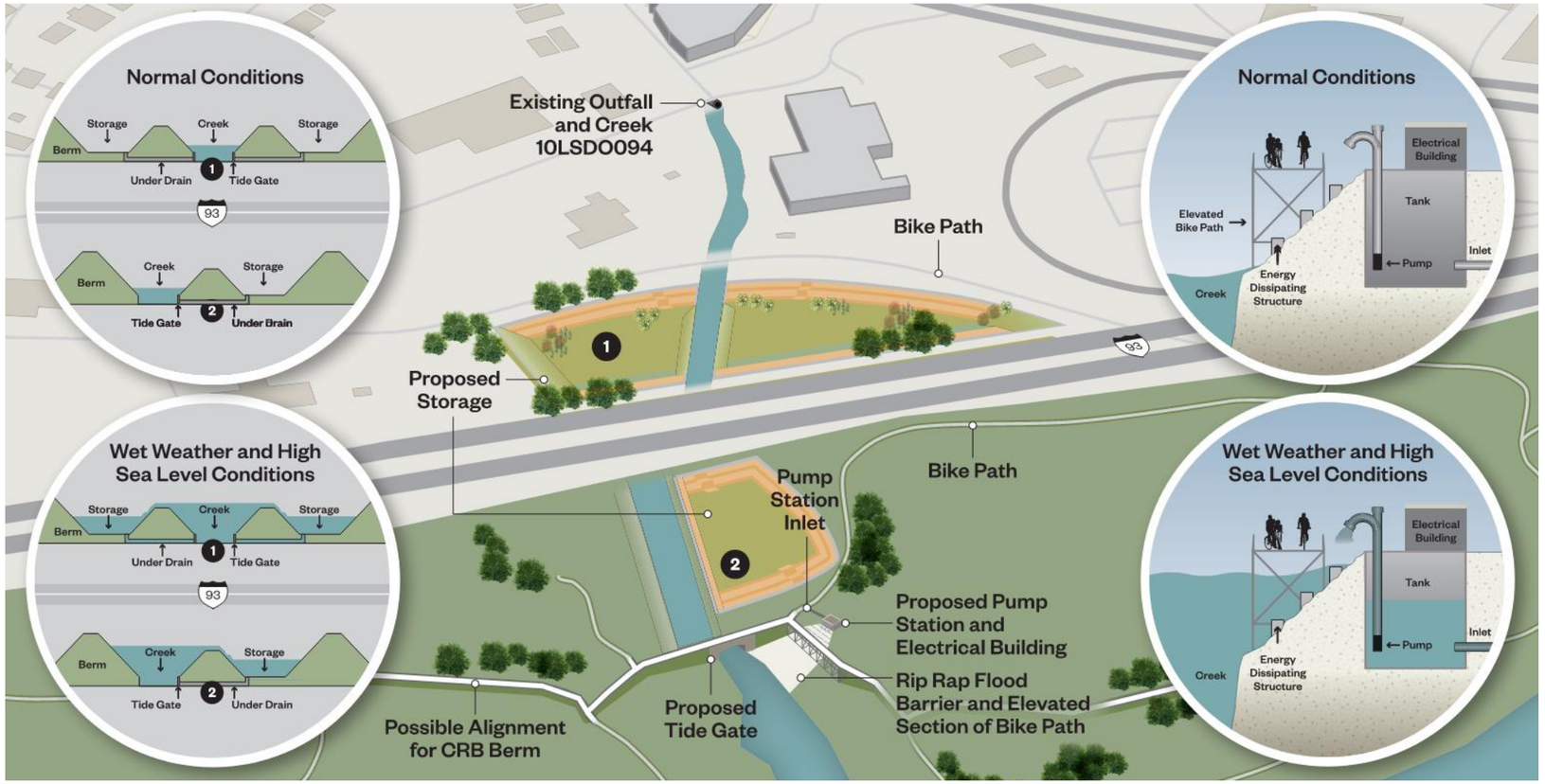
Davenport Creek Stormwater Park *Concept Overview*



Conceptual Solution

The Davenport Creek Stormwater Park includes a "natural" (surface) storage system with a pump station that can be used during larger storm events. This concept is designed to maintain sufficiently low water levels at Outfall 10LSDO094 by isolating the outfall from high tide levels with a tide gate and providing a large storage area for temporary detention of stormwater in an above ground area. During rain events which occur at high tide (triggering closure of a tide gate installed to the west of Interstate 93) stormwater discharged from Outfall 10LSDO094 can overflow proposed berms alongside Davenport Creek into the above ground storage areas. These storage areas would typically remain dry during normal conditions, and feature water tolerant native plant species and public access along the existing Neponset Trail. During larger storm events flow exceeding the capacity of the storage areas can enter a stormwater pump station that discharges into Davenport Creek near its confluence with the Neponset River. Due to the high flood vulnerability of this location, it is essential that berms (or other shoreline protection measures) be constructed around the pump station and storage areas to prevent coastal flooding. In addition to constructing the storage area and pump station, proposed storm water conveyance piping is required to divert higher elevation areas upstream directly to existing outfall 9LSDO095 (see Sheet 4).

Type: Storage and Pumping

Total Drainage Area: 641 acres

Coastal Flood Vulnerable Drainage Area Protected: 244 acres

Concept Elements:

- Above ground "nature based" storage basin
- Improved public amenity/park
- New pipeline for high elevation drainage
- Subsurface pump station and tide gate

Outfalls Included in Concept:

