Fairfield and New Haven Counties, Connecticut, Coastal Storm Risk Management Feasibility Study

August 2020

Draft Appendix D:

Civil Design

Fairfield and New Haven Counties, Connecticut, Coastal Storm Risk Management Feasibility Study

Appendix D: Civil Design

Table of Contents

List of Figures

Chapter 1: **Introduction**

1.1 Study Area

The study area faces the Atlantic Ocean and is split between the counties of Fairfield and New Haven, Connecticut. Figure 1 shows the repetitive loss and significant repetitive loss data in the study area. Five primary damage areas (Stratford, Milford, New Haven, West Haven, and Fairfield) were initially identified by the Regional Councils of Governments in Connecticut for assessment. However, the Town of Fairfield and City of New Haven areas were selected for further evaluation based on their density of development and potential to support a federally constructed project. During the course of the study, alternative coastal storm risk management solutions were developed for the Town of Fairfield, the future local sponsor would be responsible for cost-sharing of the preconstruction engineering and design phase. These alternatives would require a substantial amount of money (approximately $500 - $700 million for project first cost) as well as real estate requirements that the Town was unable to commit to. Using the Corps iterative planning process, the study area was ultimately scoped down to focus on the Long Wharf (City of New Haven) focused study area (Figure 2).

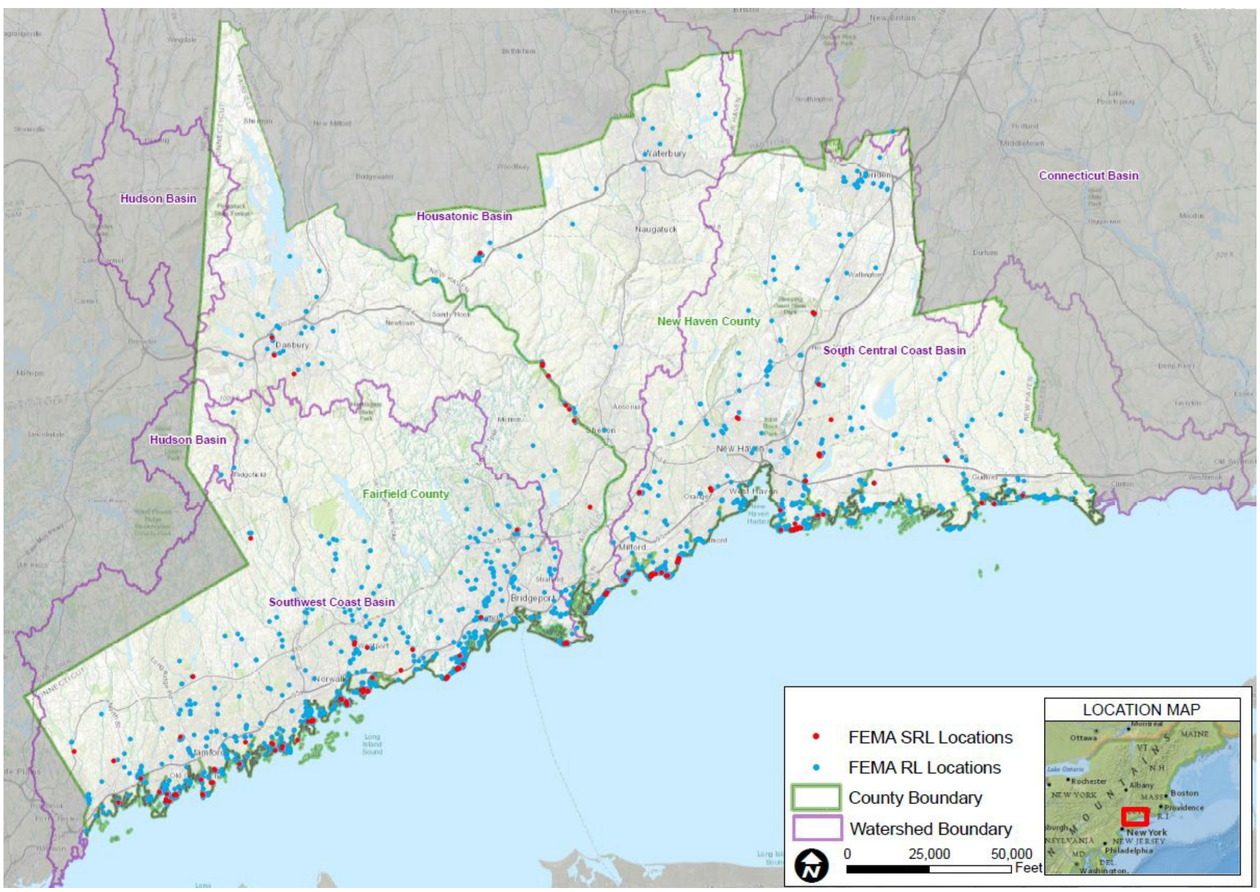


Figure 1: Fairfield and New Haven Counties Study Area

The City of New Haven is located within the 3rd Congressional District. The Long Wharf focused study area is a socio-economic center of southern Connecticut comprised largely of industrial and commercial users. More than 70 commercial properties including IKEA, ASSA ABLOY, and Jordan's Furniture, worth hundreds of millions of dollars are located within this area. These properties experience damages during coastal storm events.

Key regional transportation infrastructure is vulnerable in the study area as well. The Northeast Corridor mainline tracks, owned by the Connecticut Department of Transportation (ConnDOT), serves approximately 130,000 daily riders across multiple rail lines and carries 7.5 metric tons of freight annually through the study area. The New Haven Union Station passenger rail station opened in 1920 and serves approximately 700,000 annual boardings on four platforms with nine tracks. The New Haven Rail Yard, a 74-acre ConnDOT-owned railyard in the study area, received $1.2 billion in recent capital improvements for a new maintenance facility and 25 new storage tracks. Interstates 91 and 95 dominate vehicular access in and around the city and surrounding region. An excess of 140,000 vehicles use the Long Wharf stretch of I-95 daily (I-95 New Haven Harbor Crossing).

