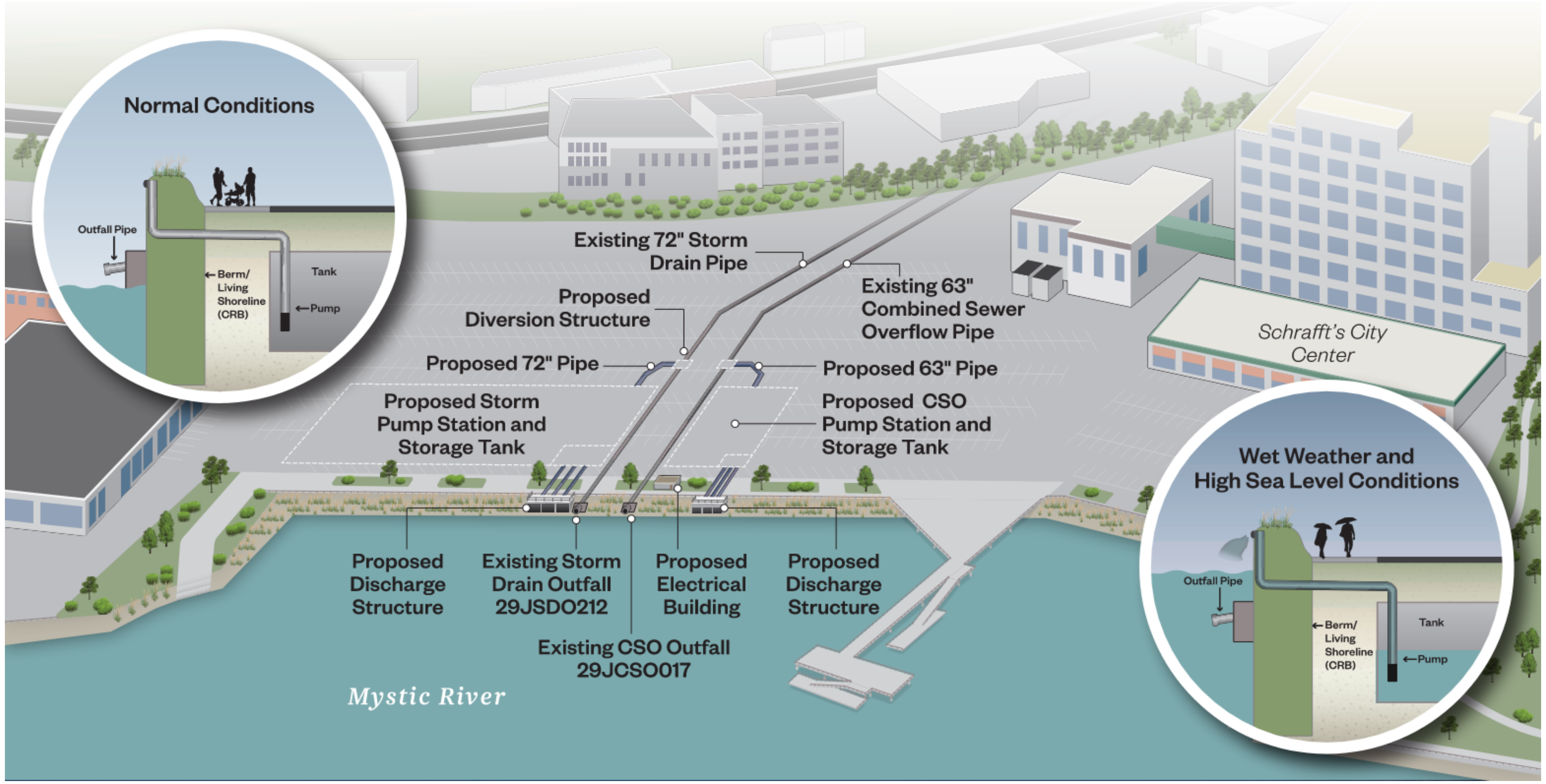
Charlestown Pump Station *Concept Overview*



Conceptual Solution

The conceptual solution herein includes two storage (peak flow shaving) tanks and pump stations to discharge wet weather flow and combined flow when tide levels are high. The tanks and pump stations are located within the Schrafft City Center Parking Lot in Charlestown. This conceptual solution was developed to adapt two adjacent outfalls, 29JSDO212 and 29CSO017. If a high tide level begins to reduce the ability of existing outfalls 29JSDO212 and 29CSO017 to discharge by gravity, the existing storm and combined sewers will begin to surcharge. Both storage tanks are designed with a diversion structure with a static weir to direct excess flow to a storage tank that is connected directly to the pump station. Both pump stations includes two duty and one standby pump. The pump stations utilize electric submersible pumps to minimize the above ground footprint of the station and mitigate negative visual and auditory impacts from diesel engine driven pumps. Each pump is designed with a formed suction inlet and non-manifolded discharge. During extreme storm conditions a portable generator could be parked within the parking lot to provide a backup power supply in the event of a power outage.

Type: Storage and Conveyance

Total Drainage Area: 144 acres

Coastal Vulnerable Drainage Area Protected: 105 acres

Concept Elements:

- Subsurface Pump Stations
- Subsurface storage tanks
- Diversion structures

Outfalls Included in Concept:

- 29JCSO017
- 29JSDO212

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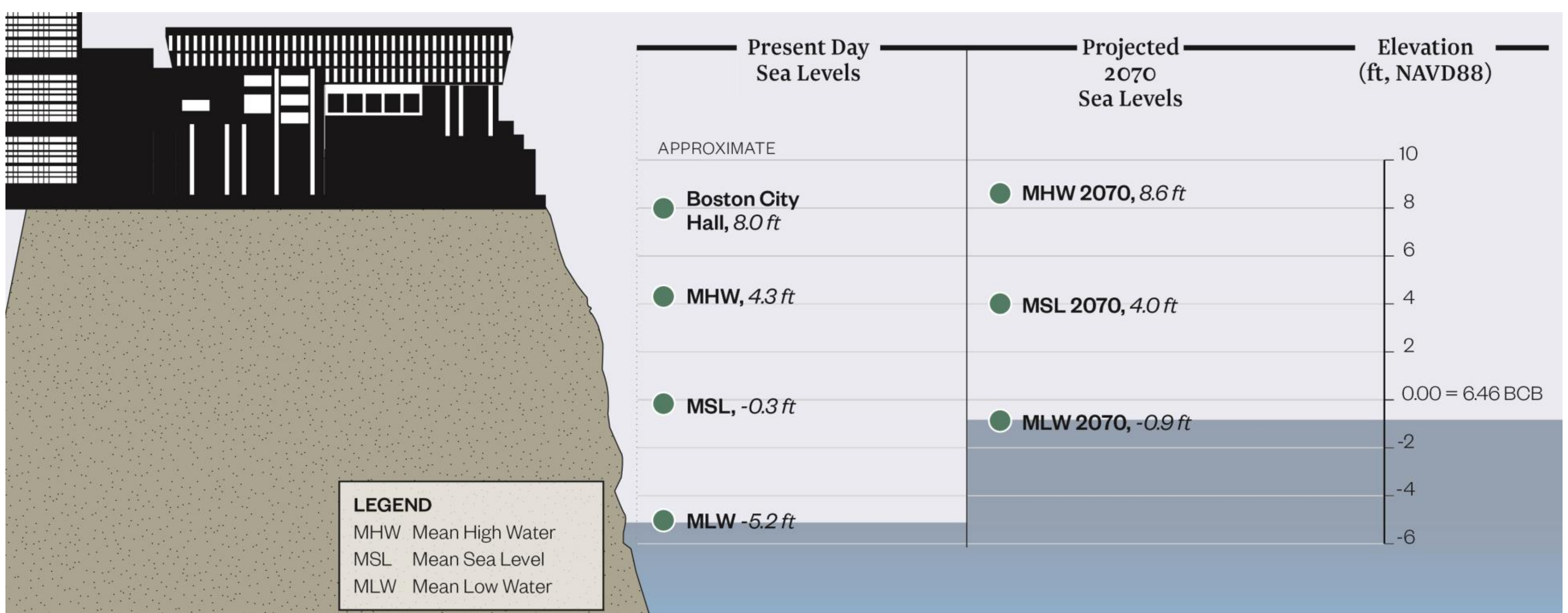
Assumptions

Sea Level Rise and Datum

The Charlestown Pump Station concept was designed for consistency with Climate Ready Boston (CRB) proposed adaptations and analyzed based on sea level rise (SLR) projections in the Massachusetts Coastal Flood Risk Model (MC-FRM). The SLR values applied in MC-FRM are consistent with the standards for the State of Massachusetts developed by Coastal Zone Management. The MC-FRM utilizes a "High" SLR scenario. This scenario is based on the relative SLR projections under Relative Concentration Pathway (RCP) 8.5 (a "worst case scenario" of increasing atmospheric carbon concentrations) and represents elevations that have a 99.5% probability of not being exceeded within the respective timeframes. In 2030, that amounts to an increase of 1.3 feet in Boston from a baseline condition (2008 centered tidal epoch), and in 2070 that amounts to an increase of 4.3 feet.