- 10LSDO094

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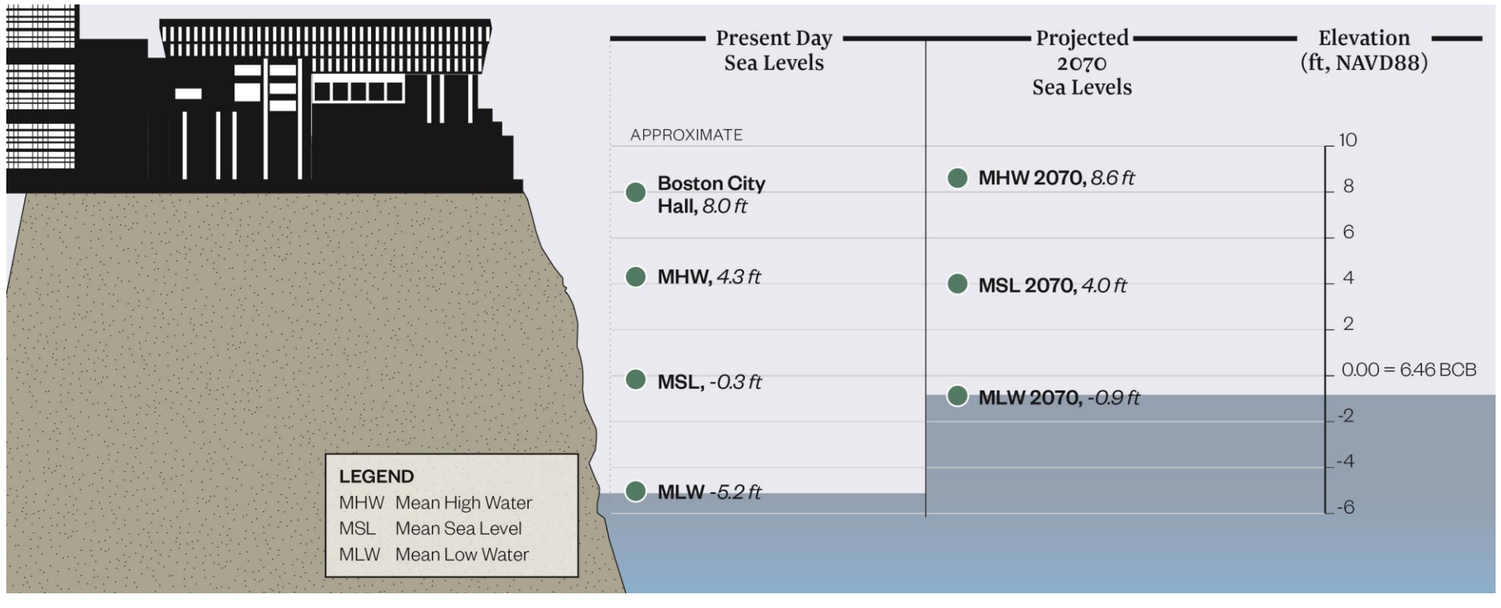
Assumptions

Sea Level Rise and Datum

The Davenport Creek Stormwater Park 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 Davenport Creek Stormwater Park concept was developed to maintain consistency with possible Climate Ready Boston (CRB) adaptations based 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 the Neponset Circle and Adams Village Zone (location of Davenport Creek), where the stated design flood elevation is 14.4 feet, pumps were designed to discharge to a minimum elevation of 14.4 feet.

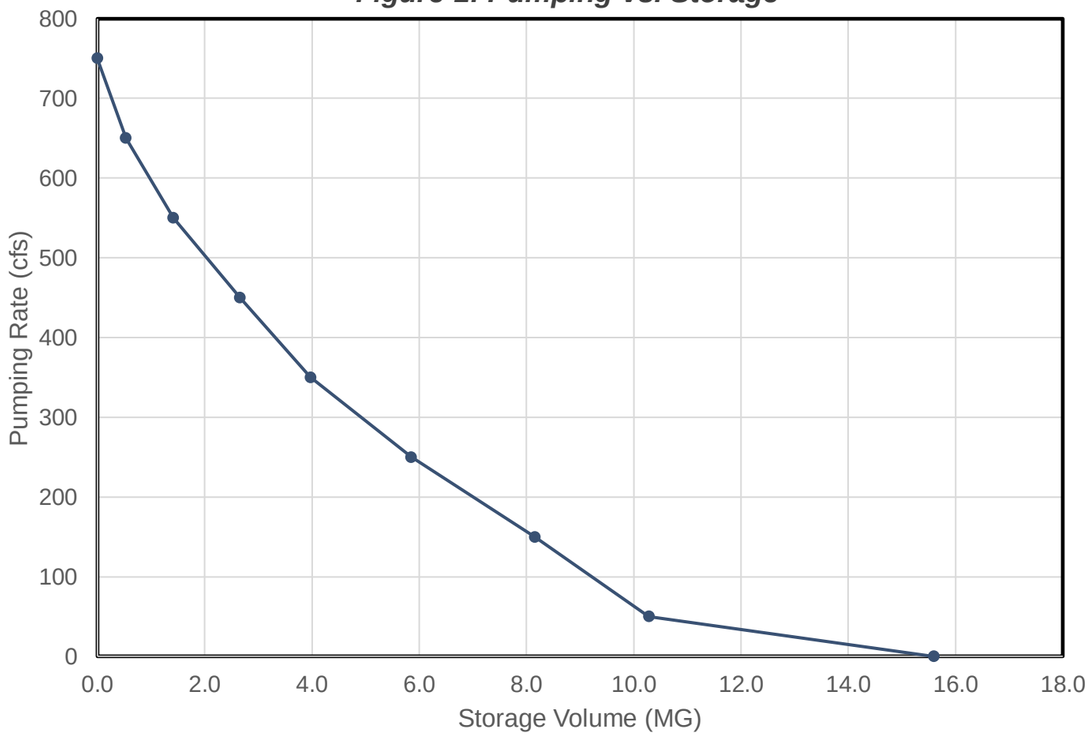
At the time of this project, many CRB concepts were in early planning stages and not fully defined. **In consideration of this, it was assumed the shoreline protection around the City of Boston is 100% effective for all modeling evaluations.** This assumption eliminates overland coastal flooding from 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

Storage and Pumping

Model simulations were conducted to determine the maximum Hydraulic Grade Line (HGL) that occurs at Outfall 10LSDO094 with the current tide cycle. Analyses were then conducted to determine the required volume of storage and rate of pumping required to maintain the existing HGL with 2070 projected sea level rise, as shown in Figure 1. The City of Boston's Parcel database was used to identify publicly owned parcels near the existing outfall. It was assumed that flow from the higher elevation portion of the Davenport Creek tributary area will be diverted as shown on the next page. Based on a maximum acceptable depth of 7.5 feet in the above ground storage areas (depicted on the next page), it was found that the above ground storage areas can detain approximately 6 million gallons, requiring a 250 CFS pump station. The storage tank and pump station occupy an area of 2,465 ft^2. After a wet weather event when the tide level recedes, the storage areas are designed to drain by gravity into Davenport Creek via underdrains. The pump station utilizes three duty pumps, one standby pump, and two dewatering pumps. All pumps are axial electric submersible pumps, arranged in parallel bays. The pump station discharges onto an energy dissipation structure located underneath a raised section of mixed-use path (a “bike bridge”).

Figure 1: 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 Davenport Creek concept was also evaluated with projected rainfall from a 100-year tropical event (developed during the Commission’s Inundation Model Project. The Davenport Creek 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 of water between the Davenport Creek tributary area and Boston Harbor. Table 2 contains a summary of the coastal conditions that were analyzed.

