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Point of Pines and Riverside Area Coastal Resilience Feasibility Study

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TASK 5 Feasibility of Coastal Resiliency Tools- DRAFT

1. Introduction

The Point of Pines / Riverside Area Coastal Resiliency Feasibility Study was conceived as an integrated coastal protection initiative for the City of Revere. The study consists of stakeholder workshops, five memoranda and one final report aimed to evaluate the flood vulnerability and potential mitigation options for the Study Area. In the Task 3 memorandum, temporary resiliency measures were identified and proposed to protect critical and community assets. The critical assets included the two main residential areas and four buildings shown in Figure 1.1 below. To protect the residential areas, three alignments were presented: Alignment A along Mills Ave and Route 1A on the River Side and Alignments B1 and B2 along Rice Ave on the Ocean Side. Other community assets included the infrastructure along Revere Beach Boulevard as well as six individual buildings in the southern portion of the Study Area; the area including and surrounding Gibson Park in the northern portion of the Study Area; and the Point of Pines Yacht Club in the northern portion of the study area.

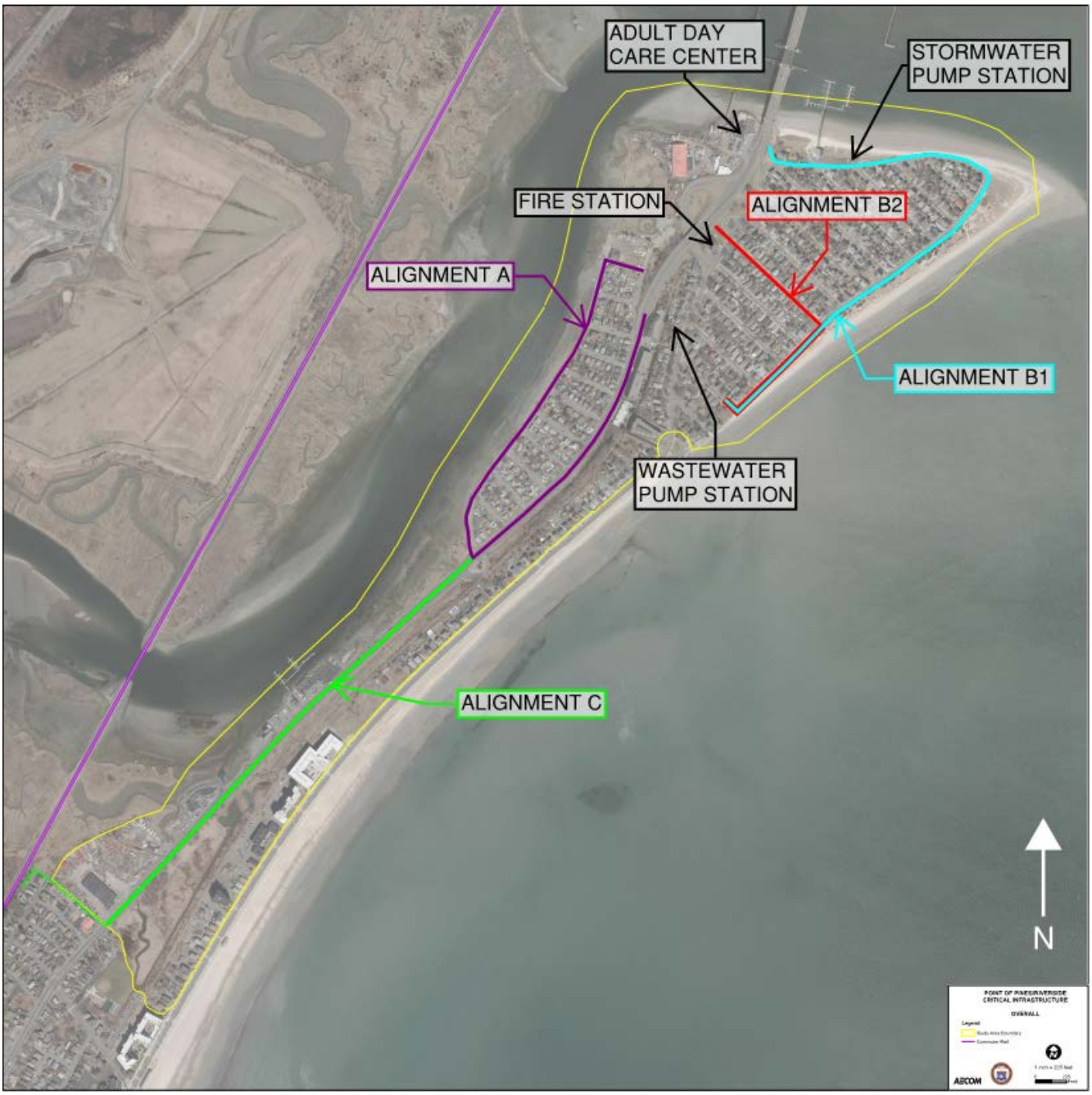

Figure 1-1 – Three Potential Alignments and Critical Infrastructure

In the May 4, 2021 Task 4 memorandum potential permanent structural, nonstructural, and nature-based resiliency tools were identified. This memorandum evaluates the feasibility of the long-term resiliency options identified in the Task 4 memorandum in regard to their ability to protect critical assets and increase resiliency in the Study Area. Parallel with the Coastal Resiliency Feasibility Study, the City of Revere has undertaken a master planning effort for the Riverfront District, which includes the area of Gibson Park, the vacant Riverside Boat Works parcel, the G/J tow/salvage yard, the former Mirage site, portions of Route 1A, the Point of Pines Yacht club, and the former Alden Mills Fire Station. Resiliency recommendations from the Riverfront Master Plan are also identified below.

2. Existing Conditions

The Point of Pines Peninsula is in the northeast section of the City of Revere. To evaluate existing conditions, a LIDAR survey was used to determine the high and low elevation points along the peninsula. For the purpose of this memo, the study was divided into the following sub-areas for purposes of resiliency tool evaluation: Point of Pines; Mills Avenue (Ave); Gibson Park; and southern Route 1A. As described in the Task 2 memorandum regarding climate science and vulnerability, the flooding flow paths to the Mills Ave., Gibson Park and southern Route 1A portions of the study area originate from the Pines River side (River Side) of the project area, whereas the Point of Pines residential area experiences flooding primarily from the Ocean side of the peninsula. The River Side has an average elevation of +7.5 ft and is located adjacent to the Gibson Park area evaluated as part of the Riverfront Master Plan. The Ocean Side is along the eastern edge of the peninsula and varies between +6.5 and +11 ft. Route 1A runs along the middle of the peninsula and is the highest point of elevation reaching +33 ft on the northern end. All elevations are measured with respect to NAVD88.

Figure 2-1 – Google Earth Image of Project Site

3. Vulnerability to Flooding

To establish a feasible design storm for the critical assets that need risk reduction from sea level rise and coastal surge, the FEMA FIRM maps and the Massachusetts Coast Flood Risk Model (MC-FRM) data provided by the Woods Hole Group/Massachusetts Department of Transportation (WHG/MassDOT) were incorporated and compared in Tables 3-1 and 3-2 below. To calculate the 2020 100-year storm design flood elevation (DFE), freeboard was added to the BFE shown on the FEMA FIRM maps. To calculate the 2030 100, 20 and 10-year storm DFEs, freeboard was added to the DFEs provided by WHG/MassDOT, since WHG stated that their MC-FRM DFEs were not inclusive of freeboard. It should be noted that the DFEs provided by the WHG /MassDOT are based on two representative elevations provided from the MC-FRM model, and are not identified for any particular site; final design of any flood risk reduction measures would necessitate additional detailed modelling to determine site specific values.

Freeboard is included in the DFEs of all the design storms listed below in Tables 3-1 and 3-2. Freeboard was identified based flood design guidance in the American Society of Civil Engineers (ASCE) Publication 24-14. This publication identifies Class 3 buildings and structures as those that "*pose a high risk to the public or significant disruption to the community should they be damaged….or fail*", including community centers, care facilities, and water/sewage treatment plants and recommends two feet of freeboard for this class of structure. The ASCE flood design guidance identifies most buildings as Class 2, including most residential, commercial, and industrial facilities, and recommends one foot of freeboard for this class of building. The DFEs for flood design class 2 were used in evaluating protection for residential areas and the DFEs for flood design class 3 were used in evaluating the critical infrastructure buildings. A summary of the DFEs are listed in Table 3-1 and Table 3-2 below, and the applicability of these DFEs to the critical residential areas and buildings are discussed in the sections that follow.

Table 3-1 – DFE for Flood Design Class 2

Design Storm	DFE Ocean Side (ft)	DFE River Side (ft)
FEMA 2020 1% (100-year storm)	12	11
MC-FRM 2030 1%	13.4	11.6
MC-FRM 2030 5% (20-year storm)	12.3	10.7
MC-FRM 2030 10% (10-year storm)	11.7	10.3

Table 3-2 – DFE for Flood Design Class 3

Design Storm	DFE Ocean Side (ft)	DFE River Side (ft)
FEMA 2020 1% (100-year storm)	13	12
MC-FRM 2030 1%	14.4	12.6
MC-FRM 2030 5% (20-year storm)	13.3	11.7
MC-FRM 2030 10% (10-year storm)	12.7	11.3

4. Resiliency Tools

As described in the Task 4 memorandum, there are a variety of tools that can be used to increase resilience. The tools fall into a few main categories and provide a range of protection. For example, some of the tools, such as floodwalls, and deployables, are barrier measures that can provide a high level of protection against flood and surge waters; while others are less able to control rising flood waters on a small scale but they may be able to either withstand and potentially recover from flooding, such as green infrastructure. The 21 tools that will be evaluated for feasibility of implementation in the Study Area are listed below. There is not a "one fits all" solution, and different tools may be more applicable and feasible in certain applications within the Study Area.