The concept developed in this project was analyzed using coastal conditions that include 2070 projected SLR and storm surge resulting from a 100-year tropical storm. The peak water surface elevation (WSE) predicted by the MC-FRM during these conditions is approximately 13.8 feet NAVD88 (varies by location). In mid 2022, the Greater Boston Research Advisory Group (BRAG) issued an updated report with new SLR projections. The report acknowledges that long term SLR projections are associated with significant uncertainty, and that updated projections include less SLR by 2100 (compared to earlier projections in the 2015 BRAG Report). According to the report, the likely range of SLR by 2070 under an RCP 8.5 scenario is 1.4 – 2.8 feet. Based on this information, projections from the MC-FRM that were utilized in this project are conservative and appropriate for long term planning purposes.

Unless otherwise noted, all elevations are based on the NAVD88 vertical datum. Elevations given in NAVD88 can be converted to Boston City Base (BCB) elevation by adding 6.46 feet.



Climate Ready Boston and Shoreline Protection

The Charlestown Pump Station concept was developed to maintain consistency with possible Climate Ready Boston (CRB) adaptations based on the latest available information at the time they were developed. As the CRB program continues to evolve, it is anticipated that proposed concepts will need to be adapted.

The concept was developed to be consistent with stated neighborhood design flood elevations. In Charlestown, where the stated design flood elevation is 15.5 feet, pumps were designed to discharge to a minimum elevation of 15.5 feet.

At the time of this project, many CRB concepts were in early planning stages and not fully defined. **In consideration of this, it was assumed the shoreline protection around the City of Boston is 100% effective for all modeling evaluations.** This assumption eliminates overland coastal flooding from model predictions, allowing for isolation of flooding that results only from rainfall and stormwater that cannot be discharged due to high sea levels. It is important to recognize that additional flooding, beyond what is depicted herein, would be expected if 100% effective shoreline protection is not implemented.

Basis of Design

CSO and SDO Pump Stations

Model simulations were conducted to determine the maximum Hydraulic Grade Line (HGL) that occurs at Outfalls 29JCSO017 and 29JSDO212 with the current tide cycle. Analyses were then conducted to determine the acceptable combinations of storage volume and pumping rate required to maintain the existing HGL with 2070 projected sea level rise, as shown in Figures 1 and 2. The City of Boston's Parcel database was used to identify publicly owned parcels near the existing outfall. An analysis of the pump station was performed to identify pump rates and physical dimensions that are hydraulically viable at the outfalls. It was found that Outfall 29JCSO017 would require a 0.5 MG storage tank at ~12 feet deep could fit on the property with a 40 CFS pump station. The CSO pump station and storage tank occupy an area of 5,885 ft^2. It was found that Outfall 29JSDO212 would require a 2.5 MG storage tank at ~15 feet deep could fit on the property with a 200 CFS pump station. The SDO storage tank and pump station occupy an area of 25,500 ft^2. Both stations utilize two duty pumps, one standby pump, and one dewatering pumps and are configured with vertical, axial electric submersible pumps in parallel bays. The storage tanks for both stations could be constructed as a single structure with a dividing wall.

Figure 1: 29JCSO017 Pumping vs. Storage

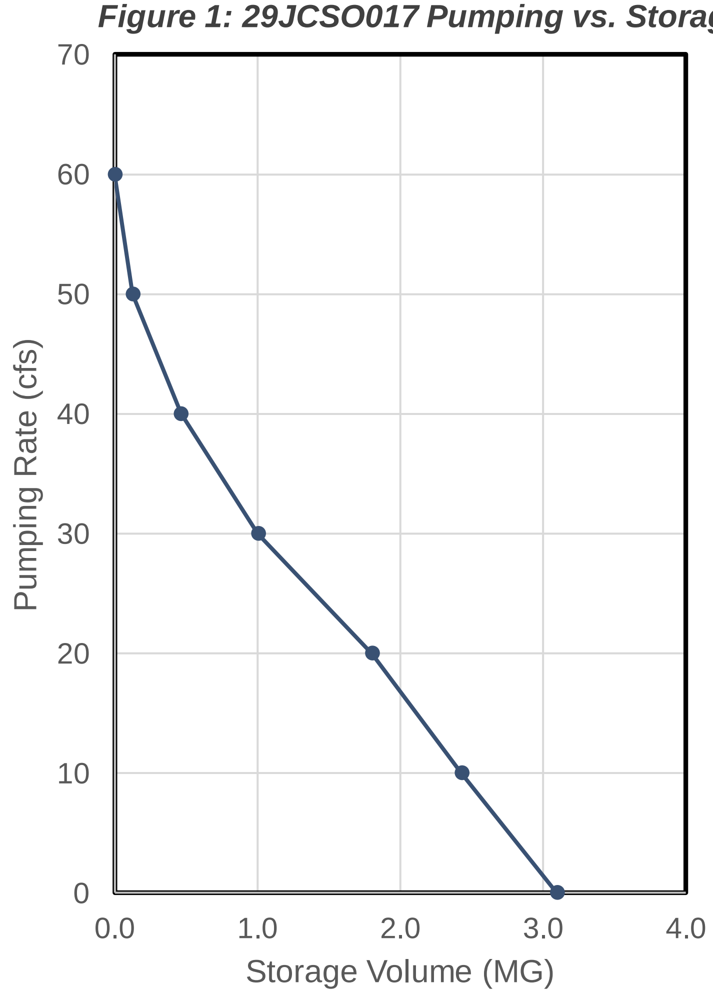
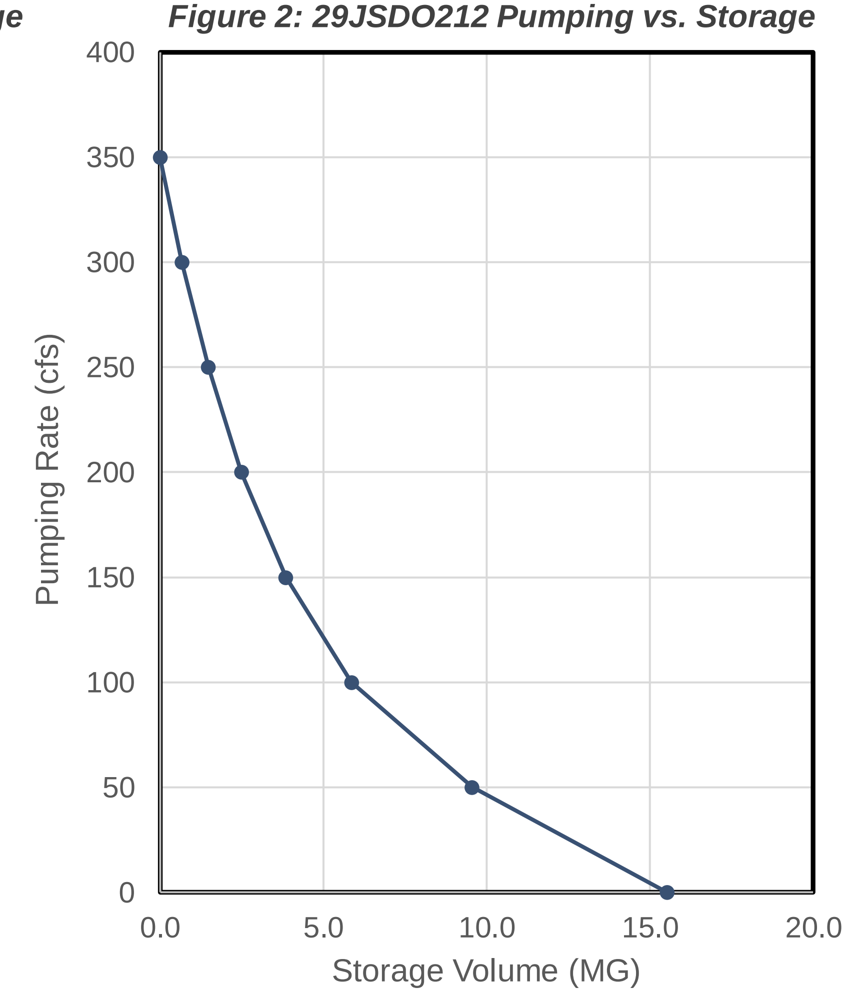


Figure 2: 29JSDO212 Pumping vs. Storage



Rainfall and Coastal Conditions

The Commission currently utilizes a 10-year, 24-hour design storm to establish its target level of service. For the purpose of sizing new piping and evaluating storage capacity, a projected 2070 10-year, 24-hour design storm was developed. For consistency with Climate Ready Boston, performance of the Charlestown Pump Station concept was also evaluated with projected rainfall from a 100-year tropical event (developed during the Commission's Inundation Model Project). The Charlestown Pump Station concept was evaluated using a 100-year return period coastal boundary condition. Data for this condition were obtained from the MC-FRM. For the purpose of evaluating the effectiveness of the concept, it was further assumed that complete shoreline protection was implemented, preventing flow between the Charlestown Pump Station tributary area and the Mystic River. Table 2 contains a summary of the coastal conditions that were analyzed.