Figure 2. New Haven Focused Study Area

1.2 Existing Condition

The City of New Haven is subjected to various FEMA flood zones encompassing large portions of land along the New Haven Harbor shore line with particular emphasis on the Long Wharf area. This land area is roughly defined and bounded by Hallock Avenue to the west, Union Avenue to the north, and Route 1 to the east. The relatively flat topography throughout the area allow tidal inundation during periods of major storm events. The 1% Annual Chance Exceedance (100-year) storm flood event limit would submerge major portions of the shoreline within this bounded area. Portions of major access routes for both highway and railroad transportation and adjoining side roads serving the area would be below water during a 1% (100-year) storm event. These elevations range from 13.0 feet NAVD88 in VE Zones to 11.0 NAVD88 in the most inland AE Zones. The majority of this area is commercial use with areas consisting of a mixture of commercial and retail areas, a major railroad hub for both freight and commercial traffic, and a marina.

Chapter 2: **Survey Data**

2.1 Topographic and Imagery Data

Topographic data used for this study consists of X, Y, and Z values derived from a 2016 Lidar survey covering approximately 5,240 square miles. The Leica ALS-70-HP and Riegl LMS-Q6801 systems were used to collect data for the survey. Data used to generate the contours only included points classified as "ground". The structure and bluff profiles include elevations at the crest, toe, and the landward intercept with the structure. Horizontal data from the survey is referenced to Connecticut State Plane Coordinate System, NAD 83, US Survey Feet and vertical data is referenced to NAVD88, US Survey Feet. The aerial imagery used was obtained from the National Oceanic and Atmospheric Administration (NOAA) and was acquired in August 2017.

Chapter 3: **Project Alternatives – New Haven**

3.1 Preliminary Alternatives Array

Preliminary alternatives considered for this study include:

- **Alternative 1:** Without Project Condition
- **Alternative 2:** Non-Structural Plan, elevating or floodproofing eligible structures
- **Alternative 3A:** Existing I-95 Embankment; Deployable Measures under I-95
- **Alternative 3B:** Enhanced I-95 Embankment; Floodwall and Deployable Measures along I-95
- **Alternative 4A**: Shoreline Floodwall; Floodwall along Long Wharf Drive ending near Route 1/I-95 interchange
- **Alternative 4B**: Extended Shoreline Floodwall; Floodwall along Long Wharf Drive encompassing commercial area at end of East Street and terminating at I-95.

3.1.1 Alternative 1: Without Project Condition

This alternative assumes no action for coastal storm risk management and does not require civil design input.