Table 1: Rainfall Conditions

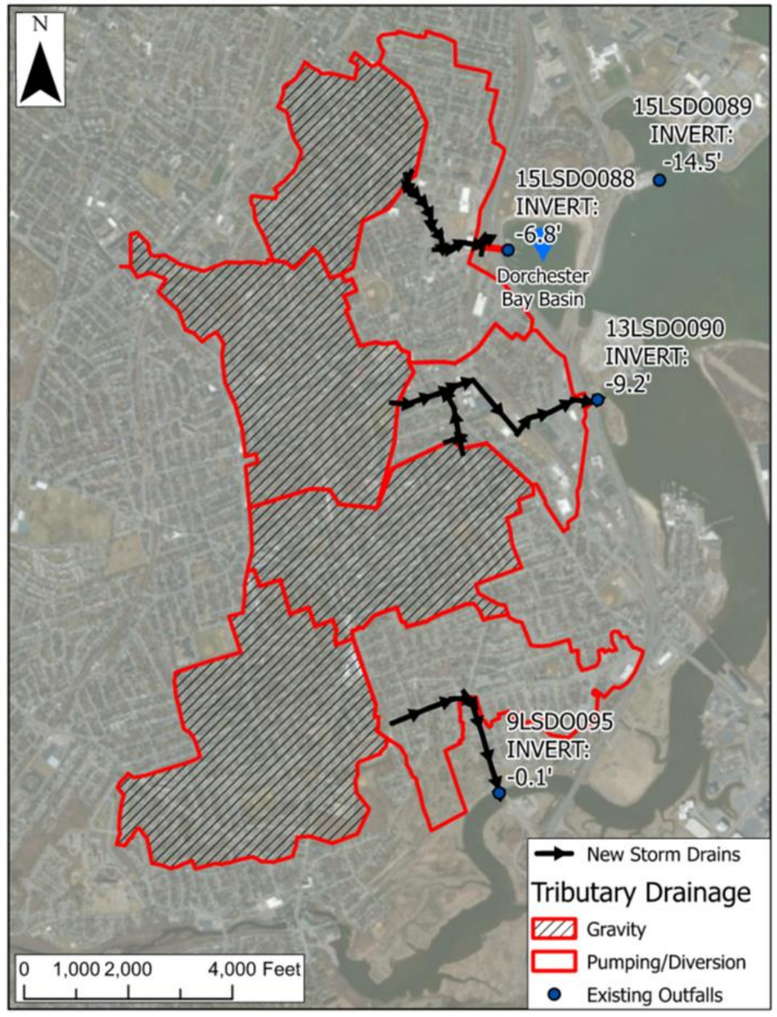
Scenario	Purpose	Rainfall Depth (in)	Peak Intensity (in/hr)
Present Day, 10-year, 24-hr design storm	Baseline Conditions	5.15	3.32
Projected 2070, 10-year, 24-hr design storm	Design Conditions	6.18	4.08
100-year Tropical Storm	Damage Analysis	9.58	0.84

Table 2: Coastal Conditions

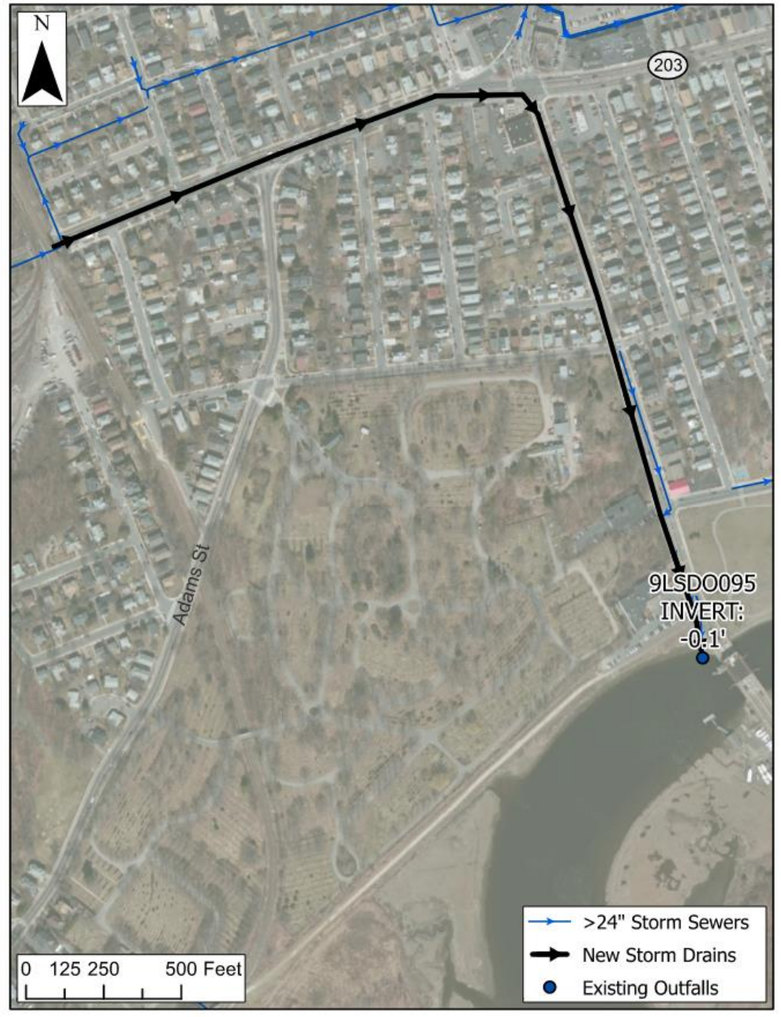
Scenario	Purpose	Peak Water Surface Elevation (ft, NAVD88)	Source
Present Day	Baseline Conditions	3.7	BWSC Existing Model (April 2016 Tide Cycle)
2070,100-year Tropical Storm	Damage Analysis	13.8	MC-FRM

Proposed Storage and Pipelines

6 MG Proposed Storage Areas and Pump Station



New Pipelines for High Elevation Flow Diversion



High Elevation Flow Diversion Pipeline
(in 10LSDO094 Drainage Area)

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Davenport Creek Stormwater Park

High Elevation Diversion Pipeline

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Flood Modeling and Damage Analysis