Table 1: Rainfall Conditions

Scenario	Purpose	Rainfall Depth (in)	Peak Intensity (in/hr)
Present Day, 10-year, 24-hr design storm	Baseline Conditions	5.15	3.32
Projected 2070, 10-year, 24-hr design storm	Design Conditions	6.18	4.08
100-year Tropical Storm	Damage Analysis	9.58	0.84

Table 2: Coastal Conditions

Scenario	Purpose	Peak Water Surface Elevation (ft, NAVD88)	Source
Present Day	Baseline Conditions	3.7	BWSC Existing Model (April 2016 Tide Cycle)
2070,100-year Tropical Storm	Damage Analysis	13.8	MC-FRM

Flood Modeling and Damage Analysis

Figure 3: Estimated Replacement Cost

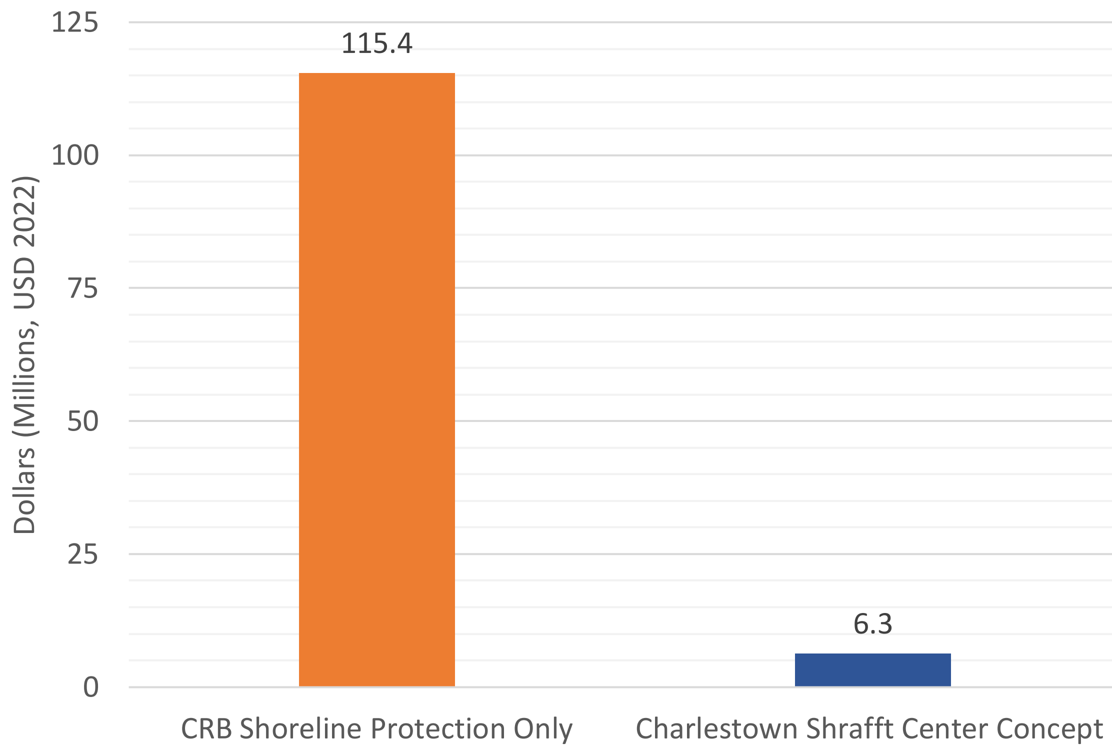


Figure 4: Loss of GDP

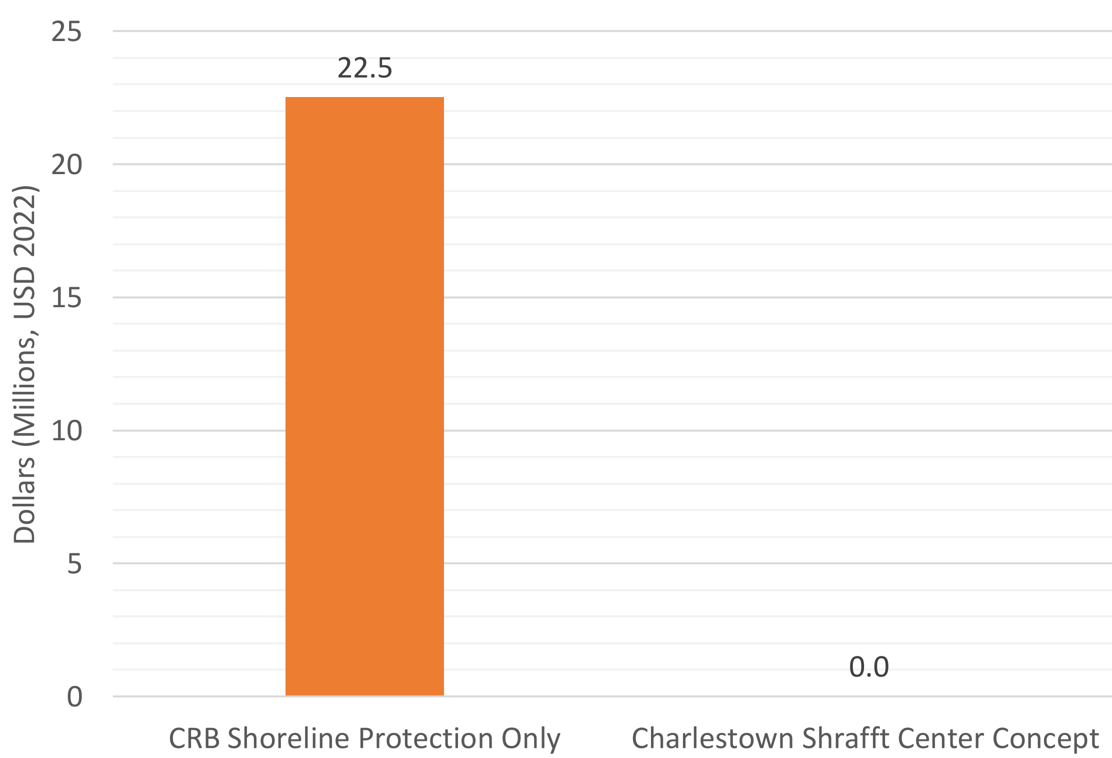
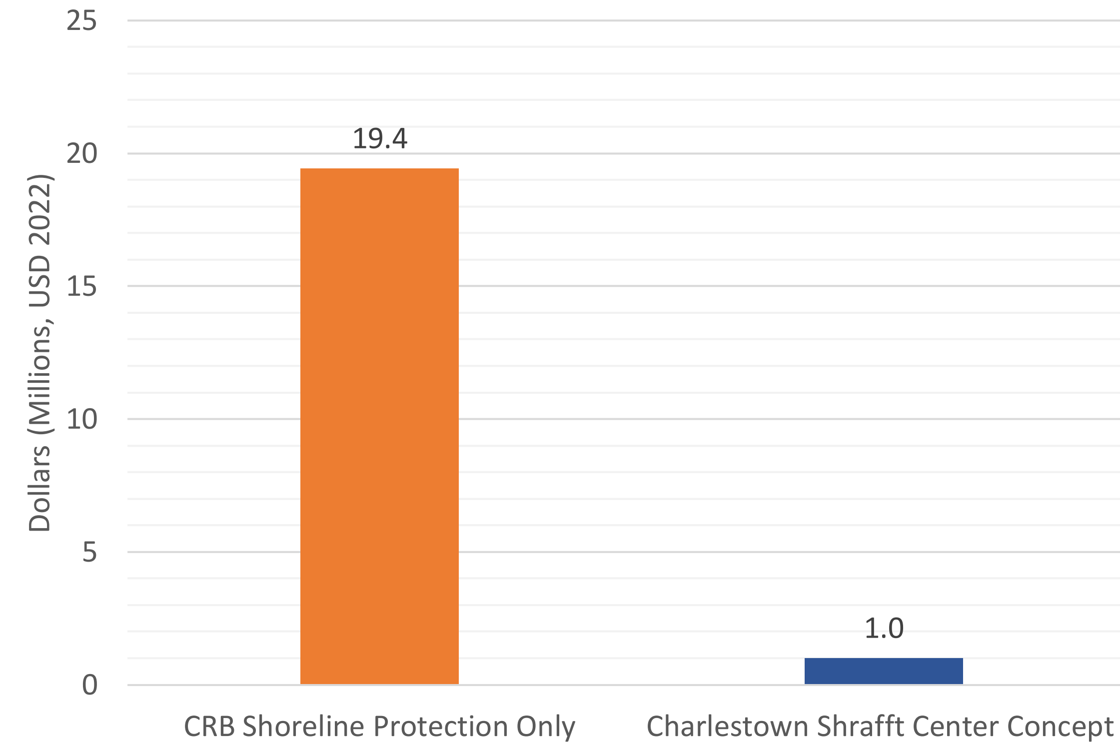