3.1.2 Alternative 2: Non-Structural Floodproofing

The Nonstructural alternative for the Long Wharf focused study area consists of providing non-structural storm risk management benefits through a combination of elevating or floodproofing eligible structures within the study area. 138 structures were initially found to be eligible for potential floodproofing or elevation of the first floor. The majority of these structures are large commercial properties. There are 12 residential structures within the study area that are potential candidates for elevating the first floor. There are 126 commercial structures within the study area that are potential candidates for either wet or dry floodproofing. Most of the buildings are large commercial buildings that would be extremely difficult, if not impossible to properly floodproof. This option would not reduce the risk of coastal storm damage to the rail and highway infrastructure.

3.1.3 Alternative 3A: Existing I-95 Embankment-Deployable Measures under Route I-95

This alternative uses deployable measures under I-95 to reduce the flood event frequency. Deployable structures would be used to prevent floodwaters from passing through where Long Wharf Drive, Canal Dock Road pass under I-95 and where Brewery Street passes under the Oak Street Connector. For costing purposes a post and panel system was assumed, however a more detailed analysis will be required at design. These systems would need to be stored near the openings and put in place prior to a storm event.

The structure to close Long Wharf Drive would be roughly 60 foot wide and 3-4 foot high. Canal Dock Road would require a roughly 190 foot wide structure 4-5 foot high and Brewery Street would be approximately 65 feet wide and 1-2 foot high.

Foundations for the system will require significant coordination with the existing utilities in the streets as well as coordination with ConnDot to tie the structures effectively into the I-95 walls or embankment. This option would provide protection up to a flood elevation of approximately elevation 10.0 after which water would start flooding across I-95 near where the Long Wharf drive crosses under I-95.

Pumps will be required to move any stormwater out of the protected area. See Chapter 5 for more detail on the proposed pumping systems. Note that this alternative was not carried forward into the final suite of alternatives given that the alternative is not technically feasible or acceptable as determined by additional collaboration with the CT Department of Transportation following release of the draft report.

3.1.4 Alternative 3B: Enhanced I-95 Embankment- Floodwall and Deployable Gates along I-95

This alternative consists of five road closure structures (one at Long Wharf Drive approximately 60 feet wide by 8 feet high; one at Canal Dock Road approximately 190 feet wide by 7 feet high; one at Brewery Street approximately 65 feet wide by 3 feet high; two at Exit 46 with a total length of approximately 160 feet wide and 5 feet high; one pumping station which would handle approximately 900 cubic feet of water per second (cfs); enhancement of the I-95 embankment with approximately 5,800 linear feet of “T-wall” type floodwall along with 475 feet of deployable closure structures. The proposed floodwall is designed to be built upon a robust, deep-pile foundation independent of the I-95 earthen embankment. The proposed floodwall would be built to a height +15 feet NAVD88. This elevation was selected considering the topography of the project area in addition to future annual exceedance probability water levels under the low, intermediate and high sea level change scenarios. By the end of the project’s 50 year period of economic analysis in 2074, the floodwall will have a 0.8-percent annual exceedance probability under the low sea level change scenario, a 1.2-percent annual exceedance probability under the intermediate sea level change scenario and a 3.5-percent annual exceedance probability under the high sea level change scenario. These levels of residual risk are considered to be low and tolerable.

This Alternative would protect the commercial and railroad areas behind I-95 from storms and waves up to approximately elevation 15’ (NAVD88).