Non-Structural Measures

- Evacuation Procedures
- Public Education/Outreach
- Local Building Code
- Land Acquisition

Nature Based Adaption Measures

- Beach/Dune Protection/Restoration
- Wetland Habitat Preservation and Restoration
- Living Shorelines

Stormwater Management Measures

- Pump Stations
- Green Infrastructure
- Flood Storage Area Creation
- Impervious Surface Removal/Reduction
- Bioretention Basins
- Backflow Prevention

Flood Risk Reduction Measures

- Flood Walls
- Deployable Structure
- Coastal Structures (seawall, bulkhead, revetment, breakwater)
- Offshore Structures (tide gates, surge barriers)

Critical Infrastructure Risk Reduction Measures

- Floodproofing Buildings
- Building Relocation
- Building Elevation
- Roadway Elevation

5. Feasibility Criteria

To evaluate the various resiliency tools under consideration, several factors were considered that affect feasibility and value of implementation. Each criterion considered is identified and described below in regard to its salient characteristics that may affect feasibility of implementation. The 21 resiliency tools were screened against the following criteria: protection against future predicted flooding conditions, funding opportunities, ownership, community acceptance, conservation restriction requirements, permitting requirements, and cost.

5.1 Protecting Against Future Sea Level/Surge

The first criterion used to assess the feasibility of the various resiliency tools was the ability to control future flood waters resulting from sea level rise and coastal surge. To determine if it was feasible to protect the critical assets against the DFEs of each design storm, two main factors were considered: the height of intervention (HOI) and the tie in location. The minimum HOI is equal to the difference between the DFE and the ground elevation. For instance, if the DFE is +12 ft and the minimum ground elevation is +7 ft, the HOI is 5 ft. This means the flood risk reduction measure at that location must be at least 5 ft tall. Each barrier measure starts and ends at a high ground tie in location, which is defined as a point where the ground elevation is equal or exceeds the DFE. This prevents flood waters from traveling around the protection measure and inundating the low-lying areas that are being protected by the risk reduction system. If the ground elevation in a tie in area doesn't meet a certain DFE, the measure cannot protect against that design storm.

.Based on this requirement, the following five resiliency tools were identified as potentially achieving protection, pending confirmation that ground elevations are conducive to achieving a tie into a high ground location: floodproof buildings, elevate buildings, flood walls, deployables and dune protection. The remaining 16 measures were unable to meet this requirement but may be beneficial in adding other resiliency benefits.

5.2 Funding Opportunities

Funding opportunities are typically determined by the ownership of the project site as well as the nature of the activity. Most projects located on private land are unavailable for government funding, whereas state of municipal projects may be eligible for a variety of grant programs. The MVP Action Grants typically require that, although feasibility studies may address potential projects on privately held land, grant funding for the construction of a project must be completed on lands held by municipal, state, or federal agencies or government bodies, lands held by non-profit conservation organizations, or lands held privately with consent of private owners. To be eligible for an Action Grant, applications that propose a project on privately owned property must be "*accompanied by a letter signed by the property owner(s) demonstrating their commitment to pursue the project's stated restoration goals and actions"* or evidence must be provided that the property will be sold to an entity that is committed to these goals To be eligible for an MVP Action Grant in particular, the City would need to have legal access to the project area prior to executing the project. Most other state or federal funding opportunities also require that the project occur on publicly owned or accessible land. Table 5-1 identifies grant funding opportunities that may be available for the resiliency tools.

Table 5-1 Funding Opportunities for Resilience Tools

Eligible Resiliency Tools	Funding Opportunities	Requirements	Website
All: Floodproof Buildings, Relocate Buildings, Elevate Buildings, Elevate Roadways, Building Codes, Offshore Structures, Coastal Structures, Pump Stations, Living Shorelines, Deployables, Public Education, Land Acquisition, Green Infrastructure, Impervious Surface Reduction, Flood Storage Areas, Bioretention, Backflow Prevention, Dune Protection/Restoration, Wetland Restoration, Evacuation Procedures	Coastal Zone Management (CZM) Coastal Resilience Grants	Project eligible for the CZM Coastal Resilience Grant must be located within the 78 municipalities located within the Massachusetts coastal zone. Nonprofit organizations that own vulnerable coastal property are also eligible to apply. The purposed project must meet one of the five project categories: detailed vulnerability and risk assessment, proactive planning, redesign and retrofits and shoreline restoration. The project proposal must include coastal hazards management, climate adaptation, needs for assistance, project description, public benefit and interest, transferability, timelines, budget, project management and partners and the overall project quality.	https://www.mass.gov/service-details/coastal-resilience-grant-program
Elevate Buildings, Elevating roadways, Evacuation Procedures, Floodwalls, Land Acquisition, Flood Controls	Massachusetts Emergency Management Agency (NEMA) Hazard Mitigation Assistance Grant Program	Projects covered under this funding source must address one of the following concerns: stormwater, drainage and culvert improvements, flood control, property acquisition, slope stabilization, infrastructure protection, seismic and wind retrofits, structure elevation. Applicants must have a FEMA-approved Local Natural Hazard Mitigation Plan in place prior to applying for funding. Applicants must include a formal Benefit-Cost Analysis (using FEMA-approved BCA V6.0 software) to document the project's cost effectiveness in their application. Community participation in the National Flood Insurance Program (NFIP) may also require for subapplicant and project eligibility.	https://www.commbuys.com/bso/external/bidDetail.sdo?bidId=BD-21-1042-CZM-ENV40-61020&parentUrl=activeBids

Coastal Structures, Wetland Restoration, Living Shorelines, Dune Protection/Restoration, Wetland Restoration, Evacuation Procedures, Public Education	National Fish and Wildlife Foundation (NFWF) National Coastal Resiliency Fund	Applicants that are eligible for NFWF fund are: non-profit 501(c) organizations, state and territorial government agencies, local governments, municipal governments, Tribal governments and organizations, educational institutions, or commercial organizations. Projects that receive funding focus on community capacity building and planning, site assessment and preliminary design, final design and permitting, and, restoration and monitoring. Applicants must submit a project proposal explaining what the project consist of, activities proposed, the outcome of the project, stakeholder's engagement, project team, and photos of the project site.	https://www.nfwf.org/programs/national-coastal-resilience-fund/national-coastal-resilience-fund-2021-request-proposals
Flood Storage Area, Green Infrastructure, Impervious Surface Reduction, Bioretention, Backflow Prevention, Dune Protection/Restoration, Wetland Restoration	Statewide Water Management Act Grant	Eligible entities for this grant consist of MA public water suppliers or municipalities with a valid Water Management Act permit. Qualified topics consist of: planning project for specific watershed or subwatershed that improved ecological conditions or identify water capacity of the water; conservation projects that will reduce the demand for water within a municipal or a watershed; and withdrawal mitigation projects that: improve or increase instream flow, wastewater projects that keep water local, stormwater management projects that improve recharge, reduce impervious cover and/or improve water quality, water supply operational improvements, habitat improvement, demand management, reduction of wastewater inflow and infiltration, and other projects that can be demonstrated to mitigate the impacts of water withdrawals. Applicants must submit a project proposal that has a problem statement with a brief narrative explaining objective and project activities; scope of service; project schedule; proposed project team and project manager; detailed budget; and the following attachments: maps, reports or links to reports, drawings, designs, photographs, resumes of key staff, examples of similar projects, support letters and other supporting material. These attachments are not included in the 6-page limit for the narrative proposal. When supporting documents are lengthy or oversized, applicants can include the information in a zip file with a table of supporting materials, with summary description of the contents. A contact list should also be submitted with the proposal.	https://www.mass.gov/doc/water-management-act-statewide-grants-fy2021-request-for-responses/download