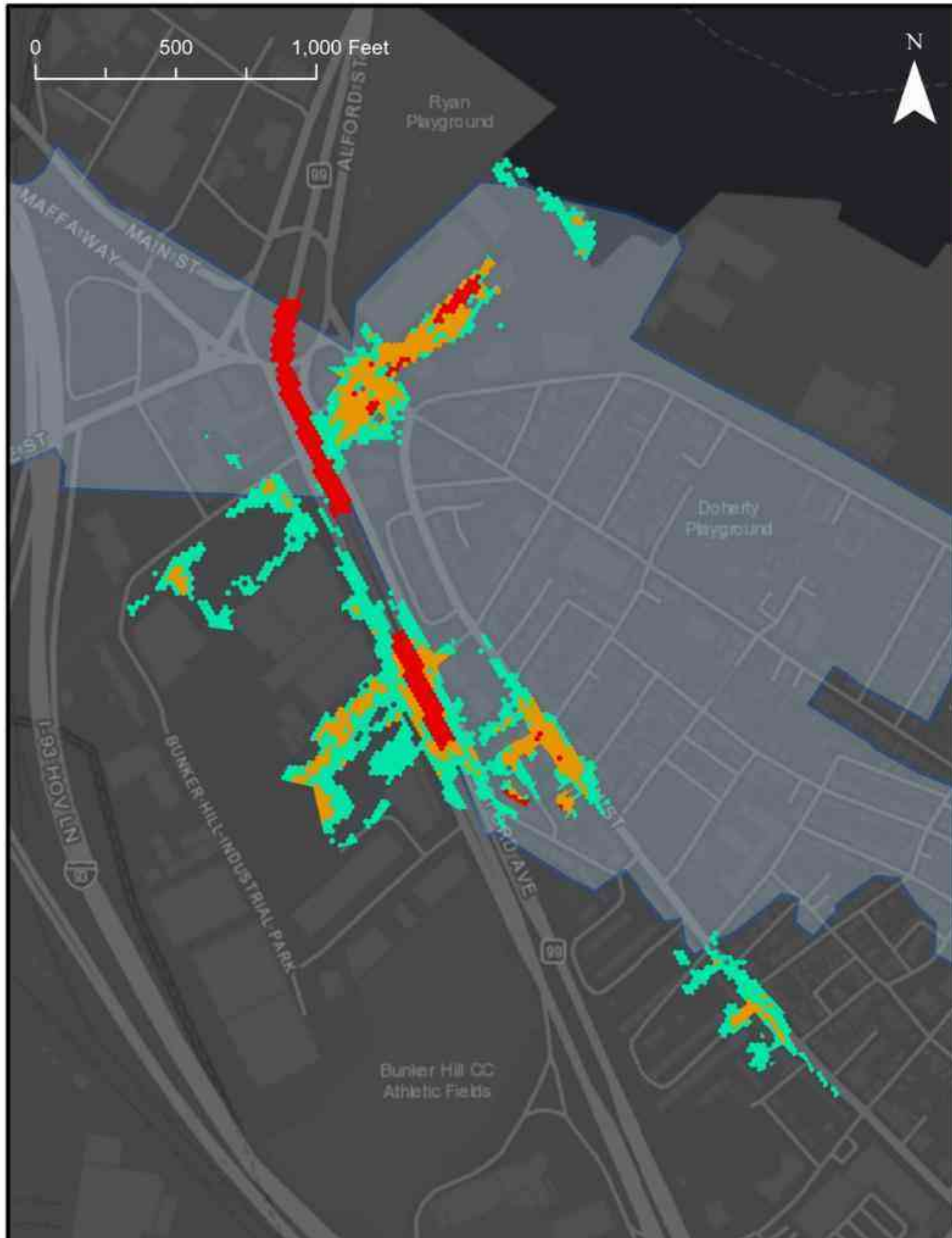
Figure 5: Physical Damage



The flood reduction benefits of the Charlestown Pump Station concept were evaluated using the Commission's 2D Inundation Model by simulating a 100-year tropical storm event with 2070 SLR and storm surge. The figures on the following page depict the peak flooding that was predicted in the Charlestown Schrafft Center drainage area with shoreline protection only and with the pump station and tide gates on all vulnerable BWSC owned outfalls. An analysis of economic losses/physical impacts from flooding under both scenarios was performed by risQ Inc.

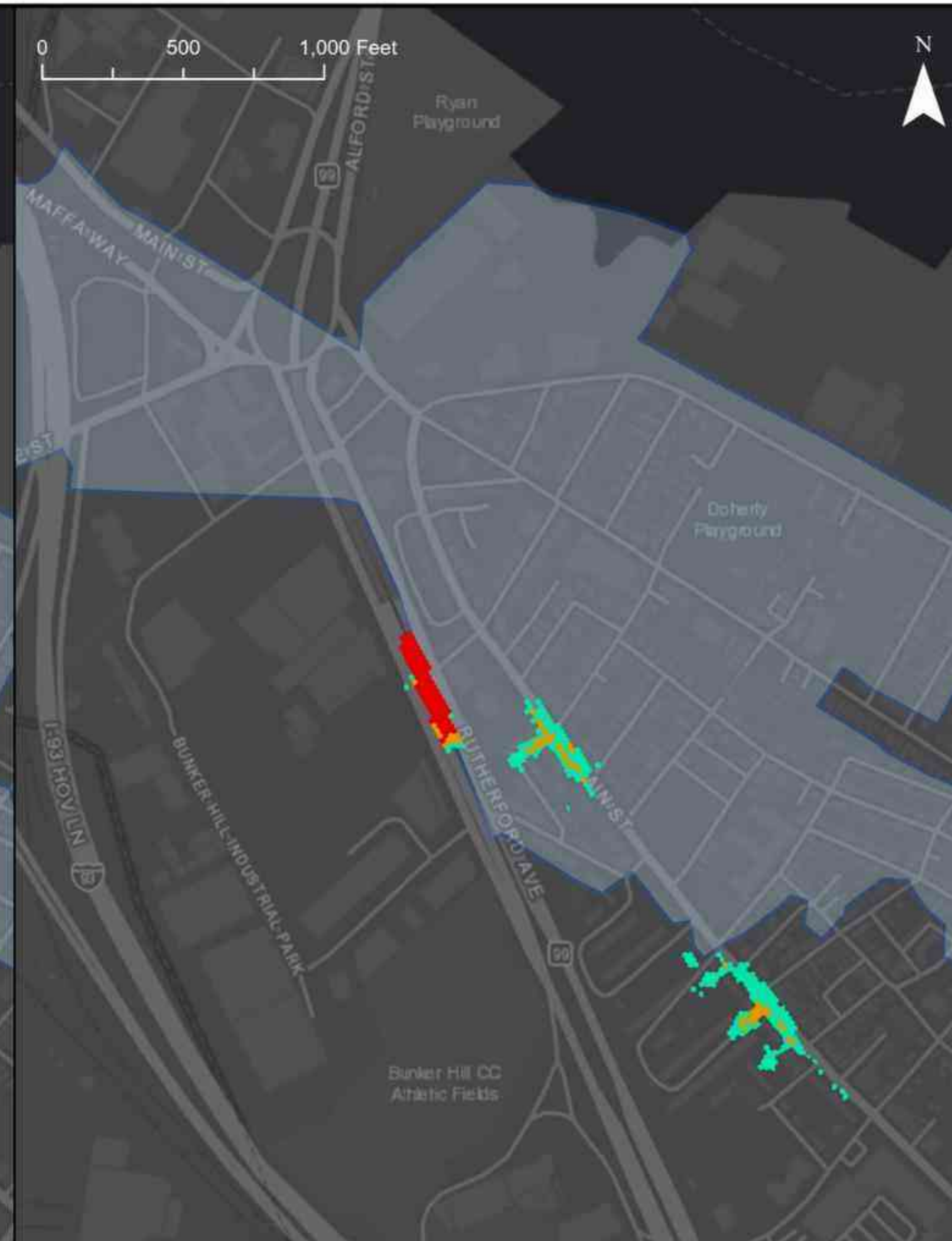
Model predictions indicate that the Charlestown Pump Station concept reduces physical damage by **$18.4 million**, avoids **$109.1 million** in rebuilding costs, and mitigates a GPD loss of **$22.5 million** during a 100-year tropical storm event in 2070 compared to shoreline protection only.