Figure 2: Estimated Replacement Cost

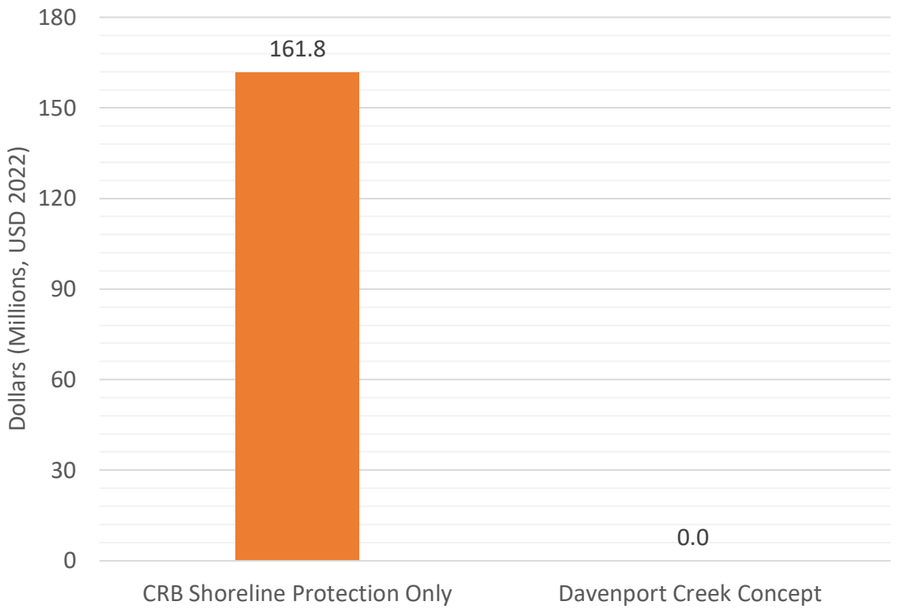


Figure 3: Loss of GDP

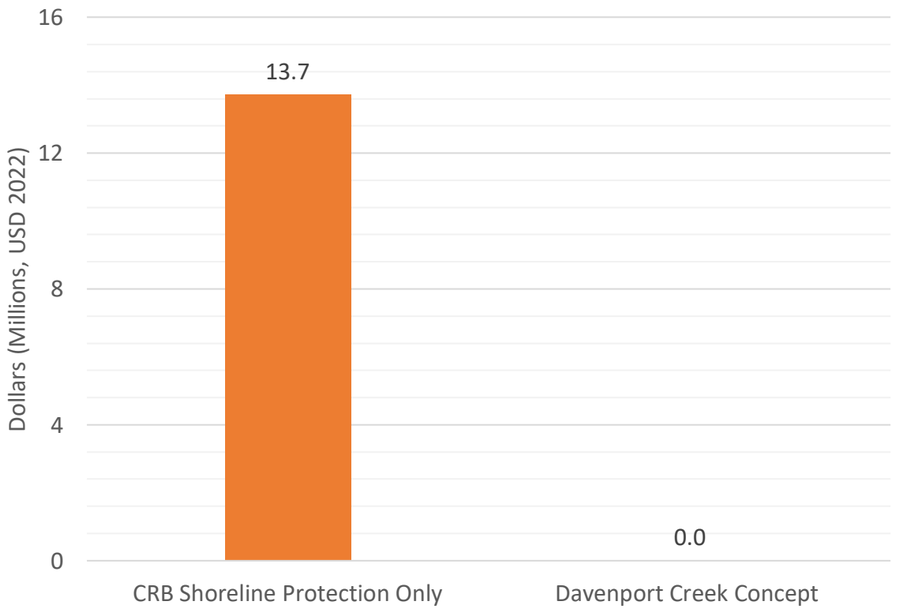
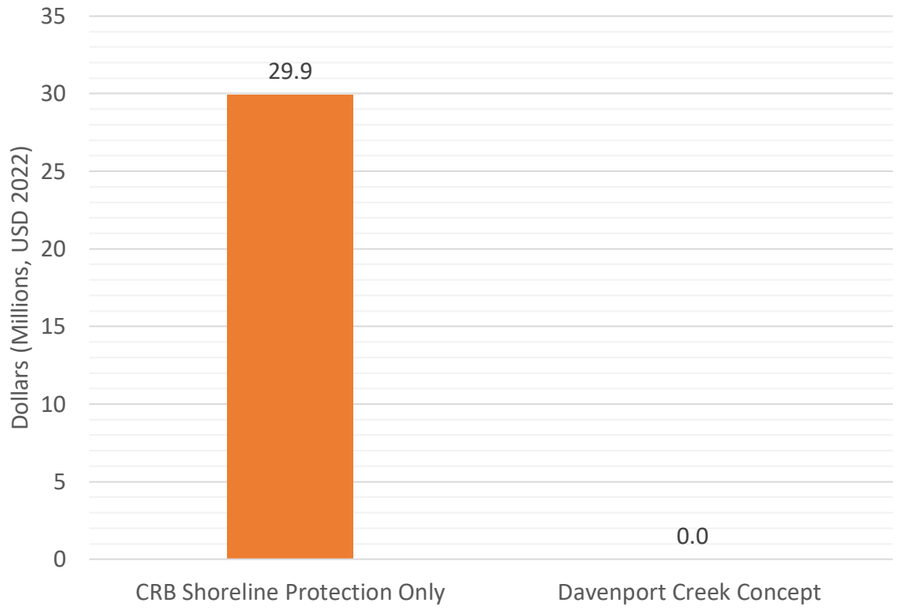