Building Code, Floodproof Buildings, Relocate Buildings, Elevate Building	Federal Emergency Management Agency (FEMA) Building Resilient Infrastructure and Communities (BRIC)	Local governmental, tribal governments, state agencies and tribal agencies are eligible to apply for BRIC. Subapplicants can also apply for funding, subapplicants consist of local governments, including cities, townships, counties, special district governments, state agencies, and Tribal governments. As a requirement, subapplicants must have a FEMA approved Local hazard mitigation plan by the application deadline. Projects that are eligible to obtain funding through this source consist of building code activities, partnerships, project scoping, mitigation, planning and planning related activities. Applications must be submitted electronically through FEMA GO and must include environmental planning and historical preservation (EHP) review; completed EHP checklist, at least one nature-based solution per project; milestone schedule; demonstrate cost-effectiveness; and provide management cost.	https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities/before-apply#eligibility
Green Infrastructure, Pump Stations, Green Infrastructure, Impervious Surface Reduction, Flood Storage Areas, Bioretention, Backflow Prevention	Department of Environmental Protection (DEP) State Revolving Fund Loan (SRF) Clean Water Program	Funding is available to cities, towns, water, and wastewater districts. The loan is a subsides 2% loan that can be used for the construction of publicly owned water supply facilities, water pollution abatement facilities, and implementation of non-point source management projects. Projects that focus on nutrient reduction may be eligible for 0% interest loans. The applicant must already have communities appropriated the necessary local project funds or have committed to a schedule to obtain those funds. Eligible construction project covered under the Clean Water Program of the SRF loan are: Combined Sewer Overflow (CSO); new wastewater treatment facilities and upgrades of existing facilities; infiltration/inflow correction; wastewater collection systems; nonpoint source abatement projects such as landfill capping, community programs that update septic systems (Title 5), brownfield remediation, pollution prevention and stormwater remediation. Nonstructural project that are eligible for the SRF loan are green infrastructure planning projects that aim to correct nonpoint source concerns and identify pollutant sources along with providing remediation strategies, and wastewater nutrients management. To apply for funding, the applicant must submit a Project Evaluation Form which should include project schedule and cost, and a project evaluation including a project narrative.	https://www.mass.gov/state-revolving-fund-srf-loan-program https://www.mass.gov/service-details/srf-clean-water-program
Land Acquisition	Division of Conservation Services Local Acquisitions for Natural Diversity (LAND) Grant	To obtain funding through the LAND grant project must include the acquisition of a forest; fields; wetlands; wildlife habitat; unique natural; cultural; or historic resources; unique natural; cultural; or historic resources; and some farmlands. To apply for funding an appraisal report, cover letter signed by an authorized town or city official giving the project manager permission to apply for the grant on behalf of the town, town meeting or city council, project description, property map, conservation restriction draft, Project reviews from: Massachusetts Natural Heritage and Endangered Species Program and	https://www.mass.gov/service-details/local-acquisitions-for-natural-diversity-land-grant-program

		Massachusetts Historical Commission and proof of land stewardship practice must be submitted.	
	Parkland Acquisitions and Renovations for Communities (PARC) Grant Program	Any town with a population of 35,000 or more year-round residents, or any city regardless of size, that has an authorized park/recreation commission is eligible to participate in the program. Communities that are smaller than 35,000 may still qualify for funding. Projects that are eligible for funding consist of acquisition of parklands, development of new parks and improvements to an existing park. The PARC must include application form signed by an authorized signatory for the applicant organization, municipal open space, and recreation plan (if not already on file with DCS). For acquisition projects, appraisal report(s)are required.	https://www.mass.gov/service-details/parkland-acquisitions-and-renovations-for-communities-parc-grant-program https://www.mass.gov/doc/parkland-acquisitions-and-renovations-for-communities-parc-grant-program-bid-fy-21/download
Offshore Structures, Coastal Structures, Impervious Surface Reduction, Flood Storage Areas, Bioretention, Backflow Prevention, Dune Protection/Restoration, Wetland Restoration, Public Education	EEA Municipal Vulnerability Preparedness Municipal Vulnerability Preparedness (MVP) Action Grant	Funding through the Executive Office of Energy and Environmental Affairs (EEA) MVP Action Grant is available for municipalities that have received designation from the EEA as an MVP Community. Projects that receive funding through this grant must provide monthly updates, project deliverables and a brief project case study that describes lessons learned throughout the project. The municipal is required to match 25% of the total project cost using cash or in-kind contributions. Proposals for this grant must include: a completed online application; project scope and budget; MVP yearly progress report describing any relevant work towards advancing community priorities since earning MVP designation; a statement of match; letter of support from landowners, partners and the public; an attachment describing the design, permitting and construction (if applicable); Draft Town Meeting or City Council vote language for land acquisition projects (if applicable);Climate Resilience Design Standards Tool attachment (Optional). The application should also include 1 of the 9 MVP Programs (core values can be views here: https://www.mass.gov/doc/mvp-core-principles/download).	https://www.mass.gov/service-details/mvp-action-grant

Coastal Structures, Deployables, Dune Protection/Restoration	EEA Dams and Seawall Repair or Removal Program Grants	Municipalities and nonprofit organizations are eligible to apply for funding. Eligible projects consist of repairing or the removal of dams, leaves, seawalls, and coastal structures. The program provided funding for the completion of designs and permit applications that repair or remove dams, seawalls and other coastal infrastructure, and levees. The program also supports the construction of dam repairs or removals along with construction of seawalls and other coastal infrastructure, and levees. Applicant are eligible to apply for a loan through the program that also support the construction phase of repair or removal of dams, seawalls and other coastal infrastructure, and levees.	https://www.mass.gov/service-details/dam-and-seawall-repair-or-removal-program-grants-and-funds
Public Education	MassDEP 319 Grants	Funding is available to any public or private Massachusetts organization. Eligible projects: implementation of measures that address the prevention, control, and abatement of NPS pollution; target the major source(s) of nonpoint source pollution within a watershed/subwatershed; contain an appropriate method for evaluating the project results; and must address activities that are identified in the Massachusetts NPS Management Plan. The application must be submitted by email and must include: a proposal with administrative summary, project description, scope of services, project budget, and project milestone schedule; the following three forms signed electronically: Contractor Authorized Signatory Listing Form; An Equal Opportunity/Affirmative Action Policy Statement; and the required Disadvantaged Business Enterprise Documentation and Forms.	https://www.mass.gov/doc/ffy-2022-s-319-nonpoint-source-pollution-competitive-grant-program-request-for-responses-0/download

5.3 Ownership

Ownership refers to who owns the property where the proposed measure will be located. Ownership will be classified as either public land or private land. As described in the above funding opportunities section, the opportunity to receive project funding is directly related to the project's location. Typically, it is a challenge for most municipalities to conduct a project on privately-held land and this arrangement requires additional effort to coordinate and manage, and would require written agreements of responsibilities and understanding of various commitments related to the project on private property in order to facilitate a successful project .

5.4 Community Acceptance

Community acceptance is an important factor in the success of a project. This criterion is subjective and evaluates whether the implementation of the proposed measure would have a negative or positive effect on the current area's aesthetics and whether it would conflict with the existing uses of the area. The community acceptance of the mitigation measures was rated as favorable or unfavorable.

5.5 Conservation Restriction Requirements

Massachusetts Executive Office of Energy and Environmental Affairs (EEA) MVP Action Grants are only issued to projects that include a conservation restriction or other mechanism that assures the "continued presence and effectiveness of such Projects". If MVP Action Grant funds are used for land acquisition, the City would need to be the fee simple owner of the property or obtain a conservation restriction for the property. Thus, the need for a conservation restriction would apply to projects on privately owned property or property acquisition of parcels that will not be owned by the City.

5.6 Permitting Requirements

The potential resilience tools would involve permit complexity ranging from low to high based on the amount and location of ground disturbance, if any. Planning and procedural tools, such as evacuation procedures, public education, relocation of structures outside of the Study Area, and land acquisition, might not require permits or approvals from any environmental resource agencies such as the Conservation Commission, MassDEP or the MA Division of Fisheries and Wildlife (MassDFW). The vast majority of the Study Area includes a resource area which, when work is proposed within it, would trigger the need for approval under the Massachusetts Wetlands Protection Act (WPA), at a minimum.

Almost all of the Study Area is mapped as FEMA 100-year floodplain, which is regulated as Bordering Land Subject to Flooding (BLSF) or Land Subject to Coastal Storm Flowage (LSCSF) under the Massachusetts Wetlands Protection Act (WPA) and triggers the need to file a Request for Determination of Applicability (RDA) or Notice of Intent (NOI) with the Conservation Commission and MassDEP. Any work that involves fill in BLSF requires creation of an equal volume of compensatory flood storage volume and an elevation above the existing 100-year floodplain. Thus, construction of a new above-ground structure, such as a pump station or elevated road, would require the construction of a compensatory flood storage area, which may be challenging given that most of the project area is already mapped as FEMA 100-year floodplain. It may be possible to locate some tools below grade and/or there may be existing fill above ground level that could be removed to provide compensatory flood storage area to off-set any BLSF fill. Work in BLSF or LSCSF for tools that do not involve floodplain fill, such as floodproofing or elevating buildings, temporary deployment of flood barriers, backflow prevention and impervious surface reduction, would have low level of permitting complexity even though some coordination with the Conservation Commission would likely be necessary.

The Point of Pines Beach area is mapped as estimated and priority habitat by MassDFW between the Route 1A Bridge and continuing east and south along the coast. Most work on the beach, except for limited activities that don't involve effects on land contours or vegetation, would trigger the need for a Massachusetts Endangered Species Act (MESA) Permit. Greater than two acres of disturbance of designated priority habitat, as defined in 321 CMR 10.02, that results in a take of a state-listed endangered or threatened species or species of special

concern triggers the need for submittal of an ENF and subsequent MEPA review. The Pont of Pines beach also includes wetland resource areas regulated under the MA WPA, including Coastal Bank, Coastal Dune, and Coastal Beach, and Barrier Beach. Any alteration of these resource areas triggers the need to file an Environmental Notification Form (ENF) with the Massachusetts Environmental Policy Act (MEPA) office for review, public/agency comments, and identification of whether or not an Environmental Impact Report (EIR) must be prepared for further MEPA and agency review.