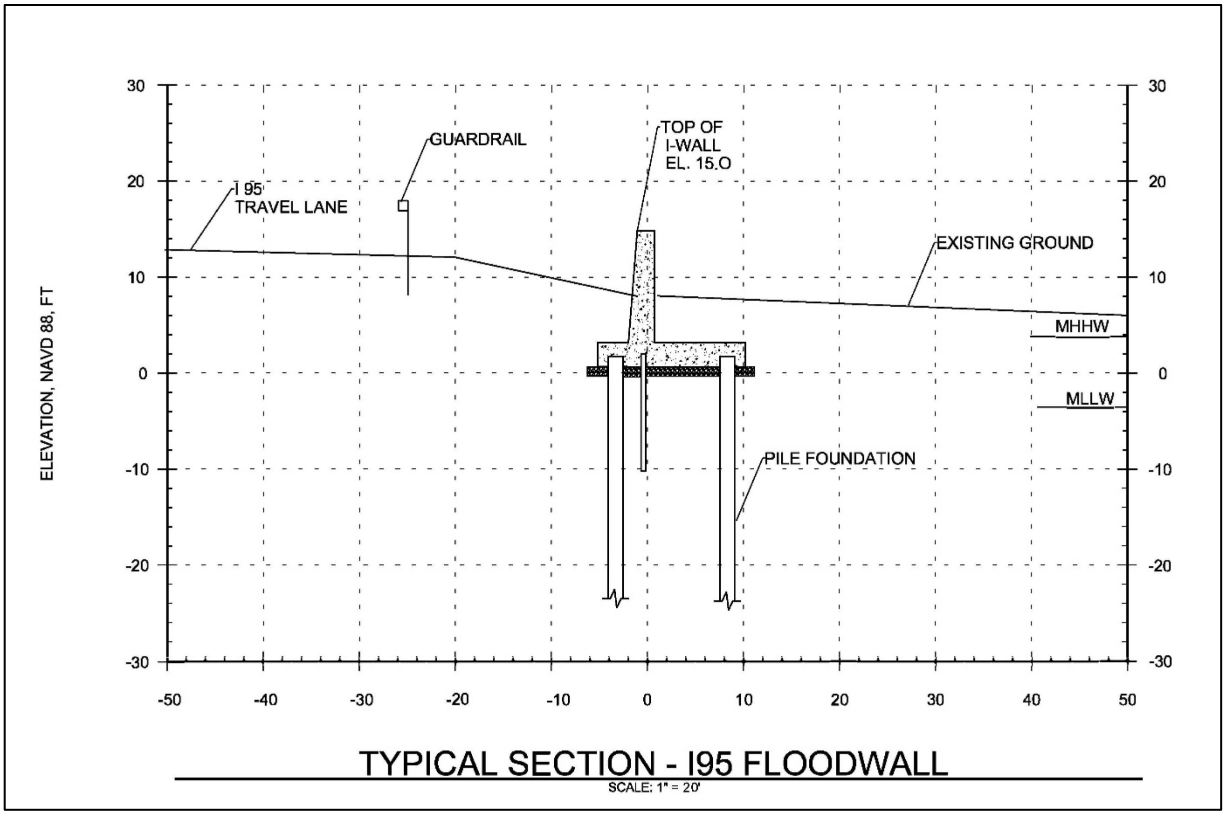


Figure 3 Typical Floodwall Section

3.1.5 Alternative 4A: Shoreline Floodwall - Floodwall along Long Wharf Drive terminating at I-95:

This alternative uses an approximate 6,700 foot long T-wall along Long Wharf Drive rather than along I-95 up to 9 feet high protect the commercial and transportation facilities extending to the same endpoints as Alternative 3B. At least 4 deployable structures would be required, one at Brewery Street described in option 3A, one crossing Long Wharf Drive roughly 65 feet wide and 7 feet high, one at the Canal Dock Boathouse Access approximately 35 feet long and 9 feet high and one at the Long Wharf Park parking area which would be roughly 50 foot wide and 5 foot high. Additional doors and/or structures would be needed to make the Long Wharf Park access convenient to pedestrians and other users.

This alternative would restrict access and views of Long Wharf Park and would require some tree removal.

This Alternative would protect the commercial and railroad areas behind I-95 from storms and waves up to approximately elevation 15’ (NAVD88). Pumps will be required to move any stormwater out of the protected area as required in Alternatives 3A and 3B. See Chapter 5 for more detail on the proposed pumping systems.

3.1.6 Alternative 4B: Extended Shoreline Floodwall - Floodwall along Long Wharf Drive encompassing commercial area at end of East Street and terminating at I-95:

This Alternative starts with all the structures in alternative 4A except the Long Wharf Drive Gate and extends the wall around the Long Wharf Maritime Center extending the wall approximately 3,000 feet and would be as high as 13 feet. Part of this alignment would be along an existing seawall alignment and would pose difficult construction and design issues due to the available space to work around the existing wall.

In addition to the deployable structures in 4A structures would be needed at the entrance to the Tank Farm, (55 foot long 9 foot high), crossing East Street (90 feet long, 5 foot high) , and crossing Water Street at the intersection with East Street (90 feet wide, 5 foot high).