Note: replacement values include the total value of impacted buildings in flooded areas (e.g., impacted buildings are fully replaced), whereas physical damage includes estimated costs to repair flood damage based on predicted flood depths and building characteristics. The values shown are the average of minimum and maximum calculated losses. Refer to the Project's Final Report for more information.



2070 SLR + 100yr Tropical Storm + Storm Surge

Shoreline Protection Only



2070 SLR + 100yr Tropical Storm + Storm Surge

Schrafft Center Pump Stations and Tide Gates

Legend

- Flood Depth > 4 in and < 1 ft
- Flood Depth > 1 ft and < 2 ft
- Flood Depth > 2 ft
- Drainage Area Analyzed

Shared Simulation Parameters

Storm Type	100yr Tropical Storm
Rainfall Depth	9.6 inches
Peak WSE 2070 SLR + 100yr Surge	13.8 feet NAVD88

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Cost Estimate and FEMA BRIC Considerations

Capital Cost Estimate

A construction cost estimate for the Charlestown Pump Station concept was developed for planning purposes. Assumptions for the cost estimate include 15-year escalation to the mid-point of construction and the inclusion of a 50% design contingency. Utility hookup costs were not included.

Table 3: Charlestown Pump Station Cost Estimate Subtotals

Remaining Design Development & Construction Administration (assumed 20% of total less design contingency)	$5,893,000
Direct Construction Costs	$11,596,079
Indirect Construction Costs	$2,319,216
Mark-Up *(Including 50% design contingency)*	$29,742,705
Total	**$49,551,000**

Social Vulnerability and FEMA BRIC Funding

FEMA BRIC funding prioritizes disadvantaged communities. Table 4 contains a summary of several indicators for the Charlestown Pump Station tributary area that could be used help characterize the community for future FEMA funding applications and prioritization of projects that benefit disadvantaged communities.

Table 4: Charlestown Pump Station Tributary Area Social Vulnerability Indicators

Low Income & Persistent Poverty	
Per Capita Income	$81,062
Below Poverty Line	5%
High Housing Cost Burden	
Stressed Renters (>40% rent-to-income)	26%
Households With Food Insecurity	14%
Racial and Ethnic Segregation	
Asian Population	6%
Black Population	5%
Hispanic Population	5%
White Population	84%
Education and Employment	
Adults Age 25+ Without High School (or equivalent) Degree	3%
Unemployment Rate (Age 16+)	2%

Data provided by risQ inc. from the US census and American Community Survey

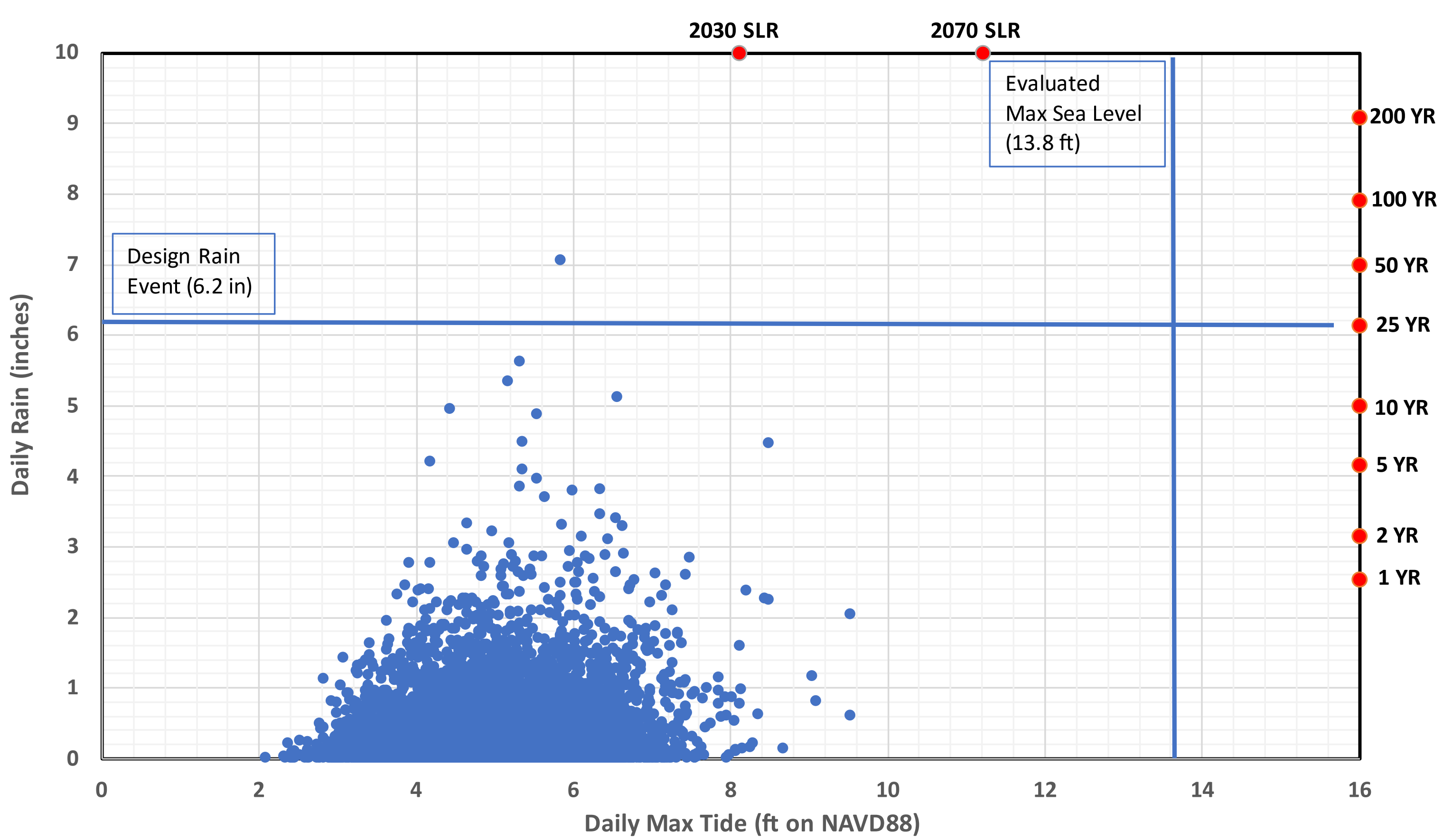
Adaptability and Implementation

Adaptability

Figure 6 below depicts historical daily rainfall totals and tide levels. As shown in this figure, the conditions that were used to design and analyze the Schrafft Center pump station are conservative and represent more extreme conditions than have occurred historically. Regardless, the following measures could be implemented to adapt the concept to more severe conditions (additional SLR, more intense rainfall, etc.) in the future:

- Increase the size of installed electric submersible pumps
- Utilize the standby pumps as a duty pump during extreme conditions
- Increase the size of the peak shaving tanks
- Combine the CSO and SDO pump stations or control flow to each station with active controls to maximize system efficiency

