Mississippi Valley Division,
Regional Planning and Environment Division South

# St. Tammany Parish, Louisiana Feasibility Study

## Appendix D, Annex 11 – Potential Failure Mode Analysis

## February 2024

# CONTENTS

# SECTION 1
# INTODUCTION

Members from the risk and design teams performed an abbreviated Potential Failure Mode Analysis (PFMA) to qualitatively described potential failure mechanisms and life safety incremental risk for the St Tammany Parish feasibility study proposed levee system. In addition to the incremental risk and potential failure modes, significant uncertainties related to life safety risk along with recommendations for consideration during PED phase have been summarized.

This potential failure mode analysis was scaled and generally covers what has historically been known to be potential failure modes for coastal loading risk reduction levee systems in southern Louisiana. The proposed St Tammany Parish system has similarities to other levee systems in the region consisting of levee and structures constructed in areas where the foundation conditions likely contain soft to very soft soils which are highly compressible. The historic knowledge of performance of similar systems and discussions contained in SQRAs performed on similar systems was used to assist in identification of high priority potential failure modes.

Recent SQRAs in southern Louisiana identified overtopping as a primary risk driver due to frequency of overtopping events on a coastal system. Additional potential failure modes were briefly discussed, and any significant uncertainties or recommendations related to those PFMs were included.

# SECTION 2
# RISK CHARACTERIZATION

The PFMA was conducted on the feasibility level design as described in the current report. Multiple components of the system still require data collection and analysis which could result in alterations to the alignment and features.

Overtopping and breach of the unarmored levee was considered the likely primary driver of life safety risk in the system. The system will be designed and constructed to the 1% AEP event with estimated OT of 0.1 cfs/ft at the 1% AEP event.

The St Tammany north shore area is seeing population increase. Currently the study area exists without storm water risk reduction system. There is potential for continued increases in population due to movement to the North Shore area.

# SECTION 3
# PROJECT INFORMATION

The Optimized TSP alignment for the levee and floodwall system would consist of a total of approximately 18.5 miles (97,700 feet) of levee and floodwall, which includes approximately 15 miles (79,500 feet) of levees constructed in separate (non-continuous) segments, and 3.5 miles (18,200 feet) of separate (non-continuous) segments of a floodwall. Western High Ground Tie-in for Year 2082 accounts for 1.6 miles of the total 18.4 miles length. The crown elevation will go as high as +19, with the final lift scheduled for 2082. 10' crown widths, 1V:3H slopes.

The Optimized TSP would consist of 8 pump stations ranging from 200 cfs to 2000 cfs pumping capacity, 13 floodgates ranging in heights from 2ft to 25ft, 21 vehicular gates ranging in height from 3ft to 16ft, and ramps. The floodwalls stem heights range from 3ft to 15ft. Structural components (pump stations, floodgates, vehicular floodgates, and ramps) would be constructed during initial construction.

Structural superiority was only accounted for Pump Stations. Structural Superiority will be considered for PED design level at an individual structure level.

# SECTION 4
# CONSEQUENCES

The primary loading consideration in coastal hurricane loading which generally has 48 to 72 hours at most of warning prior to a system making land fall.

The proposed St. Tammany Parish risk reduction system will be a new system with new levee sponsors. Therefore, emergency preparedness, flood warning, and evacuation effectiveness of people living behind a new system is unknown. Potential for new levee system to negatively impact evacuation rates and historic evacuation rates from when residents were outside a system may not apply. A new levee system may increase comfort with remaining in place during a storm due to the perceived increased protection.

The system will also include multiple closures impacting railroad and local roadways. Substantial coordination and preparation will be required for successful operation of the system.

# SECTION 5
# HAZARDS

Loading on the system will be from tropical storm loading. Potential seismic failure modes are not considered due to the very low seismic loading in the region.

# SECTION 6
# OVERTOPPING

**Description:** The levee is loaded with a storm surge and associated wave. The levee is overtopped, and landside sod cover is removed. A headcut initiates erosion on the landside. Erosion progresses across the crest of the embankment prior to retreat of storm surge. Downcutting enlarges the breach.