Figure 4: Physical Damage



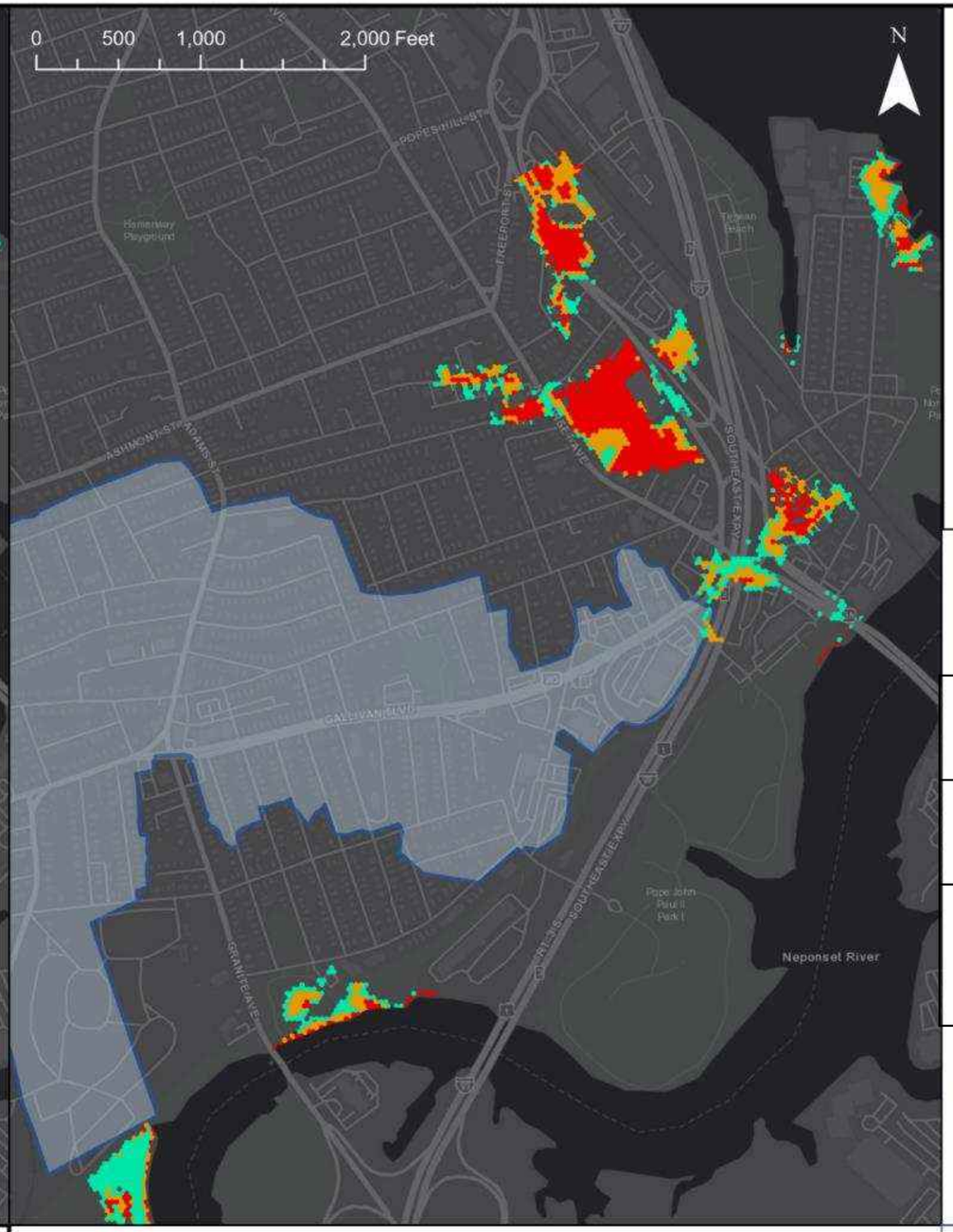
The flood reduction benefits of the Davenport Creek Stormwater Park concept were evaluated using the Commission's 2D Inundation Model by simulating a 100-year tropical storm event with 2070 SLR and storm surge. The figures on the following page depict the peak flooding that was predicted in the drainage area tributary to Davenport Creek with shoreline protection only and with the concept implemented. An analysis of economic losses/physical impacts from flooding under both scenarios was performed by risQ Inc.

*Model predictions indicate that the Davenport Creek concept reduces physical damage by **$29.9 million**, avoids **$161.8 million** in rebuilding costs, and mitigates a GPD loss of **$13.7 million** during a 100-year tropical storm event in 2070.*

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

Davenport Creek Stormwater Park 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

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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Damage Analysis

Capital Cost Estimate

A construction cost estimate for the Davenport Creek Stormwater Park 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. Additionally, for this estimate electrical duct bank allowances were based on their distance to the closest street. The cost of piles below storm drainage runs and structures as well as hookup costs to existing electrical services were not included in this estimate.

Table 3: Davenport Creek Cost Estimate Subtotals

Remaining Design Development & Construction Administration (assumed 20% of total less design contingency)	$9,119,000
Direct Construction Costs	$17,902,197
Indirect Construction Costs	$3,580,439
Mark-Up *(Including 50% design contingency)*	$46,173,364
Total	**$76,775,000**

Social Vulnerability and FEMA BRIC Funding

FEMA BRIC funding prioritizes disadvantaged communities. Table 5 contains a summary of several indicators for the Davenport Creek 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: Davenport Creek Tributary Area Social Vulnerability Indicators

Low Income & Persistent Poverty	
Per Capita Income	$40,556
Below Poverty Line	18%
High Housing Cost Burden	
Stressed Renters (>40% rent-to-income)	41%
Households With Food Insecurity	14%
Racial and Ethnic Segregation	
Asian Population	6%
Black Population	39%
Hispanic Population	15%
White Population	44%
Education and Employment	
Adults Age 25+ Without High School (or equivalent) Degree	12%
Unemployment Rate (Age 16+)	5%

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

“Dry” Planting Palette

A planting palette was developed for the “dry” areas surrounding the stormwater storage zones. After construction, planting of native plant species could provide a public amenity with new green space and environmental benefits associated with native plant species.

Trees

Amelanchier arborea
common serviceberry

Juniperus virginiana
eastern red cedar

Nyssa sylvatica
black gum

Quercus alba
white oak

Shrubs

Rosa carolina
pasture rose

Rhus copallinum
winged sumac

Aronia melanocarpa
black chokeberry

Morella pensylvanica
bayberry

Herbaceous and Grasses

Panicum virgatum
switchgrass

Schizacharium scoparium
little bluestem

Eutrochium purpureum
Joe-Pye-Weed

Solidago sempervirens
seaside goldenrod

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Conceptual Design – Not for Construction

Stormwater Storage Area Planting Palette

A planting palette was developed for stormwater storage areas that are designed to temporarily flood during intense storm events. The selected plant species are tolerant of occasional temporary flooding. After construction, planting of native plant species could provide a public amenity with new green space and environmental benefits associated with native plant species.

Trees

Amelanchier canadensis
Canadian serviceberry

Juniperus virginiana
eastern red cedar

Betula populifolia
gray birch

Celtis occidentalis
hackberry

Shrubs

Spirea tomentosa
steeplebush

Aronia arbutifolia
red chokeberry

Clethra alnifolia
sweet pepperbush

Lindera benzoin
spicebush

Herbaceous and Grasses

Eupatorium album
white throughwart

Schizacharium scoparium
little bluestem

Symphyotrichum novi-belgi
New York aster

Euthamia graminofolia
grass-leaved goldenrod

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Davenport Creek

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Conceptual Design – Not for Construction