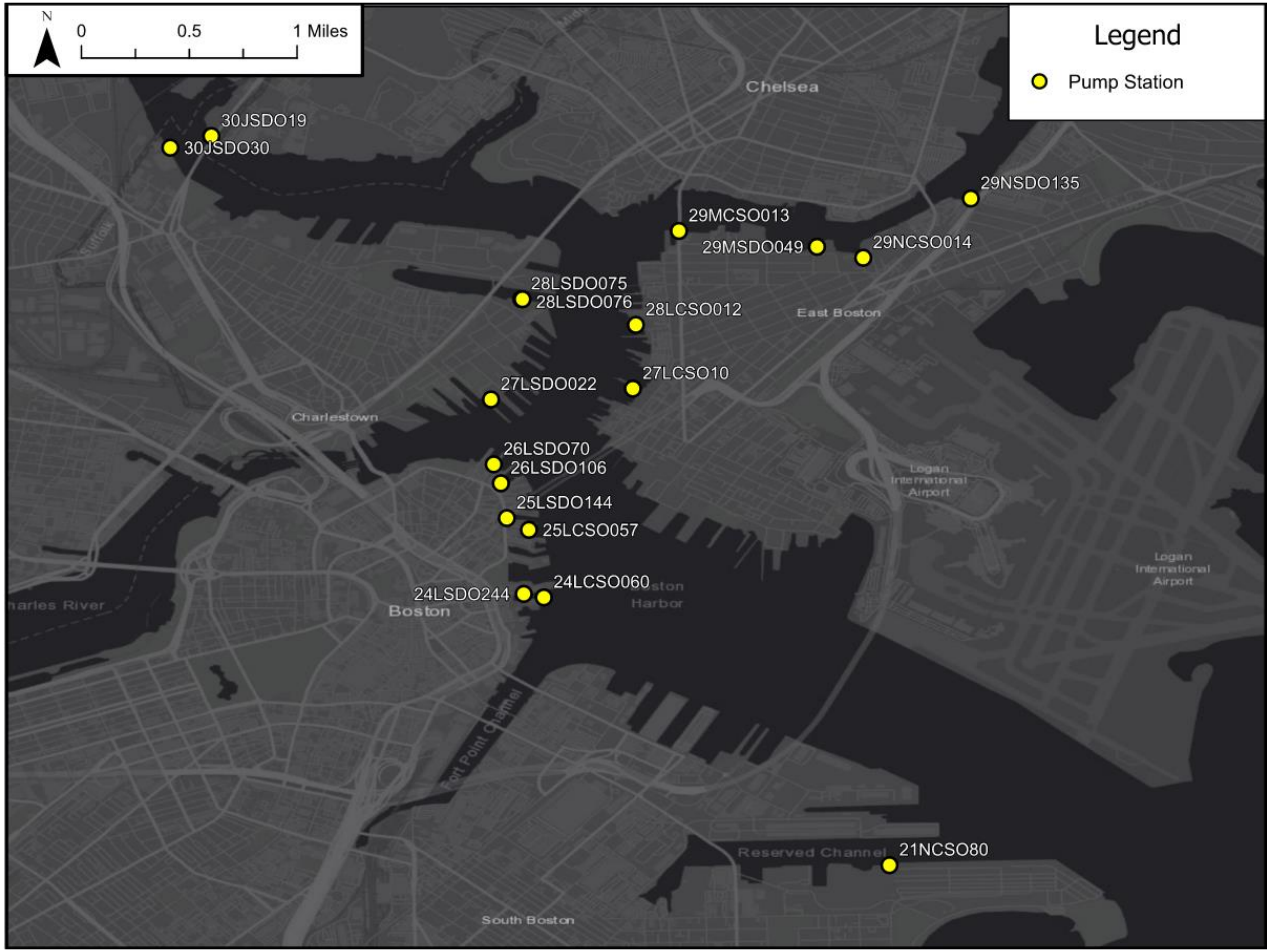
Figure 6: Design and Analysis Conditions vs. Historical Tide and Rainfall



Implementation Considerations

- Coordination with CRB is necessary to implement shoreline protection. The pump station should not be implemented without shoreline protection to prevent coastal flooding within the area tributary to it.
- Community engagement with stakeholders may help build project support by illustrating the flood control benefits of the pump station.
- A comprehensive permitting evaluation should be conducted to evaluate possible impacts from construction and operation of the pump station to the receiving water.
- If sewer separation is planned in the area tributary to the CSO outfall leading to it being converted to a storm drain outfall, a single tank and pump station could be constructed to manage flow from both outfalls.
- Coordination with the property manager at Shrafft Center should be conducted to plan for temporary loss of parking during construction.

Replicability and Implementation Timeline



Summary of Similar Concepts

Number of Sites: 18

Vulnerable Area: 422 acres

The map on this sheet depicts other vulnerable outfalls that could be adapted with electric submersible pump stations. In some locations, several outfalls could be consolidated with a new conduit that conveys flow to a single pump station.

Additional detail about these outfalls can be found in the Commission's Coastal Stormwater Discharge Analysis Implementation Timeline.

ATTACHMENT A
CHARLESTOWN PUMP STATION CONCEPTUAL DESIGN DRAWINGS

A-1: CSO and SDO Overview Plans
A-2: CSO Pump Station Plan
A-3: CSO Pump Station Section View
A-4: SDO Pump Station Plan
A-5: SDO Pump Station Section View

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Conceptual Design – Not for Construction

Charlestown Stormwater Pump Station

NOTES

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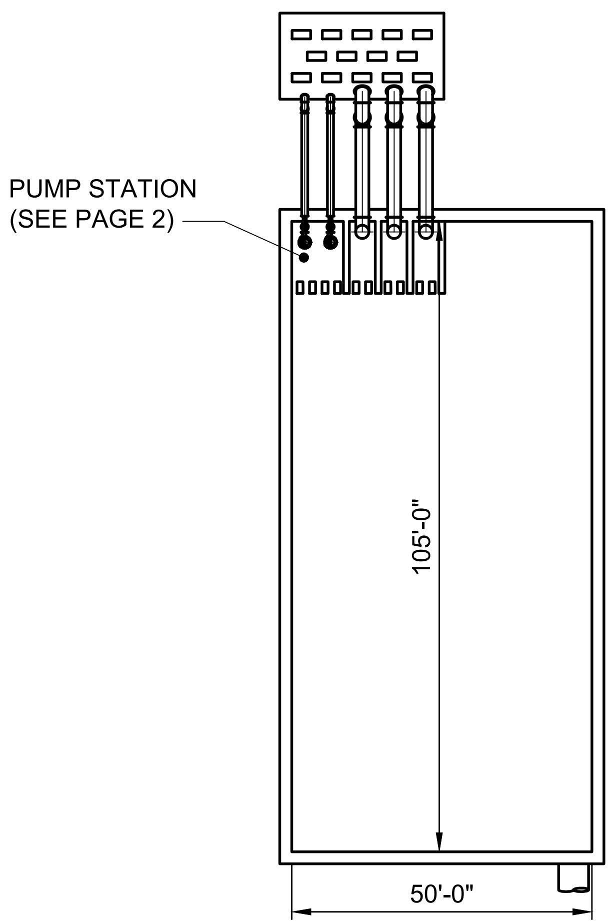
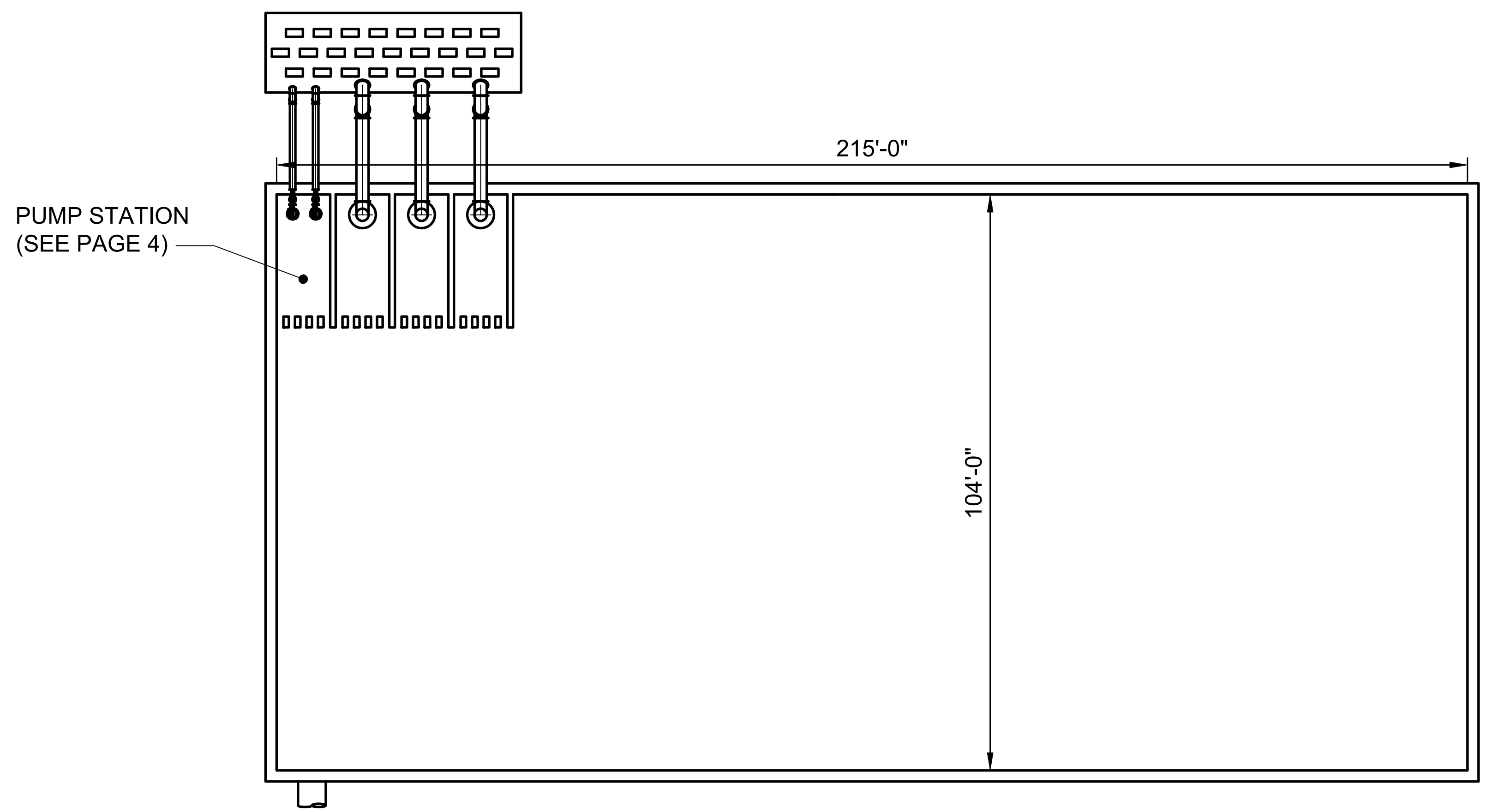
2. ALL ELEVATIONS USE THE NAVD88 VERTICAL DATUM UNLESS OTHERWISE STATED.
3. CONCEPTUAL DRAWING, NOT FOR CONSTRUCTION.