The levee system is design to the 1% AEP event, with 0.1cfs/ft volume of overtopping at the 1% AEP event. The embankment will require regular levee raises to maintain the 1% AEP elevation. Armoring was not considered during the feasibility study and is not planned for initial construction. Given the highly compressible nature of the foundation soils, significant consolidation and settlement is expected and multiple future levee raises are anticipated.

The proposed levee will be constructed using materials specified as CL or CH with less than 35% sand content by weight. Based on typical levee construction practices in the region, materials are generally expected to be high plasticity (CH) clays, but variability is expected and will include low plasticity (CL) clays as well. New Orleans has extensive experience constructing levees with clay materials. The well-compacted clay fill used in New Orleans levee construction is generally considered moderately resistant to resistant to erosion.

After fill placement, levees will be seeded with Bermuda grass. Vegetation cover will be limited immediately after construction; however, good grass cover is typical in the long-term condition for levees in the New Orleans area. Bermuda grass covers the majority of MRL sections and does not become dormant in New Orleans until approximately December, which also generally marks the end of hurricane season.

As part of the development of the armoring plans for the LPV-WBV HSDRRS, testing on potential armoring systems was conducted at Colorado State University (CSU). Field models were constructed to test resistance to overtopping flows. The CSU study on New Orleans soil and grass slope resiliency found that live Bermuda grass performed exceptionally well under sustained overtopping conditions of wave impacts. Healthy Bermuda grass resisted a total volume of over topping of approximately 177,000 cf/ft with minimal damage and failure occurred on dormant Bermuda grass at approximately 23,000 cfs/ft. There were several assumptions and limitations of the study in relation to direct application to the conditions for New Orleans levees, including limited tests on unarmored Bermuda grass. The estimated volumes should be used as guide and not limits for overtopping resistance.

Based on the design elevations and erosion resistant materials, the levee is expected to perform well during the 0.2% event. For overtopping events exceeding 12 hours, an overtopping rate of 4 cfs/ft would exceed the CSU limit on healthy grass and 0.5 cfs/ft

for dormant grass, which significantly exceed expected overtopping rates for the design events.

# SECTION 7
# ADDITIONAL CONSIDERED POTENTIAL FAILURE MODES

The following are brainstormed additional failure modes which may be excluded during an SQRA during PED.

- Operational concerns - time to close gates. Currently a ramp is being considered for the I-10 crossing to prevent closure of a major evacuation route. Additional gates are across local roadways and railroads and will require coordination to close timely.
- Damage to safe house preventing safe operations of pump stations resulting in interior rainwater flooding.
- Overtopping at tie-in. In areas outside existing developed areas, settlements exceeding 1 foot are expected in the new levee. Settlements may negatively impact performance of scour protection resulting in excessive erosion and overtopping at the tie-ins.
- SIBM. Settlements at structure to levee tie-ins induce moment loading on battered piles. Preloading was not considered during feasibility phase of the project.
- Vehicle impact to gates. The system contains 21 vehicle gates which cross at grade roadways and vehicle loading is not included as a load case in design.

# SECTION 8
# UNCERTAINITIES

- Lack of surveys and data may alter the final alignment and section.
- Limited geotechnical data available during feasibility and assumptions made based on data available and assumed c/p' strength values with depth. Additional geotechnical and geological data may result in changes to design sections, deep foundation design, settlements, etc.
- Inherent uncertainty in H&H. The 2019 ADCIRC data was used for the St Tammany Parish Feasibility project.

# SECTION 9
# FINDINGS AND RECOMMENDATIONS

- Structural superiority considerations on all structures. At this time only pump stations considered structural superiority
- Armoring is not included in the feasibility study. Overtopping risks should be evaluated in PED phase risk assessment and potential resilience measures considered for design.
- Potential settlement concerns at the structure to levee tie-in. Considerations for SIBM in battered piles of tie-in structures should be made during PED along with ways to decrease impacts of settlement on structures.
- Historic failures of levee as structure tie ins should be considered in design of scour protection systems at tie-in along with impacts of levee settlements on the scour protection.
- Design considerations for settlements to eliminate lifts for I-10 levee crossing.
- System includes new closures systems. Coordination between new local sponsors and railroads/LADOTD along with tabletop exercises to prepare for closures during a storm event.

# SECTION 10
# RISK ASSESSMENT TEAM

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|---|---|---|
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