Much of the perimeter of the Study Area and portions of the interior are regulated under Chapter 91 as filled or flowing tideland. Installation of permanent structures in Chapter 91 jurisdictional area requires either obtaining a Chapter 91 License or amending a previously issued License if one exists. Tools that would be located in Chapter 91 jurisdictional area were deemed to have a moderate degree of permitting complexity.

The Rumney Marsh Area of Environmental Concern (ACEC) is a 2,800-acre estuary located northwest of the Study Area. The ACEC includes salt marsh, tidal flats, and shallow subtidal channels and provides important habitat for a wide variety of birds and other wildlife. The boundary of the Rumney Marsh ACEC extends onto portions of the Riverside District, including Gibson Park, the Riverside Boat Works parcel to the south, and the G/J Towing parcel to the north. Any work within an ACEC triggers the need to file an ENF for review and comment under the Massachusetts Environmental Policy Act. Given the opportunity for multiple state agencies and the public to review and provide input to any work in an ACEC, any tools that would be implemented at Gibson Park or the adjacent parcels within the ACEC were deemed to have a moderate degree of permitting complexity.

5.7 Relative Cost

The final criterion used to screen the measures was the total financial cost associated with implementing and operating each measure. For the initial evaluation of each tool, the cost was represented as $, $$, $$$ or ‘varies’. For some measures, such as floodproof buildings or deployables, the cost can be highly variable depending on the combination of mitigation measure(s) implemented or level of desired protection. Measures with a high associated cost are measures that require extensive infrastructure improvements such as elevate roadways, coastal structures, offshore structures, floodwalls, pump stations, and land acquisition.

6. Feasibility Assessment Results

Table 6.1 provides a multi-criteria decision matrix that summarizes the results of the criteria evaluation for all 21 resiliency tools and provides a conclusion regarding relative feasibility for implementation. Many of the criteria were relatively straightforward to evaluate against the resiliency tools. The evaluation of the criterion regarding protection against future sea level rise/coastal surge required more detailed evaluation of the ground surface elevations as compared to the DFEs described above in Section 3.0 to evaluate feasibility of implementation. The text below summarizes salient points considered in the feasibility evaluation.

6.1 Flood Barriers (Flood Walls, Coastal Structures, and Deployables)

Flood barriers are important for protecting residential areas and other critical assets in the Study Area that cannot be relocated and cannot withstand frequent flooding. These tools tend to be relatively costly, and community acceptance in some locations may be low if the flood barriers block recreational access, obstruct views, or divide neighborhoods. Consequently, these tools are considered feasible for protecting critical assets such as residential neighborhoods or other Class 3 buildings necessary for maintaining important community functions. Floodwalls are anticipated to involve a moderate level of permitting, depending on their location and size. Any of these within the study area would likely involve work within BLSF, although given that their purpose is to reduce flooding these may not require compensatory flood storage creation. However, demonstration of flood benefits and lack of adverse flooding effects on adjacent areas may be required depending on location.

As described in the Task 2 memorandum, there are three primary residential areas in the Study Area: the Point of Pines neighborhood, the Mills Avenue neighborhood, and residences in the area southeast of Route 1A.

Table 6-1 Permanent Risk Reduction Measures Decision Feasibility Matrix

	Control of Future Predicted Floodwater	Funding Opportunities	Ownership	Community Acceptance	Conservation Restriction Requirements	Permitting Complexity	Cost	Summary
Floodproof Buildings	High	Multiple	City or Private	High	Not Applicable	Low	$-$$	Feasible at low cost/low permitting
Relocate Buildings	Medium	Multiple	City or Private	Low	Not Applicable	Low	$$	Not feasible for individual residences; may be applicable to individual critical buildings
Elevate Buildings	Medium	Multiple	City or Private	Medium	Not Applicable	Moderate	$$	Not feasible for individual residences; may be applicable to individual critical buildings
Elevate Roadways	High	Multiple	City or MassDOT	Low	Not Applicable	Moderate	$$$	Not feasible due to permitting and logistical constraints
Flood Walls	High	Multiple	City or Private	Medium	Not Needed	Moderate/ Depends on Location	$	Feasible to protect large areas/ individual buildings
Deployables	High	Multiple	City	High	Not Needed	Low	$$$	Feasible to protect large areas/ individual buildings
Coastal Structures	High	Multiple	City or Private	High	Not Needed	High	$$	Costly, difficult to permit
Offshore Structures	High	Multiple	City, State, and/or Federal	Medium	Not Applicable	High	$$$$	Extremely costly and permitting very challenging; larger perspective required
Pump Stations	High	Multiple	City	High	Not Applicable	Moderate	$$$	May be beneficial as ancillary measures;

								interior drainage analysis required
Green Infrastructure	Low	Multiple	City or Private	High	Not Needed	Moderate/ Depends on Location	$$	Most feasible location is in Riverside District
Flood Storage Area	Medium	Multiple	City	Medium	Not Needed	Moderate	$$	Most feasible location is in Riverside District
Impervious Surface Reduction	Low	Multiple	City or Private	Medium	Not Applicable	Low	$$	Most feasible location is in Riverside District
Bioretention Basin	Medium	Multiple	City	High	Not Needed	Moderate	$$	Likely infeasible due to high groundwater
Backflow Prevention	Medium	Multiple	City or MassDOT	High	Not Applicable	Low	$$	Should be implemented where not existing
Dune Protection/ Restoration	High	Limited Funding Opportunity due to current private ownership	Private	High	Based on guidance from the MVP program, a conservation restriction is needed for work on private property if grant funds desired	High	$	Implementation will be challenging due to high cost, current private ownership, and complex permitting
Wetland Restoration	Low	Multiple	City	High	May be applicable for work on private property	Moderate	$	Limited opportunities, although potential sits in Riverside District
Living Shorelines	Low	Multiple	City	High	Not Needed	High	$	Limited opportunities, although potential sits in Riverside District

Evacuation Procedures	Low	Multiple	City	High	Not Applicable	Not Applicable	$	Recommendations included in Task 3 Memorandum
Public Education	Low	Multiple	City	High	Not Applicable	Not Applicable	$	Continued implementation beneficial, but will not protect from future inundation
Building Code	Low	Multiple	City	High	Not Applicable	Not Applicable	$	Building Codes adhere to International Standards and implementation should continue
Land Acquisition	Low	Multiple	City	Medium	Might be applicable	Not Applicable	$$$	May be desirable for repetitive loss properties

There are also four critical buildings in the Study Area. Section 6.2 discusses the flood barrier options for the three residential areas, and Section 6.3 discusses the feasibility of flood barriers for the critical building assets.

6.1.1 Residential Areas

6.1.1.1 Alignment A

Alignment A is intended to protect the River Side of the peninsula south of Gibson Park. The northern tie in for this alignment, shown in Figure 6-1, is proposed between Hayes Avenue and the western edge of Route 1A. The existing elevations increase quickly here from +9 to +30, which makes this tie in location feasible for any of the proposed design storms.

Figure 6-6-1 - Alignment A Northern Tie-In

The southern tie in for Alignment A, shown in Figure 6-2 below, is proposed between River and John Ave at the median of Route 1A. The existing elevations increase quickly here from +6 to +20, which makes this tie in location feasible for any of the proposed design storms.

Figure 6-6-2 - Alignment A Southern Tie-In

The HOI along Alignment A is shown in in the profile in Figure 6-3 below. For this study, the tie in locations were both stopped at +13 since this elevation encompasses all the proposed design storms.

