to control flow from the wetland bayou areas into the MRGO and Lake Borgne. The control structures are operated by SLFPA-E in times of anticipated high water and storm surge. The Lake Borgne water body ties into the Gulf of Mexico.

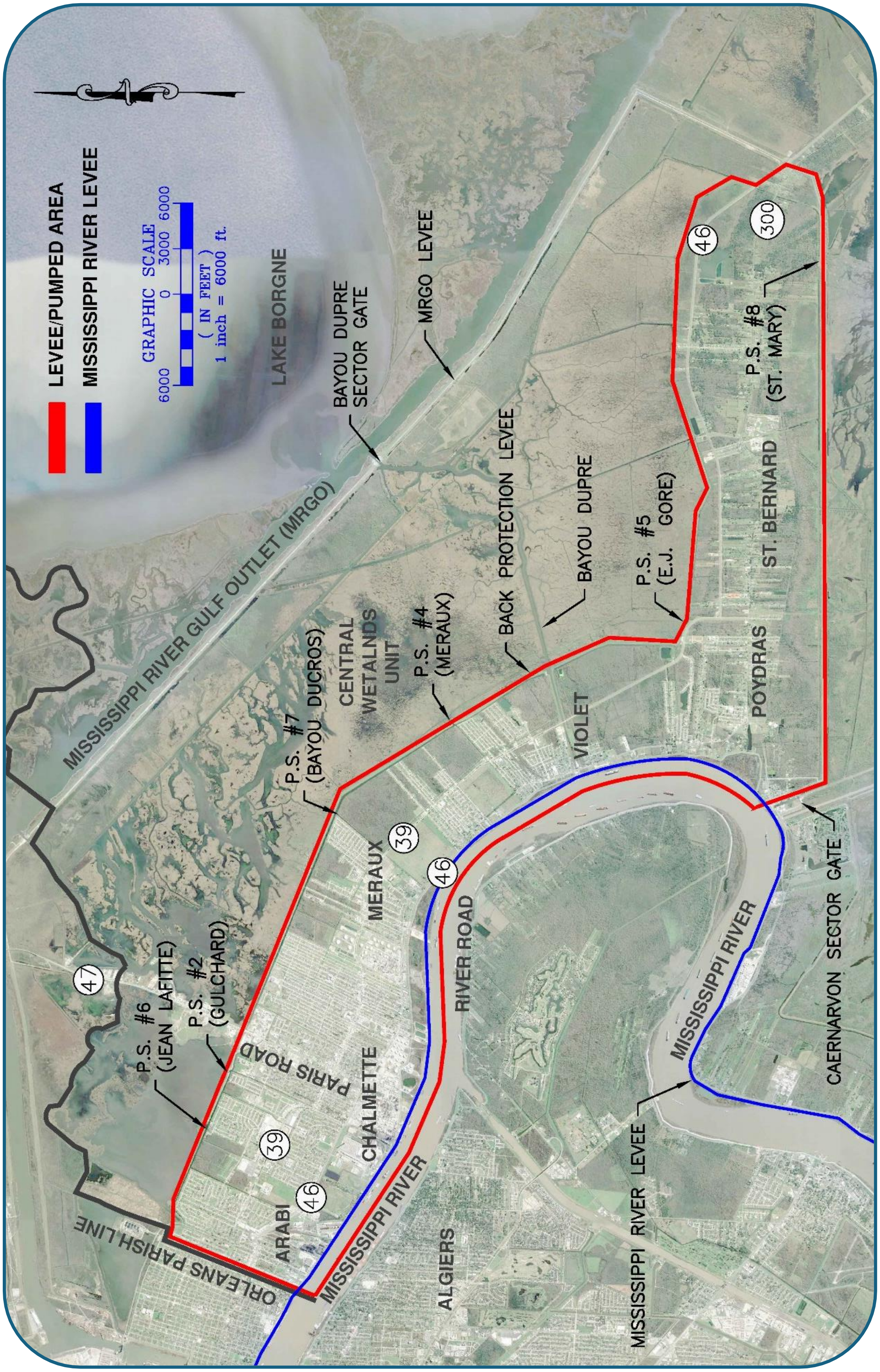

Figure 1 - St. Bernard Leveed / Pumped Areas

II. BACKGROUND INFORMATION/STUDIES/OUTREACH

Roadways and bridges form the backbone of transportation networks, facilitating the movement of people and goods. They are vulnerable to various hazards, including floods, storms, and other natural disasters. In recent years, the frequency and intensity of such events seems to have increased, posing significant challenges to infrastructure resilience. Therefore, it is imperative to design the transportation system with enhancements to bolster the resilience of roadways and bridges. Increasing transportation resiliency will minimize disruption, ensure continuous functionality and rapid recovery where possible within the budgetary constraints of available funding. The following studies were reviewed to compile relevant data of potential hazard events for the St. Bernard Parish study area:

A. “ST. BERNARD PARISH HAZARD MITIGATION PLAN” PREPARED BY THE STEPHENSON DISASTER MANAGEMENT INSTITUTE OF LOUISIANA STATE UNIVERSITY DATED 2020

The following hazards were identified in the St. Bernard Parish Mitigation Plan along with their relative probability of reoccurrence. The percent chance of the potential hazardous event happening during any given year was calculated by considering past events that have occurred within the parish. The following potential hazards were listed in the order of higher relative probability of occurrence with the hazards more likely to reoccur at the top of the list:

1. Coastal hazards/ subsidence= 100%

2. Tropical cyclones (hurricanes)= 100%
3. High wind (thunderstorms)= 80%
4. Hail (thunderstorms)= 57%
5. Flooding= 56%
6. Tornadoes= 30%
7. Lightning (thunderstorms)= 21%
8. Sinkholes= < 1%

The previous list of potential disasters considered in the Mitigation Plan as critical and prevalent disasters can be summarized in the following two main categories:

1. Flooding - riverine, stormwater, surge, backwater, coastal- levee failure, subsidence, tropical cyclone, or thunderstorm events.
2. High wind- tropical cyclone, thunderstorm, and tornado events.

Therefore, providing a transportation system that is resilient to flooding and wind types of disasters will significantly give the parish an advantage for response and recovery to these most prevalent types of disasters that potentially the parish could encounter. Potential flood heights should be investigated to incorporate resiliency into the system regarding flooding type disasters. Building code requirements for structural design regarding high wind loads should be taken into consideration during design.

B. “STATE OF LOUISIANA EMERGENCY PREPAREDNESS GUIDE” PREPARED BY THE GOVERNOR’S OFFICE OF HOMELAND SECURITY & EMERGENCY PREPAREDNESS DATED 2022

Louisiana’s Emergency Preparedness Guide addresses the state’s major evacuation routes if an evacuation order is issued by authorities. Since the City of New Orleans is a densely populated urban metropolis, the Emergency Preparedness Guide defines a contraflow plan for the New Orleans metro area in order to allow citizens to evacuate within a chosen time period ahead of an anticipated disaster as well as have them return in an orderly fashion. St. Bernard Parish is included in the first phase of a state mandated evacuation because it is south of the Intracoastal Waterway. The areas closest to the coast and waterways are typically evacuated first. The Louisiana Evacuation Routes within St. Bernard Parish are the major state routes, LA 39 (Judge Perez Drive) , LA 46 (St. Bernard Highway) and LA 47 (Paris Road). LA 47 (Paris Road) ties into the interstate, I-510 just north of the Intracoastal Waterway. For an evacuation, the intent is to proceed north on I-510 to I-10 proceeding eastbound towards I-59. From I-59, a northward contraflow would be implemented for evacuation and similarly in reverse to return to St. Bernard Parish. See Figure 2 for a Vicinity Map.

Since the Louisiana’s Emergency Preparedness Guide defines the St. Bernard Parish roadways needed for evacuation, the resiliency of these roadways and bridges should be assessed and taken into consideration during design of upgrades and improvements as well as any new major routes that would be added or tie into these evacuation routes. Enhancing emergency preparedness and response by implementing a robust emergency management plan and having a resilient infrastructure can improve the ability to respond effectively and recover quickly from natural disasters as well as other emergencies.

Figure 2-Vicinity Map

C. "LOUISIANA'S COMPREHENSIVE MASTER PLAN FOR A SUSTAINABLE COAST" PREPARED BY THE COASTAL PROTECTION AND RESTORATION AUTHORITY, 4TH EDITION DATED MAY 25, 2023

The Coastal Protection and Restoration Authority (CPRA) prepared a coastal master plan to enhance sustainability against future land loss and flood risk along the coast of Louisiana. For the St. Bernard vicinity, the CPRA plan proposes a 3,800-acre Central Wetlands Marsh Creation Project, which is under construction as of this writing, in the Bayou Bienvenue vicinity north of Chalmette, Louisiana to nourish existing marsh and create new wetland habitat, restore degraded marsh, and reduce wave erosion.