At least one additional pump would be needed in the Long Wharf Maritime Center to handle stormwater behind the floodwalls.

This Alternative would protect the commercial and railroad areas behind I-95 from storms and waves up to approximately elevation 15. The Long Wharf Maritime Center would be protected.

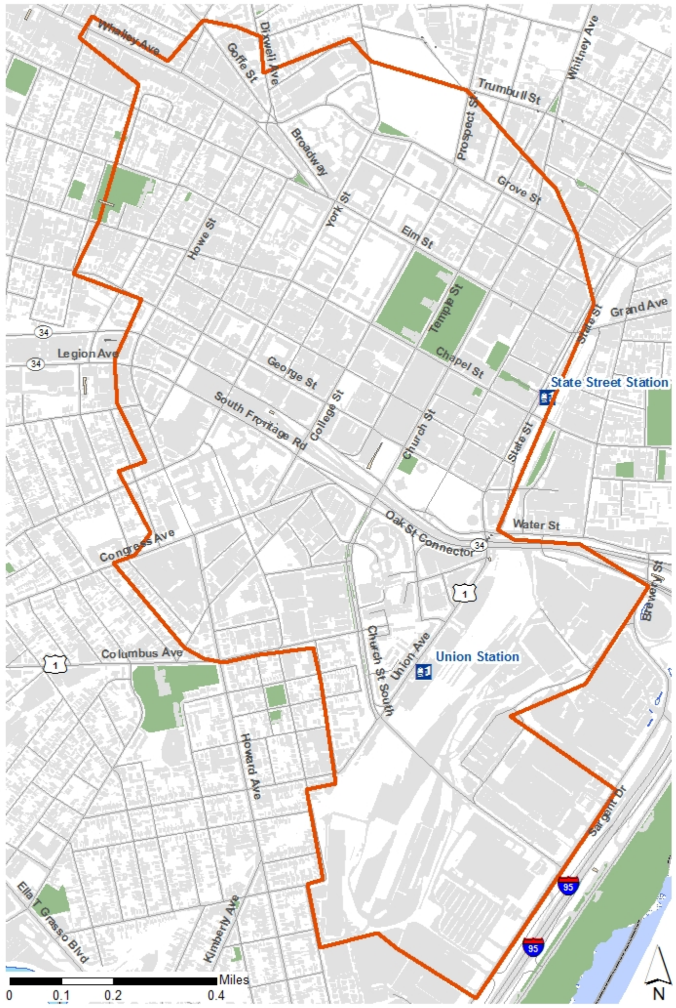
Chapter 4: **Project Tie-In**

The tie-ins for all of the walls would be in native soils to the extent feasible. The deployable structures listed in Alternate 3A will need to be tied either to the I-95 embankments or to the I-95 abutments. The other alternatives will have most of the deployable structures tied to the new wall except at Brewery Street. The exact location and requirements will need to be reviewed in the design portion of this work.

Chapter 5: **Stormwater Pump Stations**

The proposed pumping stations are designed to support interior drainage during major storm events that would require the closing of the deployable closure structures. Pump stations would be located underground near I-95 or the T-wall (for 4B) and will pump through the structural feature to the bay. A pump station will be required intercepting and connecting to the existing New Haven stormwater outfalls. It is anticipated that the main pump station would be in an undeveloped parcel between Sargent Drive and I-95 and the Oak Street connector (Pump A). For Alternative 4B a second station (Pump B) would be required around Lenny and Joes Fishtale Restaurant. All stations will have elevated gravity inlet piping to allow interior drainage to flow into the bay by gravity under normal conditions and bypassing entry into the pump stations. There are 3 smaller internal drainage systems in the Long Wharf area which for this report we are assuming can be directed to the larger pump stations for the major events. This will need to be confirmed during the design phase of the project. Back-up power will be provided for each station probably by natural gas powered generators located adjacent to each station. A single 900 cfs pump station is part of the recommended plan (see figure 6). The pump station will not require a permanent staff at the station and therefore will not require any special amenities (e.g. bathrooms, kitchens). It is assumed that the pump station will only run intermittently when there are large and/or intense storm events (i.e. only a few times a year). The pump station will have only the bare minimum (pumps, control system, backup generator, etc).

In the attempt to reduce visual impact and to maintain the present uses of the site, submersible pumps are



proposed for this project. The emergency generators will need to be housed inside water tight structures with ventilation openings located above maximum predicted flood level.