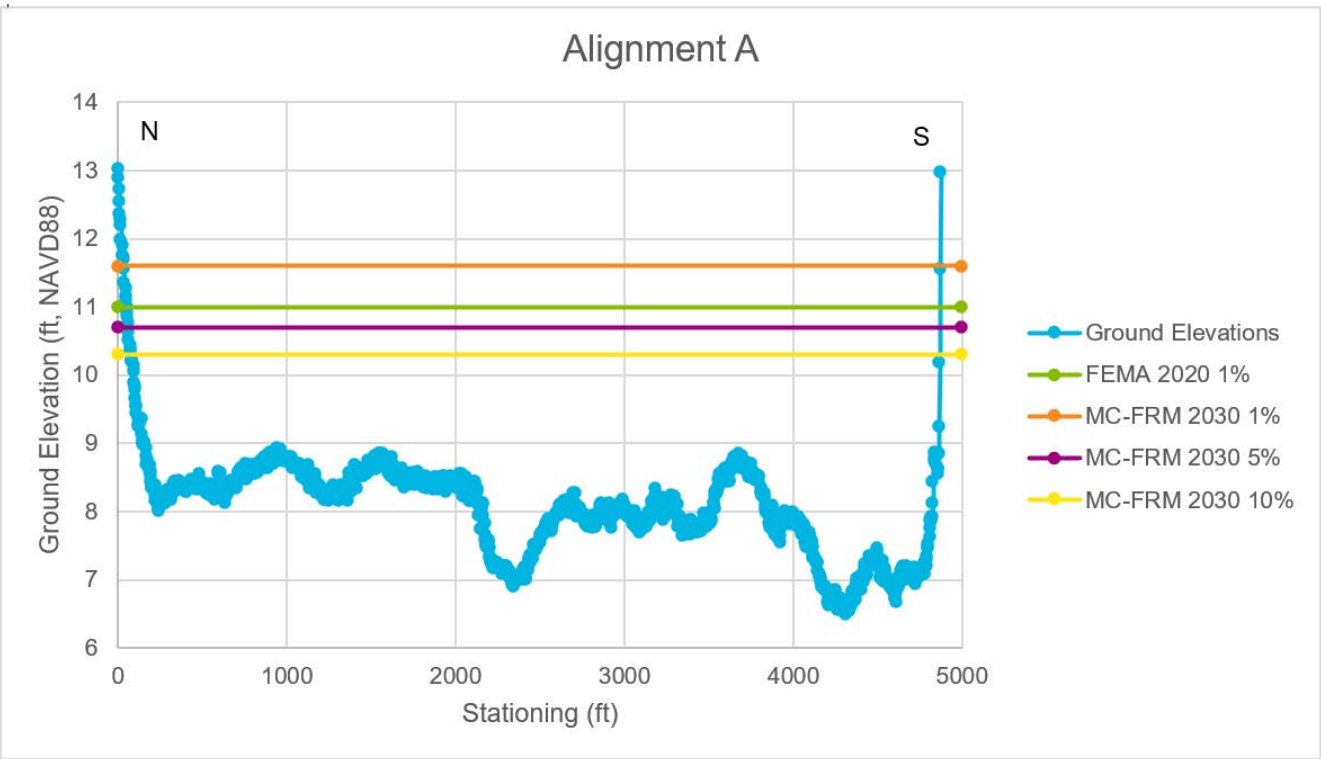

Figure 6-6-3 Alignment A Profile

A summary of the HOIs and tie in locations in relation to the proposed design storms are listed in Table 6-2 below.

Table 6-2 Alignment A Feasibility

Design Storm	MAX HOI (ft)	Northern Tie In	Southern Tie in
2020 1% DFE	4.6	Feasible	Feasible
2030 1% DFE	5.2	Feasible	Feasible
2030 5% DFE	4.3	Feasible	Feasible
2030 10% DFE	3.9	Feasible	Feasible

6.1.1.2 Alignment B1

Alignment B1 is intended to protect the Ocean Side of the peninsula. The southern tie in for this alignment, shown in Figure 6-4 below, is proposed between Rice and Harrington Avenue. The existing elevation here is +12 ft, which makes this tie in location feasible for only the 2020 100-year and the 2030 10-year design storms.

As an alternative, the tie in may begin at Carey Circle, which reaches a higher elevation of +13. However, to reach this location, the alignment would have to run on the private properties between Carey Circle and Harrington Avenue. This extended tie in option is shown in grey in Figure 6-4 below. This option was not studied further due to concerns with gaining access to private property

Figure 6-6-4 - Alignment B1 Southern Tie-In

The northern tie in for Alignment B1, shown in Figure 6-5 below, is proposed just east of Route IA. The existing elevations increase from +10 to +17 here, which makes this tie in location feasible for any of the proposed design storms.

Figure 6-6-5 - Alignment B1 Northern Tie-In

The HOI along Alignment B1 is shown in in the profile in Figure 6-6 below. For this study, the northern tie in location was stopped at +14 since this elevation encompasses all the proposed design storms.

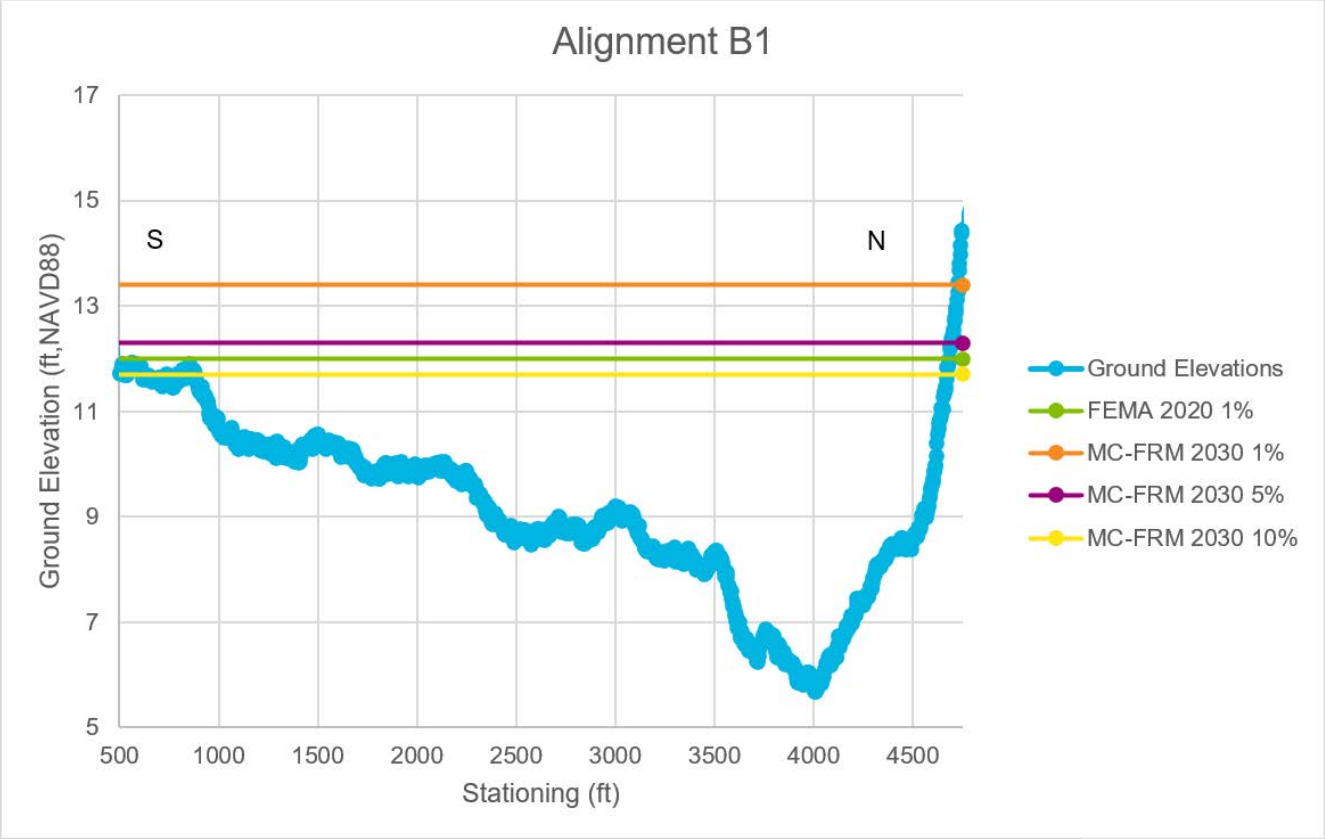

Figure 6-6-6 - Alignment B1 Profile

A summary of the HOIs and tie in locations in relation to the proposed design storms are listed in Table 6-3 below.

Table 6-3 Alignment B1 Feasibility

Design Storm	MAX HOI (ft)	Northern Tie In	Southern Tie in
2020 1% DFE	6.4	Feasible	Feasible
2030 1% DFE	7.8	Feasible	Not Feasible
2030 5% DFE	6.7	Feasible	Not Feasible
2030 10% DFE	6.1	Feasible	Feasible

6.1.1.3 Alignment B2

Alignment B2 is intended to protect the Ocean Side of the peninsula. The southern tie in for this alignment is proposed to be the same as alignment B1 and is detailed above in section 6.1.1.2. The northern tie in for this alignment, shown in Figure 6.5 below, is proposed east of Route 1A parallel to Alden Ave. The existing elevations increase from +11 to +24 here, which makes this tie in location feasible for any of the proposed design storms.

Figure 6-6-7 - Alignment B2 Northern Tie-In

The HOI along Alignment B2 is shown in in the profile in Figure 6-3 below. For this study, the northern tie in location both stopped at +14 since this elevation encompasses all the proposed design storms.

A summary of the HOIs and tie in locations in relation to the proposed design storms are listed in Table 6-4 below.