A long-term Central Wetlands Diversion Project is proposed near Violet, Louisiana to provide sediment for emergent marsh creation and freshwater to sustain existing wetlands. With planned CPRA projects in place, the most dramatic future flooding potential using a higher rate of environmental changes such as sea level rise and subsidence, the storm surge - based flood depths were calculated for future projections. By year 2073 with planned coastal improvements, the storm surge flood depth for a 10% annual exceedance probability was calculated to increase over the next 50 years to a depth of four feet (4') for the lower areas of St. Bernard Parish south of the Violet Canal. St. Bernard Parish may incur relatively high wetland loss over the next 50 years without further coastal protection or restoration actions. Chalmette and other areas within this levee system may experience up to six feet (6') storm surge flood depths without proposed coastal improvements and restoration over the next 50 years.

These storm surge flood height projections should be taken into consideration when designing a resilient roadway and bridge transportation system. If feasible, roadways should be elevated above this storm surge flood projection and the low chord elevation of bridges should clear this projected storm surge flood height.

D. "LAKE PONTCHARTRAIN & VICINTY & WESTBANK & VICINITY" PREPARED BY THE USACE NEW ORLEANS DISTRICT DATED MARCH 2021

Climate change issues such as rising sea levels, increased temperatures, and more frequent extreme weather events, pose significant challenges to the resilience of transportation infrastructure.

In order to address the rising sea level, the USACE prepared a hydrology and hydraulics study of Lake Pontchartrain and its vicinity. The study included an analysis of the potential relative sea level change (RSLC). St. Bernard Parish is just 4 miles south of Lake Pontchartrain. The USACE's study identified the following 50-year projections in sea level rise for the year 2073 for the general Lake Pontchartrain and vicinity area:

Low	1.3'
Intermediate	1.8'
High	3.4'

The USACE has used the intermediate projection of a sea level rise of 1.8’ for modeling projects within the study area. Being consistent with the USACE, it is recommended to use the RSLC of 1.8’ for a more resilient bridge design.

E. RPC PILOT TRANSPORTATION VULNERABILITY ASSESSMENT SCORING TOOL (VAST) DATA SETS

The Regional Planning Commission completed a pilot program for Transportation Vulnerability Assessment Review in August 2023. Using a variety of input data such as exposure, sensitivity, and adaptive capacity of stressors such as precipitation, sea level rise and storm surge, vulnerability scores were established for roadways and bridges using the Federal Highway Administration (FHWA) Vulnerability Assessment Scoring Tool (VAST). This pilot study showed that the stressor data projections are limited and require additional analysis. It also showed that scoring and weighting can be subjective requiring extensive stakeholder input. Therefore, the VAST and results of the RPC pilot study were not used for evaluation of transportation resiliency. However, the following data sources referenced by this pilot study for input values were analyzed to determine resiliency factors.

1. Louisiana Department of Natural Resources Office of State Lands - State Water Bottoms dated 2022

Reviewing the Louisiana Department of Natural Resources’ Interactive Sonris Maps on their website, there are several state claimed water bodies through the Central Wetlands. The Central Wetlands is the marshy area north of the developed area of St. Bernard Parish. The parish's major drainage pumping stations discharge into the Central Wetlands. The state claimed water bodies that run through the Central Wetlands are bayous that act as tributaries for the Central Wetlands to drain into Lake Borgne.

Depending on the proposed alignment of an elevated roadway through the Central Wetlands, several bayous could be crossed. The water bodies possibly affected within the Central Wetlands by a proposed elevated roadway through this area could include Bayou Chaperan, Violet Canal, Bayou Dupre, Bayou Ducros, Bayou Villere and Bayou Bienvenue. Once the long-term roadway elevated alignment is laid out through this area, the water bodies affected will be determined. A permit will be required for impact to these state claimed water bodies and wetlands.

2. <u>Federal Highway Administration- National Bridge Inventory</u>

The Federal Highway Administration (FHWA) has a National Bridge Inventory for its federal roadways and bridges. Investigating this data source from RPC's VAST program, provided insight into FHWA's Seismic and Multi-Hazard

Resilience Program. Their goal is to analyze extreme events such as earthquakes, major hurricanes, flooding and major vessel/vehicular collisions because these events can have a profound impact on the transportation system even though they may have a rare occurrence. The program's primary goal is to assist local, state and metropolitan organizations to improve highway network resiliency while utilizing federal funding taking into account protecting life and boosting economic growth.

FHWA has statutes and regulations that require states and MPOs to consider resilience in the transportation planning process. On the FHWA's website, https://www.fhwa.dot.gov/environment/sustainability/resilience/, there are many publications and guidance documents that can be referenced to design the roadway and bridge system for flood, scour and wave action as well as aerodynamics for highway structures. These resources should be evaluated in the preliminary design phase in order to provide a greater level of resiliency for the transportation system.