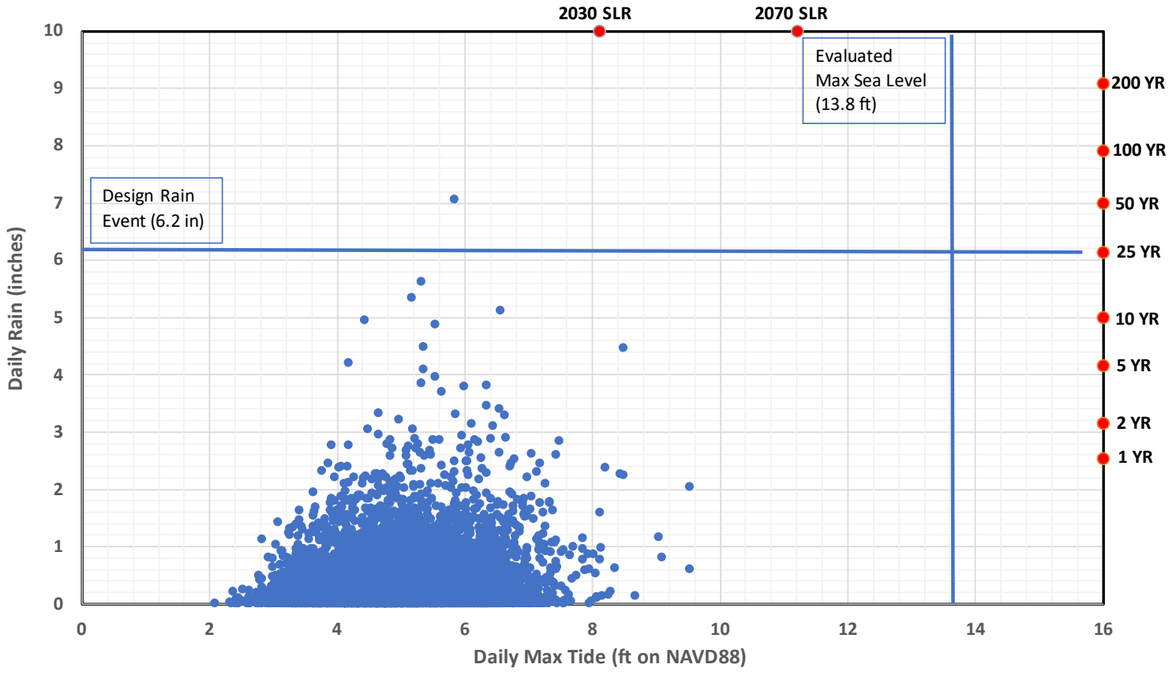
Adaptability and Implementation

Adaptability

Figure 5 below depicts historical daily rainfall totals and tide levels. As shown in this figure, the conditions that were used to design and analyze and design the Davenport Creek Stormwater Park are conservative and represent more extreme conditions than have occurred historically. Considering this, it is expected that the Davenport Creek Stormwater Park will function as a storage only facility (not requiring pumping) during most storm events. Regardless, if additional storage or pumping capacity is required in the future, the following options could be considered:

- The pump station could be expanded to increase pumping capacity if more intense rainfall causes larger than predicted inflows.
- The storage area could be expanded into the adjacent athletic fields in Pope John Paul II Park. If this larger storage area is implemented flow from other adjacent outfalls could be diverted into the storage area.

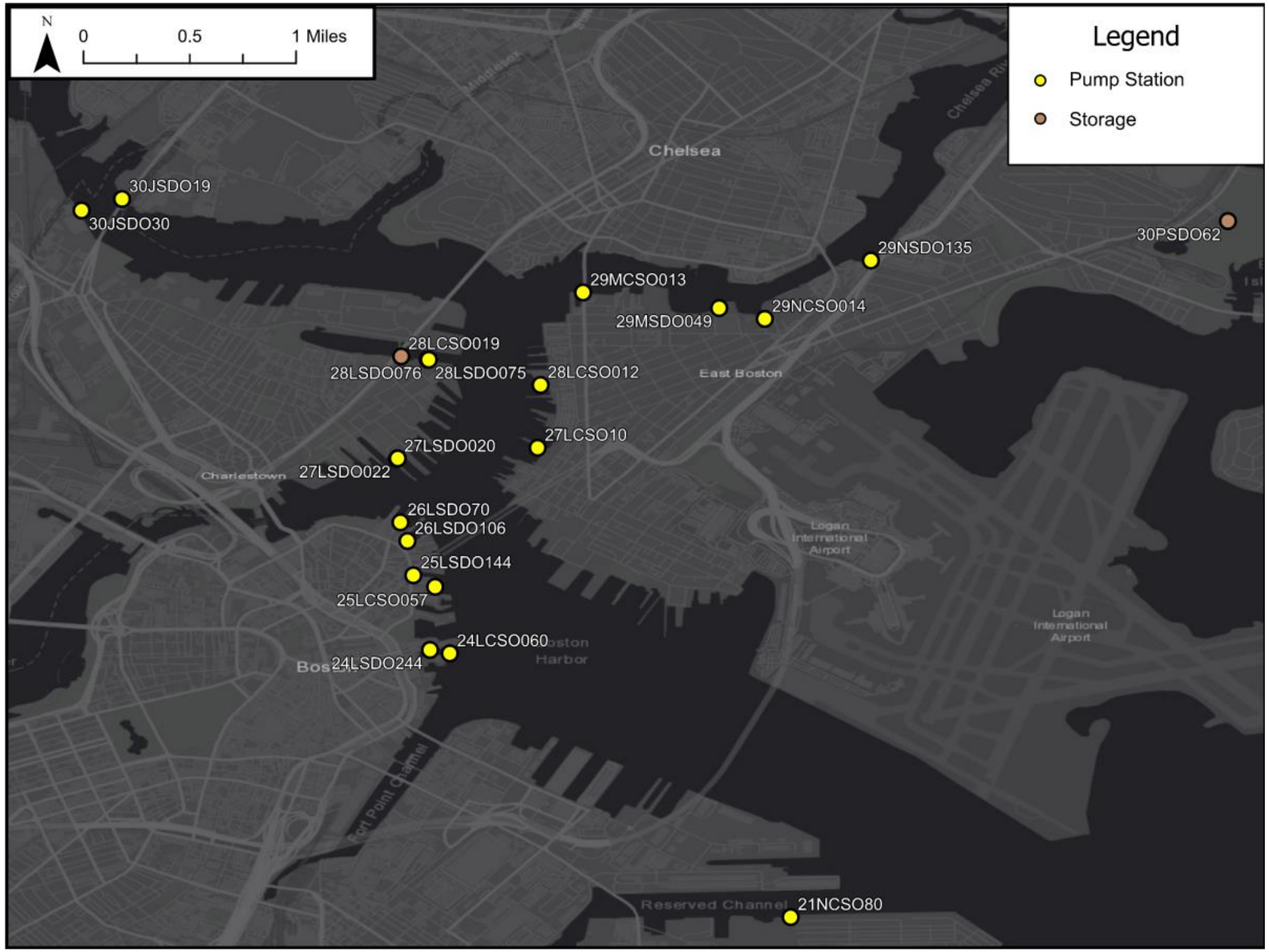
Figure 5: Design and Analysis Conditions vs. Historical Tide and Rainfall



Implementation Considerations

- Coordination with CRB (and other relevant stakeholders) to construct adequate shoreline protection around the Davenport Creek Stormwater Park is essential for successful implementation of this concept.
- The new pipelines that drain higher elevation portions of the tributary areas are designed only to convey flow from areas upstream of their origin. Lower elevation areas with higher flood vulnerability along these pipelines should not be connected to the new pipelines.
- The Neponset River is federally designated superfund site. A survey of hazardous materials, and detailed list of required permits, should be developed before beginning the final design process.
- Before beginning the final design process geotechnical investigations should be conducted to determine the groundwater elevation in the proposed storage areas; high groundwater levels could significantly reduce the usable storage volume.
- Coordination with residents and stakeholders could be conducted to determine preferences for features to be included in the above ground storage areas.