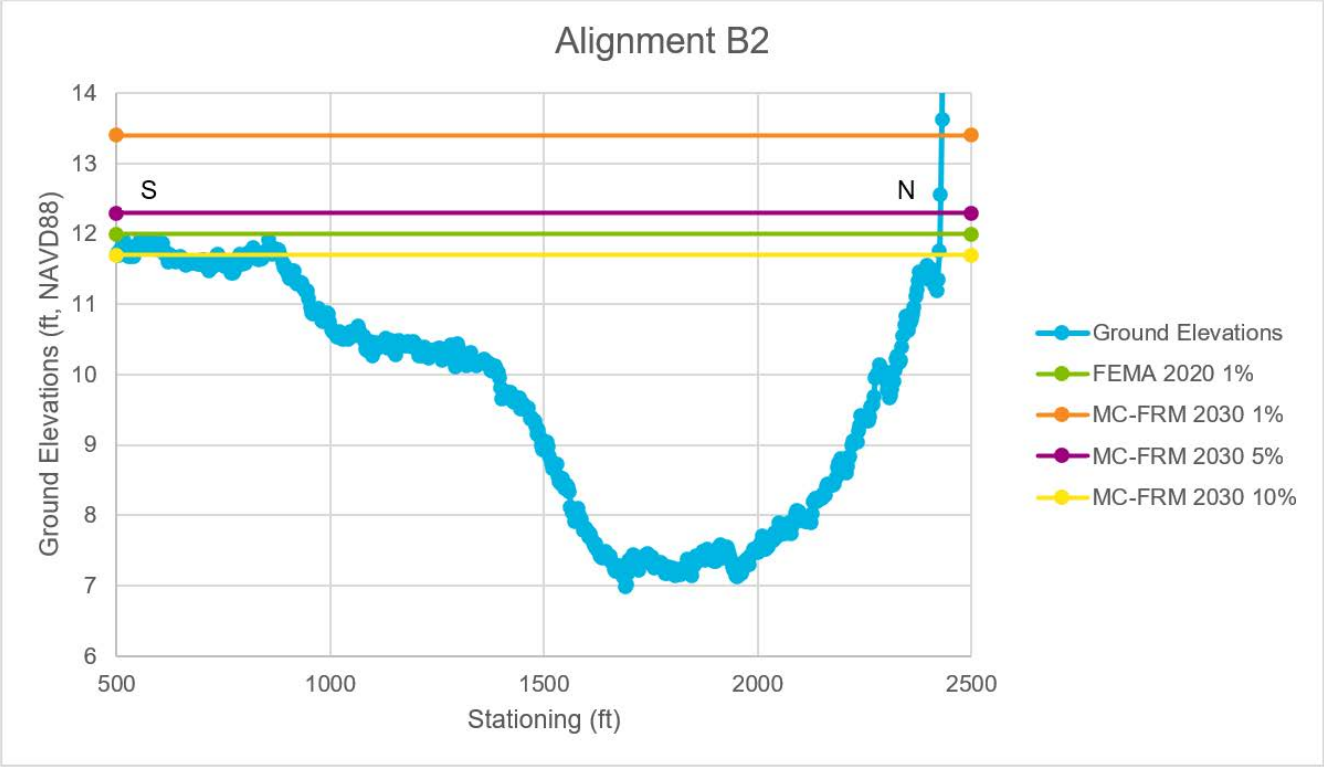

Figure 6-8 - Alignment B2 Profile

Table 6-4 Alignment B2 Feasibility

Design Storm	MAX HOI (ft)	Northern Tie In	Southern Tie in
2020 1% DFE	5.1	Feasible	Feasible
2030 1% DFE	6.5	Feasible	Not Feasible
2030 5% DFE	5.4	Feasible	Not Feasible
2030 10% DFE	4.8	Feasible	Feasible

6.1.2 Critical Buildings

The four critical buildings in this study are the Adult Day Care Center, the Stormwater Pump Station, the Wastewater Pump Station, and the Fire Station. Based on the existing elevations shown in Figure 6-8 below, the respective HOI for each building and design storm is listed in Table 6-5. Since the proposed method of protection of the buildings does not require tying into high ground, the feasibility of a northern and southern tie in is not considered for these buildings.

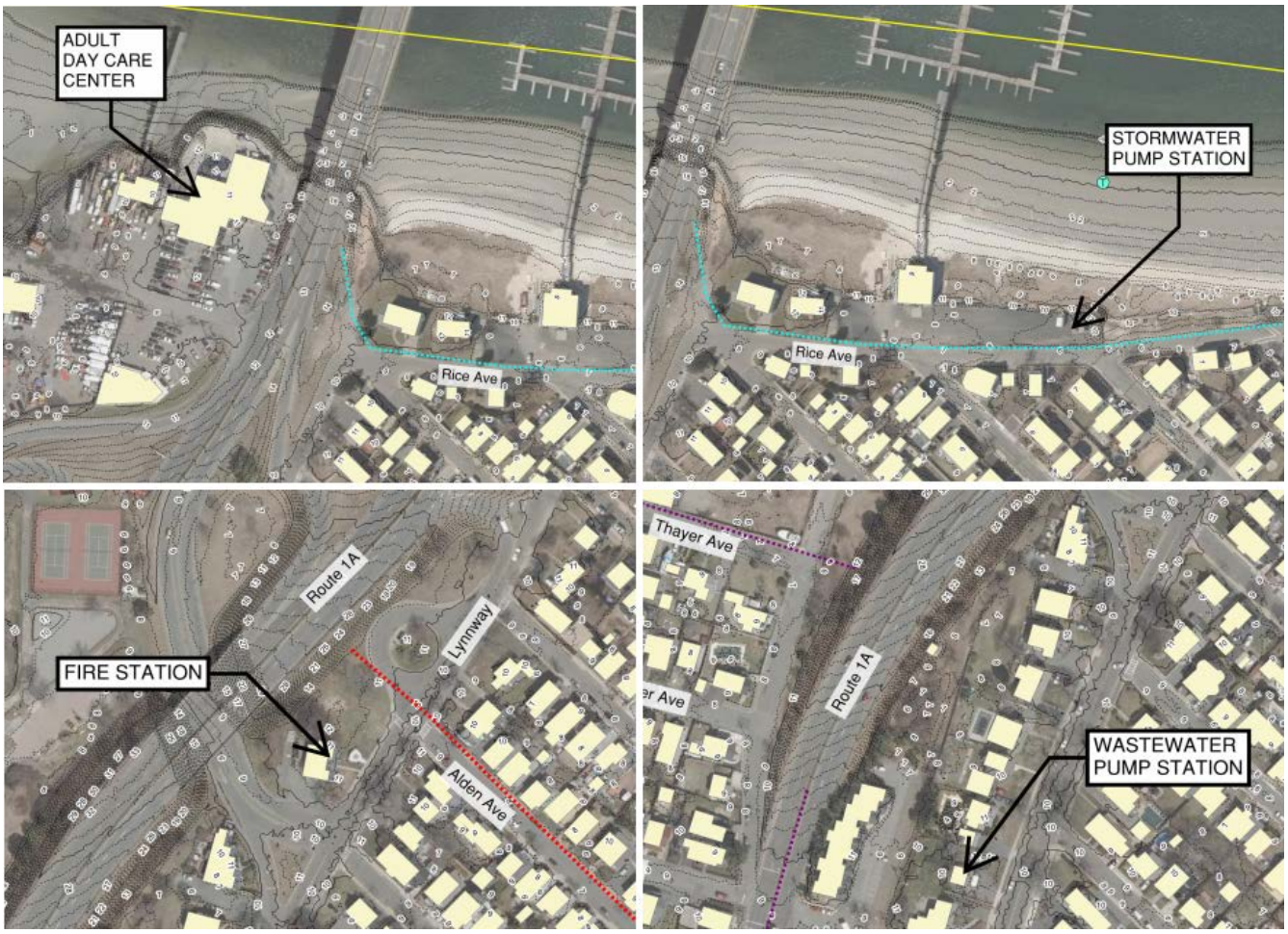

Figure 6-6-9 - Critical Building Elevations

Table 6-5 - Critical Infrastructure Feasibility

Design Storm	Wastewater Pump Station MAX HOI (ft)	Fire Station MAX HOI (ft)	Adult Day Care Center MAX HOI (ft)	Stormwater Pump Station MAX HOI (ft)
2020 1% DFE	2	Not in flood zone	4	4
2030 1% DFE	2.6	Not in flood zone	5.4	5.4
2030 5% DFE	1.7	Not in flood zone	4.3	4.3
2030 10% DFE	1.3	Not in flood zone	3.7	3.7

For the purpose of this study, the Wastewater Pump Station HOI is based on the River Side DFE and the Adult Day Care Center and Stormwater Pump Station HOIs are based on the Ocean Side DFE. Design of any flood risk reduction measures would necessitate additional site-specific values.

6.1.3 Design Storm Feasibility

A summary of the design storm feasibility for the proposed alignments and critical buildings is detailed in Table 6-6 below.

Table 6-6 – Design Storm Feasibility

Design Storm	Alignment A	Alignment B1	Alignment B2	Critical Infrastructure
2020 1% DFE	Yes	Yes	Yes	Yes
2030 1% DFE	Yes	Not Feasible	Not Feasible	Yes
2030 5% DFE	Yes	Not Feasible	Not Feasible	Yes
2030 10% DFE	Yes	Yes	Yes	Yes

6.2 Relocate Buildings

Relocating buildings requires significant cost and may be logistically challenging due to the lack of available area within the Study Area for relocation, considering that most of the area is predicted to be inundated at a high frequency in the future. In addition, most buildings in the study area that are at risk are private residential buildings and thus relocation is likely to have low community acceptance and be infeasible from a practical perspective. Only two buildings, the adult day care center and the stormwater pump station, are public at-risk buildings that could be considered for relocation, although potential sites are limited. It may be feasible to relocate the adult day care center outside of the Study Area, although this may face community acceptance challenges if this facility serves the local population.

6.3 Floodproofing Buildings

Floodproofing buildings is a relatively low-cost resiliency tool when targeting a single critical building but is costly to implement for a large number of residential homes. It would achieve the goal of controlling floodwaters and may be an effective tool to implement for targeted individual critical buildings in the Study Area that cannot be relocated and are important to providing critical functions for the community during storm events.