3. <u>United States Federal Emergency Management Agency-National Flood Insurance Program Flood Insurance Maps (FIRM):</u>

As part of the National Flood Insurance Program, the United States Federal Emergency Management Agency (FEMA) produces Flood Insurance Maps (FIRM) maps, which identify Special Flood Hazard Areas to aid in planning development and infrastructure to avoid areas of flood risk as well as flood insurance rating. FEMA's FIRM flood maps show how likely it is for an area to flood. Any area with a 1% chance or higher chance of experiencing a flood each year is considered to have a high risk. Those areas have at least a one-in-four chance of flooding during a 30-year period. FEMA runs flood analyses to determine flood elevations where applicable and flood zones. These flood elevations should be referenced during preliminary design of roadway and bridge transportation infrastructure to bolster resiliency of the system in regards to flooding. Costs that improve the resilience of the transportation system are generally eligible for funding under the National Highway Performance Program and the Surface Transportation Block Grant Program. Considering these potential funding sources, could help provide a means of funding.

F. DOTD HYDROLOGY / HYDRAULICS DESIGN CRITERIA

The DOTD Hydraulics Manual dated 2011 is a comprehensive document of the department's current design policies regarding surface runoff. The design storm frequency is one design parameter to consider because it identifies the level of risk accepted for the design of the roadway. The general design storm frequency for a roadway design project is a function of the 20-year Projected Annual Average Daily Traffic (PAADT). When the PAADT is $\leq$ 3,000, a 25-year frequency is required. When the PAADT is > 3,000, a 50-year frequency is required. The 50-year frequency is the highest storm frequency, which is for interstates. Bridges, roadway cross drains, and side drains under important side roads should be designed for a 25-year or 50-year design storm frequency depending on the PAADT. Using the future projected traffic count to determine the design storm frequency makes the road more resilient to flooding.

Another parameter to consider when selecting the design storm frequency is the projected land use for the next 20 years. Different types of land use generate different runoff flow rates when factors are applied to the runoff calculations based on the land use.

Lastly, other conditions to consider for design storm frequency are the following:

1. The site is on a primary route for emergency vehicles or community evacuation.
2. The structure is considered a major drainage structure in a designated wetland area.
3. It is for urban arterial roads and streets.

4. The roads and streets have four or more lanes.

5. Ramps and approach roadways are within control of access boundaries of freeways.

III. CONCEPTUAL RESILIENT TRANSPORTATION DESIGN PARAMETERS

A. EXISTING INFRASTRUCTURE IMPROVEMENTS

The design year for existing infrastructure improvements is 2030. In order to incorporate resilient features into the existing infrastructure, roadways that currently show a diminished Level of Service from the traffic analysis and also serve as evacuation routes as well as emergency response routes near major hospitals and critical governmental offices should have resiliency features considered in their design.

Reconstructing existing roads above potential flood waters would make the road more resilient to flooding but could possibly have the following detrimental effects:

1. Raising roads could create dams for rainwater within the existing drainage system, possibly impounding storm water outside of the roadway right-of-way.
2. Raising roadways could impact the driveways of businesses and residents that tie into the roadway by creating undesirable grades.
3. Raising roadways and providing the associated fill to slope back to existing grade could affect trees within the required fill area.
4. Raising roadways could result in right-of-way acquisition issues.

Roadways deemed as requiring an increased intersection capacity for existing and future projected traffic needs should be improved by implementing enhanced roadway features for lane capacity and turning movements. Adding additional through lanes or turn lanes, can add capacity at an intersection. Where feasible, a roundabout can be designed for a greater efficiency as well. Adjusting signal timing to optimize intersection operations can also improve capacity of an existing intersection without geometric improvements.

The associated utility work such as drainage could also be accomplished at the time of roadway improvement in order to address existing street flooding problems. The St. Bernard Parish drainage design storm for their local roads is the 10- year storm event. For state and federal roads, the design storm will have to be in accordance with their mandated guidelines. Nature based solutions to add green infrastructure to the roadway network such as planted bioswales, vegetated swales or permeable pavements should be evaluated during roadway design to increase resiliency.

In order to rehabilitate existing roads and bridges for greater resiliency, the projected truck traffic design vehicle should be taken into consideration in order to provide a pavement typical section that can withstand the design parameters for truck loading.