Replicability and Implementation Timeline



Summary of Similar Concepts

Number of Sites: 21

Vulnerable Area: 462 acres

The Davenport Creek Stormwater Park is a unique solution that is not directly replicable in other locations. The design of the pump station could be replicated at other locations in the City. Additional detail about outfalls that could be protected with a similar pump station can be found in the Commission's Coastal Stormwater Discharge Analysis Implementation Timeline.

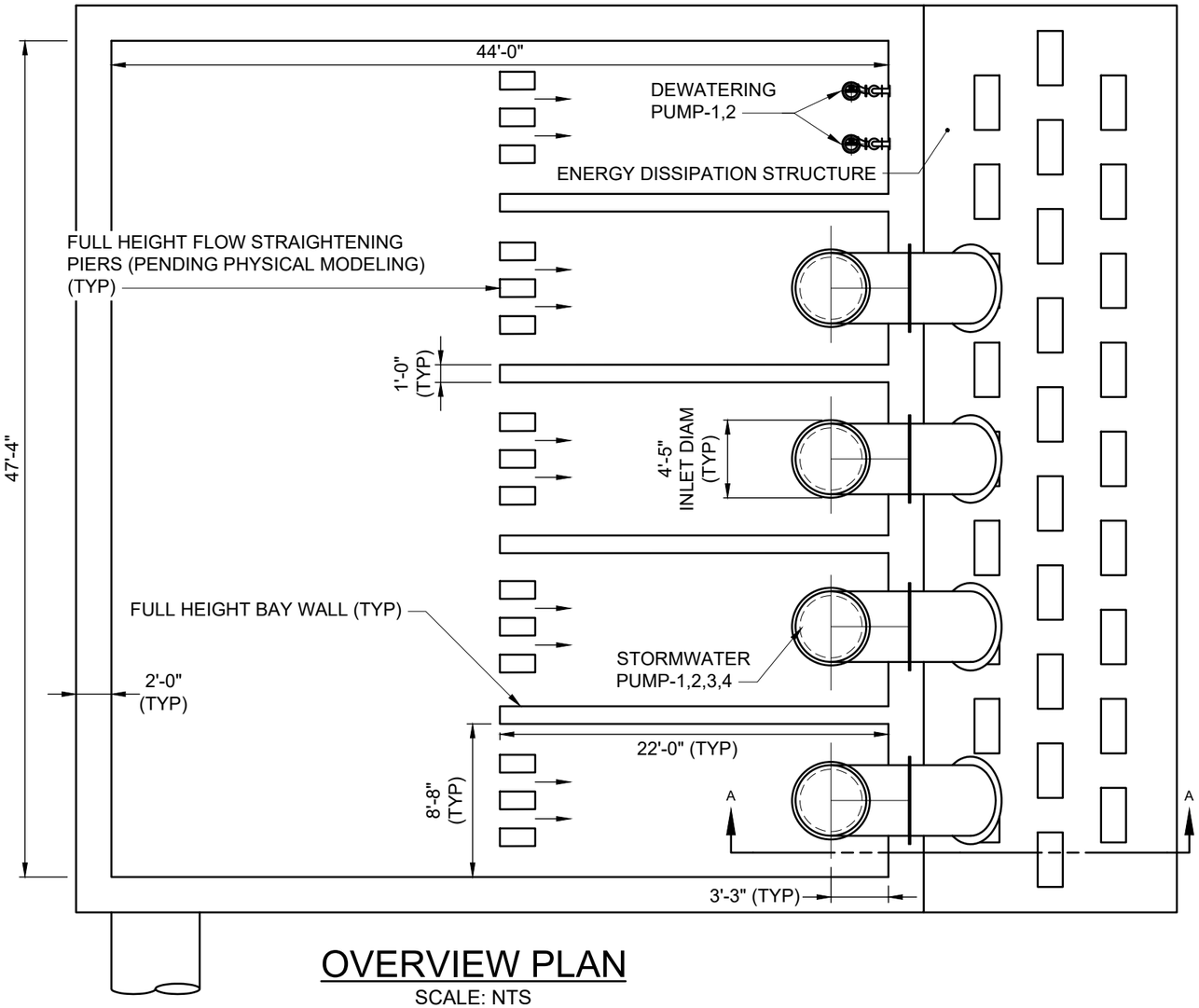
ATTACHMENT A

DAVENPORT CREEK STORMWATER PARK CONCEPTUAL DESIGN DRAWINGS

A-1: Pump Station Overview Plan

A-2: Pump Station Section View

Davenport Creek Stormwater Pump Station



OVERVIEW PLAN

SCALE: NTS

NOTES

1. FOR WATER SURFACE ELEVATIONS REFER TO OPERATIONAL TABLE.
2. ALL ELEVATIONS USE THE NAVD88 VERTICAL DATUM UNLESS OTHERWISE STATED.
3. CONCEPTUAL DRAWING, NOT FOR CONSTRUCTION.

STORMWATER PUMP-1,2,3,4 OPERATIONAL PARAMETERS	
FLOW RATE, CFS	83
STATIC HEAD RANGE, FT	14.7 - 22.7
DESIGN FLOOD ELEVATION, FT	16.5

STORMWATER PUMP-1,2,3,4 OPERATIONAL WSE TABLE

NOTE	OPERATION	ELEVATION, FT
A	HIGH LEVEL ALARM	2.8
B	LAG PUMP ON	0.8
C	LEAD PUMP ON	-1.2
D	LEAD PUMP OFF	-2.2
E	LOW LOW ALARM	-3.2
G	MIN PUMP SUBMERGENCE	-4.2