6.4 Elevate Buildings

Like floodproofing, elevating buildings may be appropriate for individual critical community assets but is likely to be impractical for the City to implement on a wide scale for individual homes due to high costs and logistical challenges. Residents could consider this tool for their individual properties, although it would be costly for an individual homeowner to implement and therefore was deemed feasible only for individual municipal buildings of key importance.

6.3 Elevate Roadways

Elevating roadways is challenging due to the utilities that are often located within roads and the interface of most roads with driveways to private residences and businesses. It would be very costly to relocate utilities and also potentially infeasible in many locations to raise the main roadway elevations above the elevations of adjacent driveways. Raising Rice Ave, Mills Ave, and Route 1A was deemed infeasible for these reasons. As discussed above, many of the roads within the Study Area are in BLSF; adding fill in these areas would require finding an

equivalent volume in the same general area where compensatory flood storage could be created. Because this tool was evaluated unfavorably in comparison to most of the screening criteria, it determined to have low feasibility for the study area.

6.4 Offshore Structures

Offshore structures are high in cost and are not feasible for protecting the study area unless evaluated on a larger-scale basis to protect an area inclusive of, but not restricted to, the Study Area. Coastal structures are typically large barriers made up of a series of gates that would be used to prevent water levels from increasing during a storm surge. Any large offshore structures would need to be built at the mouth of the Broad Sound if they were going to protect the entire study area. This tool has an extremely high cost, and extensive permitting requirements. The City has previously considered recommended offshore structures from the United States Army Corps of Engineers (USACE). In 1990 USAE published the *Flood Damage Reduction Study for the Saugus River and Tributaries.* The structural recommendations in the report were the installation of tidal floodgates by the mouth of the Saugus River; ten flushing gates on the left and right side of the navigation gates along Lynn and Revere; and a dike in Lynn harbor. The recommended floodgate also contained two concrete gravity wall sections. Implementation of the 1990 project requires additional study to confirm previous modelling assumptions, update of cost, and evaluate conformance with current regulatory conditions; these evaluations are beyond the scope of the current MVP Action Grant Feasibility Study. Given the extremely high cost, required input from multiple municipalities, and complex modelling required, this tool was deemed infeasible in the context of this Feasibility Study, however additional evaluation in larger context may be warranted.

6.5 Pump Stations

Although pump stations will not control floodwaters from inundating an area by themselves, they can be used in conjunction with a barrier tool to remove excess precipitation. A stormwater pump station exists already in the Point of Pines neighborhood and may be beneficial in the Mills Avenue and/or Gibson Park area to address future predicted coastal flooding and increased precipitation. The Riverfront Masterplan recommends the installation of a pump station adjacent to Gibson Park. The utility of a pump station in this location could be confirmed based on an interior drainage analysis, which would also be needed to size the pump station. In the southern end of the Study Area, given the long narrow and low-lying topography present, a pump station is unlikely to provide a valuable function since there is not a discrete area where floodwaters are contained, existing wetlands provide some storage, and the area is able to naturally drain after a storm event. It may be possible to locate a pump station below grade and/or there may be existing fill above ground level that could be removed to provide compensatory flood storage area to off-set any BLSF fill; therefore, permitting for this tool was identified as moderately complex.

6.6 Green Infrastructure

Green infrastructure (GI) tools such as permeable pavement, rain gardens, and vegetative swales do not provide a barrier to control floodwaters, but they can help with creating a resilient stormwater management system that can manage predicted increases in rainfall due to climate change and also provide co-benefits such as environmental sustainability and improved water quality. There are multiple funding opportunities for green infrastructure on public property, and these tools typically receive high community acceptance rates while being relatively low-cost measures to implement. A challenging factor for Green Infrastructure tools is often the identification of locations for implementation or retrofits. Much of the Study Area is heavily developed with numerous residential properties and privately owned businesses, which makes siting of GI challenging without private property consensus. Installation of GI would likely require demonstration of water quality benefits and avoidance of unanticipated adverse flooding effects on adjacent areas and therefore was considered to entail a moderate degree of permitting complexity.

The Riverfront District along the Pines River in the northwest portion of the Study Area is the primary location that offers an opportunity for siting Green Infrastructure. This area was the subject of a master planning effort by the City, which culminated in the release of a Riverfront Master Plan final report dated January 2021. The area includes the former Boat Works site, the G&J Towing site, and Gibson Park. The Boat Works and G&J sites are

a privately held parcels proposed for redevelopment, while Gibson Park is a municipal property. Green infrastructure could be sited throughout the parcels in the Riverside District, either directly by the City on municipal property, or by redevelopers of private parcels based on requests and requirements implemented through the City permitting process. The January 2021 Master Plan identifies the concepts of including rain gardens, bioswales, and porous pavement at Gibson Park and the adjacent privately held parcels.

6.7 Flood Storage Area

Flood storage areas would not control predicted higher flood waters or coastal surge from the Study Area, but could be used to contain water either above or below ground if water can be directed to the storage facility without adversely affecting residences and critical facilities. Locations for at-grade flood storage areas in the study area are limited as the area is already heavily developed other than existing wetlands, which provide natural storage, and the parcels in the Riverside District discussed above. Since the Riverside District municipal property includes playing fields, there would be low community acceptance for converting this area into a dedicated storage facility. Although the playing fields currently do provide some amount of storage during a flood event, it is not possible to increase storage to address future predicted climate change events without raising elevations around the site to contain water, which would have low acceptance as this would conflict with the existing uses of the site. Below-ground storage at the playing fields may be a feasible measure and between 1.62- and 2.34-acres feet of below-ground storage was identified as a recommendation in the January 2021 Master Plan. Implementation of a below-ground flood storage area at Gibson Park requires additional evaluation of geotechnical and water table conditions at the site, as well as a hydraulic evaluation to assess mechanisms for water to enter and exit the underground storage facility. Installation of below-grade flood storage would likely require demonstration of water quality benefits and avoidance of unanticipated adverse flooding effects on adjacent areas, and would be subject to MEPA review via an ENF; therefore this tool was considered to entail a moderate degree of permitting complexity.

6.8 Impervious Surface Reduction

Implementation of impervious surface reduction (ISR) in the Study Area is not feasible on a large scale due to the land usage of the study area. The land usage is primarily residential properties connected by public roadways that are key access points and most of this impervious surface is not feasible to reduce. There may be relatively small areas of impervious surface in pockets throughout the Study Area that could be removed and replaced with either permeable pavement or vegetated area, but other than roads and homes, the majority of impervious surface in Study Area is at parking lots associated with private businesses such as the Point of Pines Yacht Club, Broadsound Tuna Club, The Marina at the Wharf, Rick's Auto Collision, Maxim Crane Works, and businesses along Revere Beach Boulevard Reduction of any available or unused impervious surfaces would not provide enough infiltration to control predicted future flood waters from inundating sections of the Study Area. However, ISR can help with creating a resilient landscape that can infiltrate some additional rainfall to offset predicted increases due to climate change and also provide co-benefits such as environmental sustainability and improved water quality. The most feasible location for ISR would be in the Riverside District discussed above, at either Gibson Park or in one of the properties proposed for redevelopment. The January 2021 Riverfront Master Plan includes a recommendation to convert hard-packed gravel areas on the parcels proposed for redevelopment into vegetated greenspace.

6.9 Bioretention Basin

Due to high groundwater throughout the study area, infiltration from bioretention basins may be difficult to achieve. In addition, similar to Green Infrastructure discussed above, it would be challenging to identify locations throughout the Study Area for bioretention basins since much of the area is heavily developed with numerous residential properties and privately owned businesses. Given these constraints, it is not feasible to implement enough basins to achieve a sufficient volume to contain future predicted flood waters and prevent them from inundating portions of the study area in the future. However, bioretention basins can help with creating a resilient landscape that can infiltrate some additional rainfall to offset predicted increases due to climate change and also provide co-benefits such as environmental sustainability and improved water quality. It is possible that bioretention basins could be sited in the Riverside District, either directly by the City on municipal property, or by redevelopers of private parcels based on requests and requirements implemented

through the City permitting process. Implementation of bioretention basins in this portion of the Study Area would require additional investigation of groundwater levels to confirm seasonal high-water levels, however it is likely that subsurface conditions may preclude implementation.

6.10 Backflow Prevention

Backflow prevention would possibly control some tidal water from portions of the Study Area if these measures do not already exist on tidal outfalls present in the Riverfront District or along Route 1A in the southern part of the study area. Since these tidal outfalls are currently inundated at high tide, adding backflow prevention will not necessarily protect against future sea level rise, however they will add some resiliency to the Study Area to minimize additional intrusion of floodwaters to interior areas during high tides now and in the future. The 2021 Riverfront Master Plan indicates that some of the tidal outfalls may have backflow controls already, however some of the outfalls are crushed and some previously installed controls may no longer be functional. In addition, some outfalls on Route 1A are owned by MassDOT and may not include functional backflow controls. Inspecting and improving backflow controls in the tidal outfalls would assist in managing floodwater intrusion into the Study Area.