CSO OVERVIEW PLAN
SCALE: NTS



SDO OVERVIEW PLAN
SCALE: NTS

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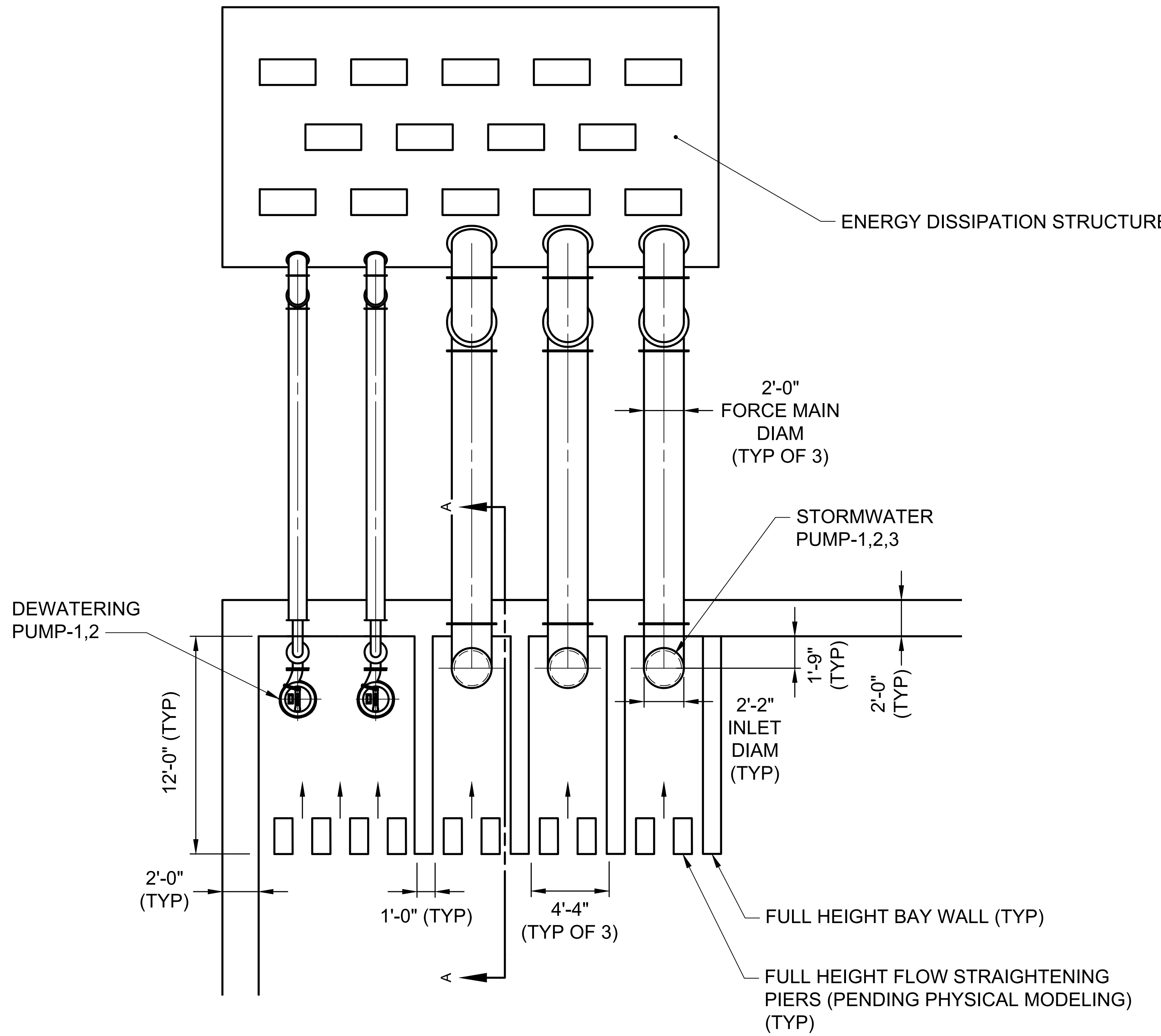
Charlestown Stormwater Pump Station



CSO PUMP STATION PLAN

SCALE: NTS

NOTES

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STORMWATER PUMP-1,2,3 OPERATIONAL PARAMETERS	
FLOW RATE, CFS	20
STATIC HEAD RANGE, FT	12.6 - 17.2
DESIGN FLOOD ELEVATION, FT	15.5

STORMWATER PUMP-1,2,3 OPERATIONAL WSE TABLE

NOTE	OPERATION	ELEVATION, FT
A	HIGH LEVEL ALARM	1.9
B	LAG PUMP ON	1.4
C	LEAD PUMP ON	0.9
D	LEAD PUMP OFF	0.4
E	LOW LOW ALARM	-0.1
G	MIN PUMP SUBMERGENCE	-0.6

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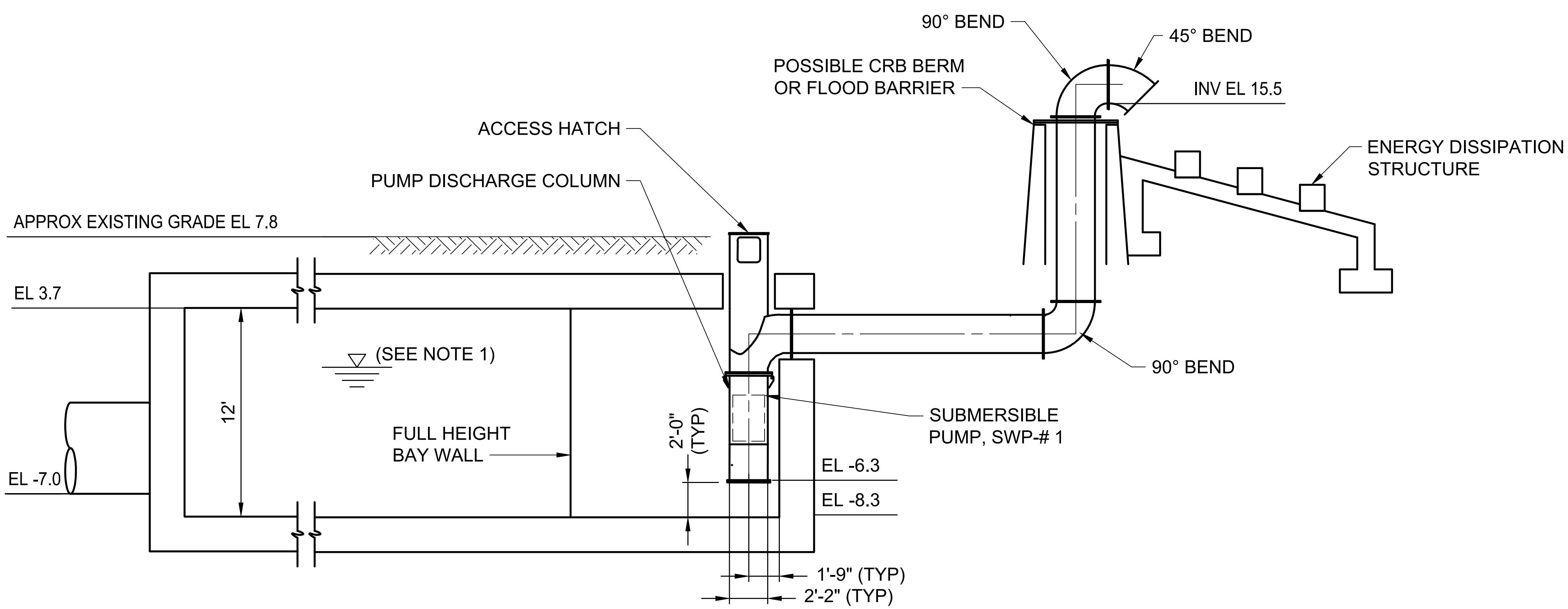
Charlestown Stormwater Pump Station



SECTION A

SCALE: NTS

NOTES

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STORMWATER PUMP-1,2,3 OPERATIONAL PARAMETERS	
FLOW RATE, CFS	20
STATIC HEAD RANGE, FT	12.6 - 17.2
DESIGN FLOOD ELEVATION, FT	15.5

STORMWATER PUMP-1,2,3 OPERATIONAL WSE TABLE

NOTE	OPERATION	ELEVATION, FT
A	HIGH LEVEL ALARM	3.0
B	LAG PUMP ON	2.3
C	LEAD PUMP ON	1.5
D	LEAD PUMP OFF	0.7
E	LOW LOW ALARM	-0.1
G	MIN PUMP SUBMERGENCE	-0.9