COASTAL STORMWATER DISCHARGE ANALYSIS

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November 2022

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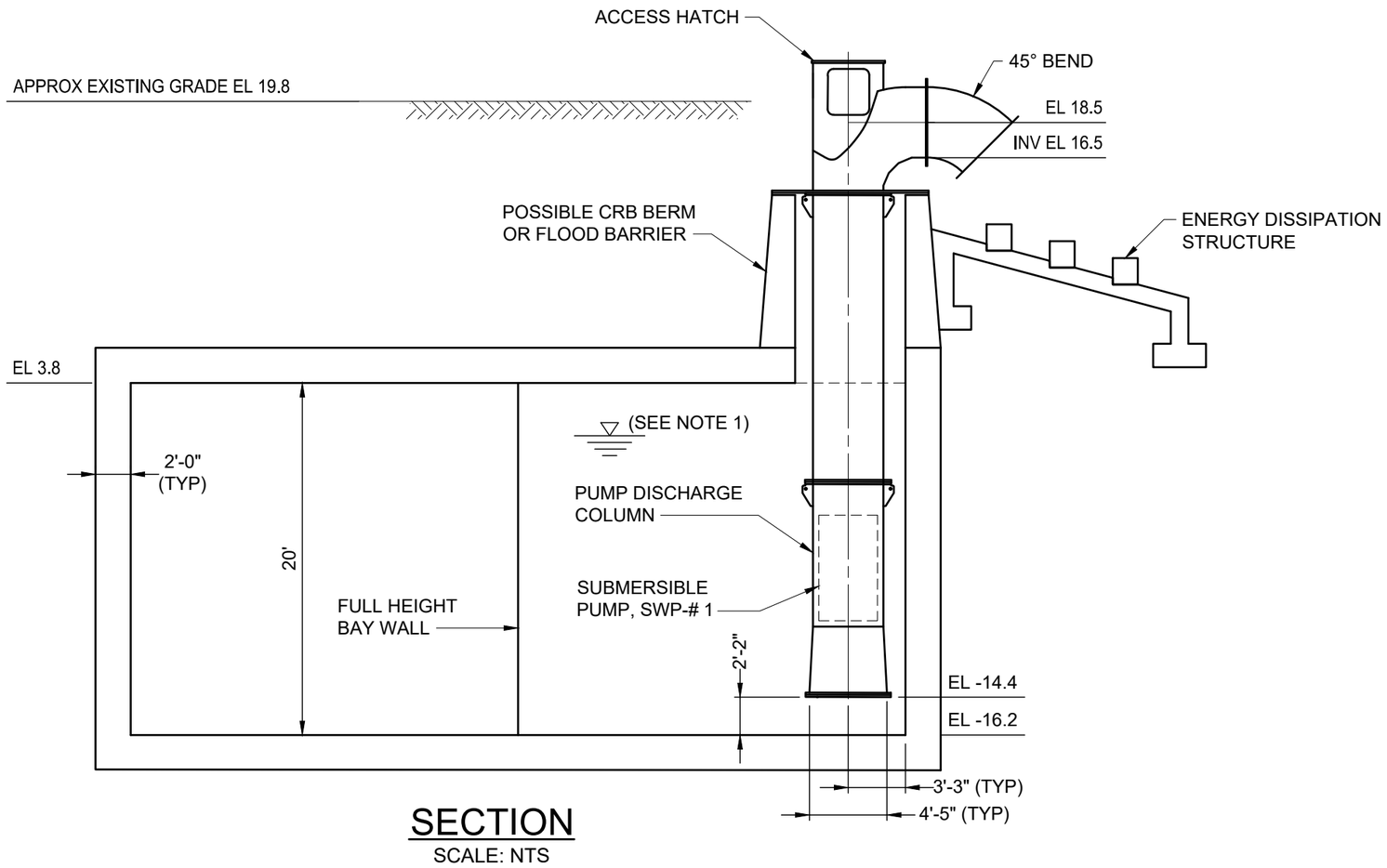
Davenport Creek Stormwater Pump Station



SECTION
SCALE: NTS

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G	MIN PUMP SUBMERGENCE	-4.2

COASTAL STORMWATER DISCHARGE ANALYSIS

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ATTACHMENT B
DAVENPORT CREEK STORMWATER PARK DIVERSION PIPELINE ALIGNMENT DRAWINGS

B-1: Pipe Alignment Drawings

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Davenport Creek Stormwater Park

High Elevation Diversion Pipeline

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B-1

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PROP-PIPE-21

Plan
1"= 30'

0 30 60 120 Feet

PRELIMINARY
DO NOT USE FOR
CONSTRUCTION

ASSUMPTIONS, DEFINITIONS, AND DISCLAIMERS

-EXISTING PIPE ALIGNMENTS AND ELEVATION DATA PROVIDED BY BWSC ON 12/21/2020
-ALL ELEVATIONS THROUGHOUT ARE REFERENCED TO NAVD88 DATUM
-PROPOSED PIPE AND MANHOLE ALIGNMENTS ARE PRELIMINARY AND CONCEPTUAL
-DETAILED SURVEY AND AN EVALUATION FOR SUBSURFACE CONFLICTS SHOULD BE PERFORMED BEFORE ADVANCEMENT OF THESE CONCEPTS

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PROP-PIPE-22

Plan
1"= 30'

0 30 60 120 Feet

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N

PROP-PIPE-32

Plan
1"= 20'

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Coastal Stormwater Discharge Analysis
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N

PROP-PIPE-23

Plan
1"= 10'

0 10 20 40 Feet

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N

Z

PROP-PIPE-24

Plan
1"= 30'

0 30 60 120 Feet

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Coastal Stormwater Discharge Analysis
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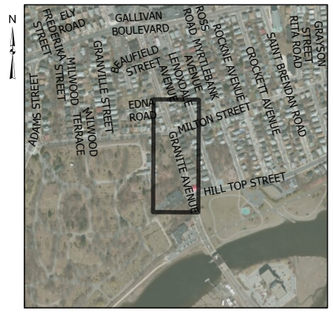

N

PROP-PIPE-25

Plan
1"= 30'

0 30 60 120
Feet

PRELIMINARY
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CONSTRUCTION

ASSUMPTIONS, DEFINITIONS, AND DISCLAIMERS

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Coastal Stormwater Discharge Analysis
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Z

PROP-PIPE-26

0 20 40 80 Feet

Plan
1"= 20'

PRELIMINARY
DO NOT USE FOR
CONSTRUCTION

ASSUMPTIONS, DEFINITIONS, AND DISCLAIMERS

-EXISTING PIPE ALIGNMENTS AND ELEVATION DATA PROVIDED BY BWSC ON 12/21/2020
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Coastal Stormwater Discharge Analysis
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Plan
1"= 20'

PRELIMINARY
DO NOT USE FOR
CONSTRUCTION

ASSUMPTIONS, DEFINITIONS, AND DISCLAIMERS

-EXISTING PIPE ALIGNMENTS AND ELEVATION DATA PROVIDED BY BWSC ON 12/21/2020
-ALL ELEVATIONS THROUGHOUT ARE REFERENCED TO NAVD88 DATUM
-PROPOSED PIPE AND MANHOLE ALIGNMENTS ARE PRELIMINARY AND CONCEPTUAL
-DETAILED SURVEY AND AN EVALUATION FOR SUBSURFACE CONFLICTS SHOULD BE PERFORMED BEFORE ADVANCEMENT OF THESE CONCEPTS

PROP-PIPE-33

Coastal Stormwater Discharge Analysis
Davenport Creek

Boston Water and Sewer Commission

Hazen

B-9

November 2022