A complete analysis for determining the design flows will need to be done during the design phase of the project. The existing stormwater system experiences frequent flooding at several locations and the City has done extensive modeling in this area. The City of New Haven Engineering Department has a calibrated Storm Water Management Model (SWMM) of the Downtown/Long Wharf storm sewershed. The approximately 800-acre drainage area for this model is shown in the figure below.

Figure 4. Pump “A” Watershed

To assist with the Feasibility Study and sizing of the pump stations, the City utilized its SWMM model of the area to analyze the proposed solution under a scenario where there is a significant storm surge coupled with a large rain event. A 10-year, 24-hour design rainfall event as defined by NOAA Atlas 14 (5.22 inches) with a SCS Type III distribution curve was used to simulate the runoff volumes. A 7.5% increase in the rainfall event was applied to account for the increasing precipitation trend in the Northeast for a total of 5.61 inches over 24 hours. The storm surge boundary condition was defined by the December 1992 Nor’easter with an additional sea level rise component of 1.37 feet, corresponding to the USACE

Intermediate sea level change curve for year 2074. As a conservative assumption, the peak rainfall and peak storm surge coincided. The modeling results show that in order to keep the hydraulic grade line below ground level (i.e. prevent surface flooding), one 900-cfs pump station could be installed at the northern end of Long Wharf.

Pump Station “B” (for alternative 4B only) is for a 5 acre commercial area at the North end of Long Wharf. It was estimated by the rational method as needing no more than 100 cfs.

Figure 5 Pump “B” Watershed

For ease of maintenance and interchangeability of parts, one universal pump which can be used in multiples for each station in order to achieve the peak flow condition with one pump out of service is preferred.

The pumps will be configured to alternate between starts and may be controlled with variable frequency drive (VFD) equalization. The VFD regulates the speed of individual pumps and fine tunes the transition stage of hydraulic flow when multiple pumps are running. As multiple pumps are activated, the analog output signal recalculates so that the net flow through the discharge piping is averaged over the activated pumps. The controlling signal adjusts, so that all the pumps are running at the same speed to convey the required flow. Equally sharing the flow across multiple pumps allows the pumps to create less starting load on the emergency generators and allows them to operate within a more efficient range.

The existing outfalls are a 72 by 72” box culvert (North Outfall) and a 72 inch outfall (South Outfall) with tide gate structures at the outfalls. These pipes and structures will need to be evaluated during the design phase to determine if they can be used with the forcemains or if a new forcemain will need to be constructed crossing I-95 for these pumps. For the purposes of this feasibility study, it was assumed that the new pump station would be integrated into the existing drainage infrastructure.

Chapter 6: **Right-of-Way**

The proposed alternatives will require acquisition of a right-of-way corridor wide enough to allow for the footprint of all permanent design features as well as enough room for future flood event monitoring and recurring inspection activities. For the final alternatives array, the following assumptions for right-of-way acquisition were used:

- Permanent easement: Minimal easements are assumed to be needed as the walls are assumed to be able to be placed on State Highway Right of Ways, Easement will be needed for the pump stations and possibly part of the wall located east of the Howard Street Overpass

Contractor staging areas will be required and will be based on available real estate. The actual location(s) for contractor staging will be determined during Pre-construction Engineering and Design.

Chapter 7: **Utilities**

Utility costs associated with this project have been captured as part of the cost analysis for the required interior drainage and pump stations. Required interior drainage features and pump stations are incorporated into all four structural alternatives. The features will be further analyzed during the Pre-construction Engineering and Design phase of the project.

Utility interferences are a major concern for the deployable structures and will also have an impact on the proposed wall alignment as all utilities along and crossing I-95 will need to be identified during the design phase. This is also true along Long Wharf Drive where a major sewer force main runs on the opposite side from I-95 which would be a potential issue for the final alignment of the wall for Alternatives 4A and 4B.

Chapter 8: **Recommended Plan**

Following evaluation of the Alternatives, Alternative 3B which includes 5,800 feet of T-wall along I-95, 5 closure structures totaling 475 linear feet, and a 900 CFS pump station has been identified as the recommended plan.

Figure 6 The Recommended Plan, Alternative 3B. The location of the flood wall is shown in blue, closure structures in purple and the 900 CFS pump station is highlighted in green.