COASTAL STORMWATER DISCHARGE ANALYSIS

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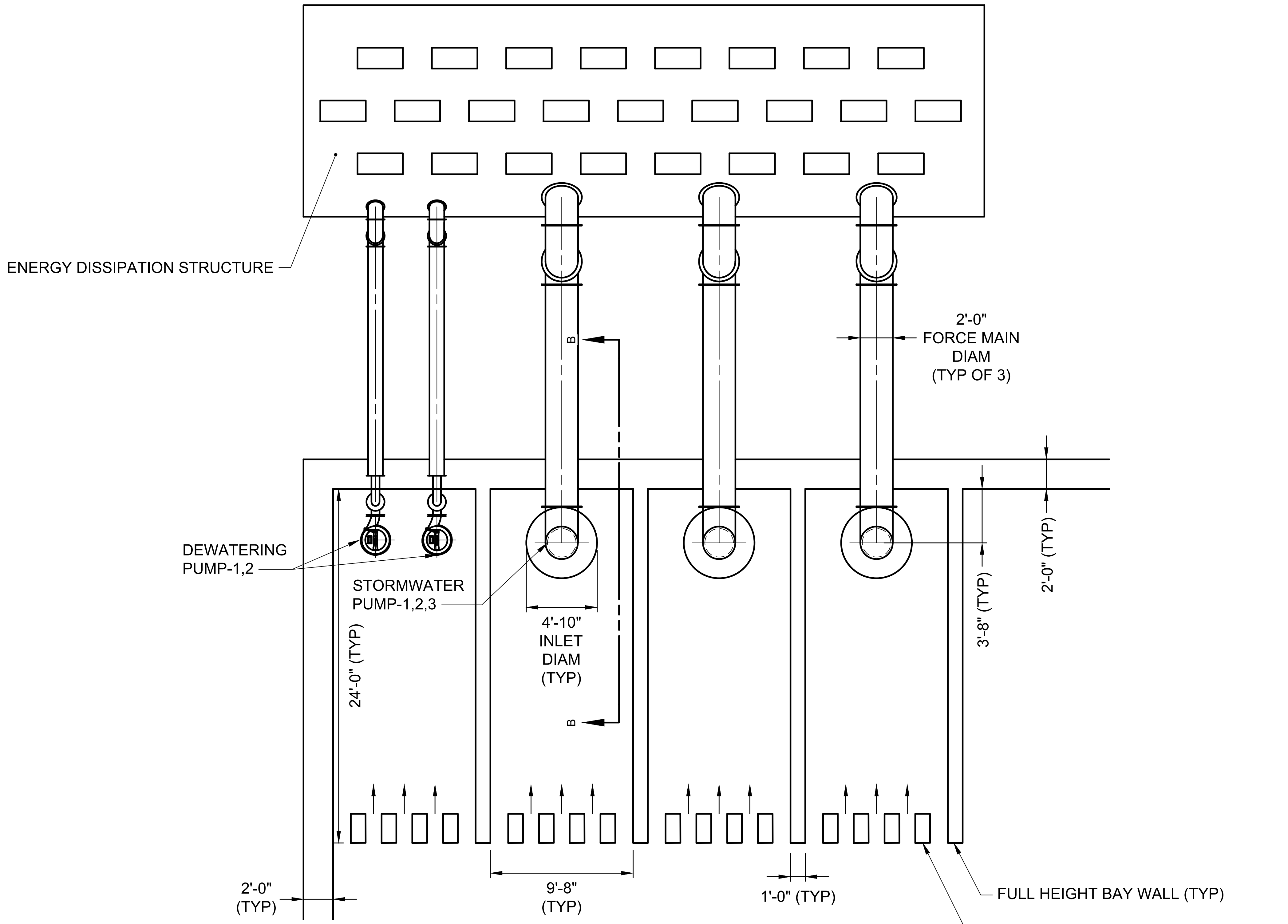
Charlestown Stormwater Pump Station



SDO PUMP STATION PLAN

SCALE: NTS

NOTES

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STORMWATER PUMP-1,2,3 OPERATIONAL PARAMETERS	
FLOW RATE, CFS	100
STATIC HEAD RANGE, FT	12.6 - 17.3
DESIGN FLOOD ELEVATION, FT	15.5

STORMWATER PUMP-1,2,3 OPERATIONAL WSE TABLE

NOTE	OPERATION	ELEVATION, FT
A	HIGH LEVEL ALARM	2.3
B	LAG PUMP ON	1.8
C	LEAD PUMP ON	1.3
D	LEAD PUMP OFF	0.8
E	LOW LOW ALARM	0.3
G	MIN PUMP SUBMERGENCE	-0.7

COASTAL STORMWATER DISCHARGE ANALYSIS

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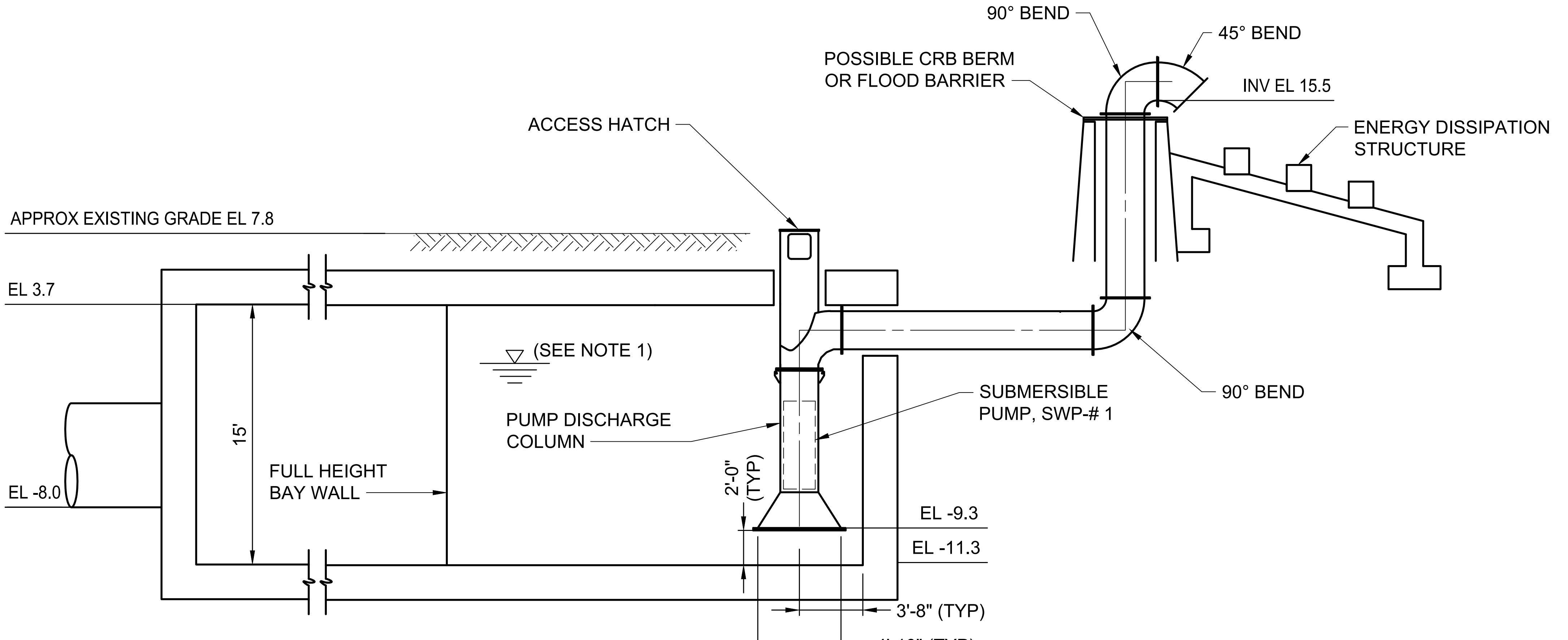
Charlestown Stormwater Pump Station



SECTION B

SCALE: NTS

NOTES

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STORMWATER PUMP-1,2,3 OPERATIONAL PARAMETERS	
FLOW RATE, CFS	100
STATIC HEAD RANGE, FT	12.6 - 17.3
DESIGN FLOOD ELEVATION, FT	15.5

STORMWATER PUMP-1,2,3 OPERATIONAL WSE TABLE

NOTE	OPERATION	ELEVATION, FT
A	HIGH LEVEL ALARM	3.0
B	LAG PUMP ON	2.2
C	LEAD PUMP ON	1.4
D	LEAD PUMP OFF	0.6
E	LOW LOW ALARM	-0.2
G	MIN PUMP SUBMERGENCE	-1.0

COASTAL STORMWATER DISCHARGE ANALYSIS

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