Implementing a comprehensive approach to flood risk management, including the use of levees and enhanced drainage systems to protect critical transportation infrastructure such as roadways and bridges is paramount. Implementing adaptive maintenance practices such as regular inspection, maintenance, and retrofitting of existing roadways and bridges can help mitigate transportation system vulnerabilities and extend their service life. Integrating nature-based solutions by incorporating green infrastructure elements can help manage stormwater runoff and enhance resilience to flooding.

B. ELEVATED HIGHWAY ALTERNATIVES

The design year for elevated highway alternatives is 2050. The proposed elevated highways or bridge through the Central Wetlands is protected from storm surge by the Mississippi River Gulf Outlet (MRGO) federal levee system to the east.

A surge barrier exists on the northern end of the MRGO closing the convergence of the levees bounding the northern edge of the Gulf Intracoastal Waterway (GIWW) and the southern edge of the MRGO, lowering the risk of future storm surges from penetrating into the inner harbor of the Industrial Canal and Intracoastal Waterway. Two gates were built, one at Bayou Bienvenue and another across the GIWW, to permit the passage of barge and other small commercial traffic during normal weather conditions. These navigable sector gates are fifty-six feet (56’) wide at a height of 32’ MSL (Mean Sea Level) to prevent storm surge from impacting St. Bernard Parish and Orleans Parish. The Lake Borgne Storm Surge Barrier, the largest of its kind in the United States, should protect against storm surges up to twenty-eight feet (28’) in height. It is two feet lower than the levees it will connect to in New Orleans East and St. Bernard Parish. This will allow water to spill over the control structure before it overtops these levees.

As discussed with DOTD and Flood Protection Authority officials, the Bayou Bienvenue flood gate is closed when high tide reaches elevation 1.5’ MSL or when the wind is blowing hard from the east. Closing these gates for certain water levels prevents the businesses along LA 47 (Paris Road) from flooding.

The proposed elevated highway through the Central Wetlands could potentially cross the Violet Canal. Navigable waterways such as the Violet Canal are governed by the United States Coast Guard’s decision for the minimum height and clearance required for the navigable vessels that use the waterway. At the time of United States Army Corp of Engineers (USACE) permit application for the proposed elevated highway, they would distribute the permit application to the U.S. Coast Guard for their determination if the Violet Canal is a federal channel, if dedicated to commerce and the type of vessel. LA 39 (E. Judge Perez Dr.) currently crosses the Violet Canal. Therefore, a new bridge in this vicinity would have to clear at least this same elevation as the existing Violet Canal bridge and meet U.S. Coast Guard permit requirements. The following are a few relative LA DOTD bridge height design criteria:

1. LA DOTD Bridge Low Chord Design Criteria - Standard:

a. Rainfall events: 2’ above 50-year water surface elevation (WSE) and 1’ above 100-year WSE if debris in water.

b. Storm surge: 500- year elevation (Flood Insurance Rate Map or run HEC-RAS model)

c. Navigation: bridge height determined from Coast Guard navigable design vessel height.

For a more flood resilient bridge design the potential relative sea level rise (RSLC) should be incorporated into the design.

2. LA DOTD Bridge Low Chord Design Criteria - Greater Level of Flood Resiliency:

a. Relative Sea Level Rise- 1.8’ (intermediate projection for year 2073): Based off the USACE study completed in March 2021, the intermediate projection for Relative Sea Level Rise is 1.8’. Adding 1.8’ to the design water surface elevation, will be consistent with the USACE’s design of projects within the study area and provide a more resilient bridge design.

IV. CONCLUSION

Incorporating factors of resiliency into transportation design such building higher roadways and bridges, as well as incorporating nature based solutions will account for possible climate change impacts, such as higher flood levels and increased precipitation. Since St. Bernard Parish is entirely surrounded by levees or floodwalls, creating a bowl, the need for flood mitigation is paramount. Therefore, rainwater must be pumped out of the parish that exceeds the ground's absorption. Enhancing the flood resiliency of roadways and bridges is crucial for ensuring the reliability, continuous functionality, rapid recovery and safety of transportation infrastructure in regards to potential flooding.

The parish's other prevalent disaster identified in their Hazard Mitigation Plan was evaluated to be high wind. By adopting resilient practices from high wind design standards, implementing adaptive maintenance practices, leveraging advanced technologies, and promoting collaboration and policy coordination, a more resilient transportation network capable of withstanding these challenges of the 21st century, can be built. Including resilience measures while planning for new infrastructure may yield savings in the future through reduced repair costs as well as provide a safer transportation network, quicker recovery, continuous functional ability, and less travel disruption. These resilient measures can translate to a stronger economy, which is a win for the public as well as local, regional, and state governments.