6.11 Dune Protection/Restoration

Dune protection and restoration could assist with minimizing predicted future coastal floodwaters in the area of Point of Pines (PoP). These are the only coastal dunes in the Study Area. Areas for dune restoration were detailed in the Beach Management Plan included as part of the Task 3 memorandum. However, feasibility of implementing the measures in the Beach Management Plan may be limited by lack of opportunities for public funding, unless the Point of Pines Beach Association is able to raise funds for dune restoration or some tools outlined in the Beach Management Plan are low cost/easy to implement measures that volunteers in the PoP Association may be able to implement, but the restoration measures require substantial funds to implement. In addition, there are numerous permitting challenges associated with dune restoration, due the presence of NHESP mapped Priority/Estimated habitat, the need to file an ENF for MEPA review, and the need for compliance with MassDEP WPA performance standards for work on coastal dune. Given the numerous permitting review and approvals required for work on the Point of Pines Beach as well as the multiple opportunities for public and agency review and comment, permitting for work on the beach, including dune restoration, was identified as highly complex. Similarly, coastal or off-shore structures near the beach would entail highly complex permitting.

6.12 Wetland Restoration

Restoring previously filled wetlands can assist with resiliency by absorbing and storing excess floodwaters, which may prevent some coastal floodwaters from entering a target area. There are multiple funding opportunities for wetland restoration. Because much of the Study Area is heavily developed with numerous residential properties and privately owned businesses, there are limited opportunities for wetland restoration in the Study Area. Salt marsh already exists in many areas which are not currently developed, including the area southeast of Route 1A and the shoreline along the Gibson Park parcel. Restoration of wetlands in other areas of the Study Area would require removal of existing pavement and associated business uses, which is unlikely to receive a high rate of community acceptance. One area that has potential for additional salt marsh restoration would be the northern shore along the Riverside District, adjacent to existing salt marsh at Gibson Park. The January 2021 Master Plan identifies additional salt marsh restoration in this area also. Due to the small area available for salt marsh creation, this tool by itself is unlikely to substantially reduce predicted future coastal flooding in the Study Area, but the area could flood and recover after a storm event, and over time, may build up sediments such that the restored salt marsh area may increase in elevation to keep pace with rising sea levels.

6.13 Living Shorelines

Living shorelines are valuable for aiding in erosion protection along a shore while also providing co-benefits of habitat and water quality improvement. The height of living shorelines is limited by the height of the existing land

and therefore this tool is not aimed at excluding flood water and would not protect the Study Area from inundation due to predicted future coastal events. However, living shorelines consisting of coir logs with native vegetation could be incorporated into portions of the Study Area coastline for the co-benefits it provides. There is an existing rock revetment along Route 1A in the southern portion of the Study Area. Adding a living shoreline in this location may be feasible but would require integration with the existing rock revetment. Another potential location for implementing a living shoreline would be along the shore of the Riverfront District in the area of the G/J Towing parcel, in conjunction with the wetland restoration tool identified above. The 2021 Riverfront Master Plan identifies that bank in this area is eroded and includes portions of deteriorated granite block, concrete, and pavement. The bank in this area could be improved through restoration with a living shoreline, either directly by the City, or by redevelopers of the private parcel based on requests and requirements implemented through the City permitting process.

6.14 Evacuation Procedures

Modifications to the current evacuation procedures were recommended as part of Task 3 of this study. Implementation of these recommendations will serve to better manage emergency situations but will not prevent the Study Area from increasing inundation by coastal flood waters in the future.

6.15 Public Education

The City should continue to use public education in conjunction with other public outreach programs to inform the public on the City's efforts towards resiliency measures and public safety. Increased public education regarding future flooding conditions in the Study Area will allow residents to better plan for emergency flooding events but will not prevent homes and business from inundation from coastal flood waters in the future. Dissemination of predicted future conditions may help residents and businesses in the area to make informed decisions regarding their properties and how best to manage them to address future conditions.

6.16 Building Code

The City currently relies on the Massachusetts Building Code, which includes adherence to International Building Codes that require that structure elevations be raised above flood levels. The City should continue to keep building codes as up to date as possible in conjunction with future climate change predictions and apply these codes to any new property developments.

6.17 Land Acquisition

To evaluate the feasibility of land acquisition as a permanent resiliency measure the determination would need to be made of how many properties would need to be purchased that are in flood zones. This measure rates low on the community acceptance scale but there could be the possibility for FEMA grant funding for some homes that have a history of reporting repetitive losses if the owner was receptive. Land acquisition could be evaluated further by the City as they would need to be the buyer or purchase agency in this scenario.

7. Implementation

An initial evaluation of implementation of the tools identified as most feasible for protecting residential areas and other critical assets in the Study Area is included below, and will be further refined as part of the Final Task 6 Feasibility Report for the project, based on discussion and input from the City of Revere. Based on DFE analysis above, the FEMA 2020 100-year storm and the 2030 10-year storm are feasible for all alignments and the four critical buildings in the study area. Since the FEMA 2020 100-year storm is the more conservative of the two, this was the design storm chosen for the evaluation below.

For this study, this section focuses only on the above grade structure. To achieve the protection of a comprehensive flood protection system, site specific interior drainage and geotechnical conditions must be studied further.

7.1 Alignment A

Alignment A is proposed to protect the western half of the peninsula south of Gibson Park. A variety of different flood risk reduction measures are proposed as shown in Figure 7-1. Along Mills Ave on the water, a glass floodwall is proposed to preserve views, flip up gates could be used across streets to mitigate traffic disruptions, and fixed flood walls could be used in areas where vertical barriers currently exist.

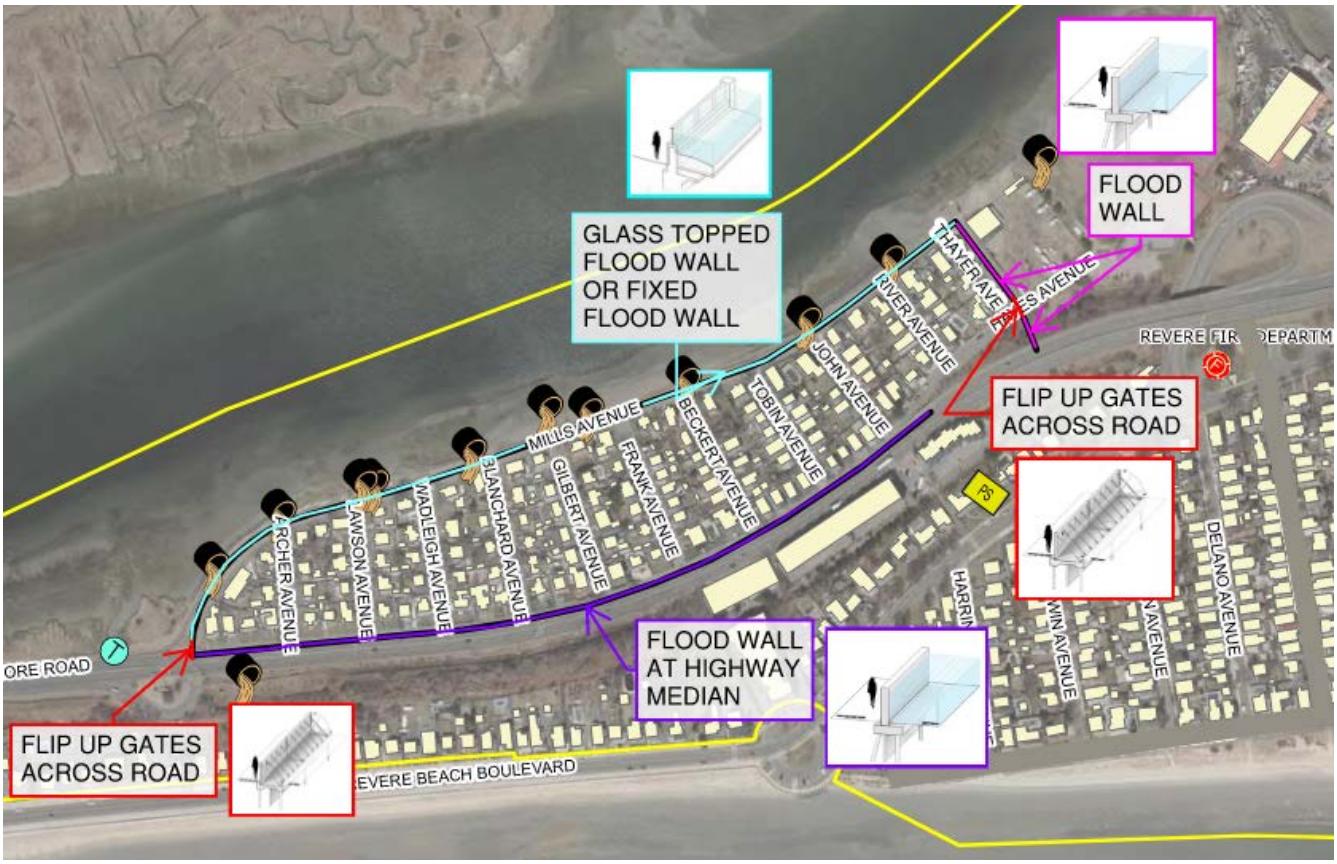

Figure 7-7-1 - Alignment A Flood Risk Reduction Measures

Alignment A begins at the start of Thayer Ave, just west of Route 1A. A fixed floodwall is proposed from the tie in point at +11 ft and down the vegetated slope towards Hayes Ave. Across Hayes Ave, flip up gates are proposed to allow for current traffic operations to remain in place in the absence of a storm. The flip up gates are shown in

Figure 7-3 below and will tie into the fixed floodwall on either side of Hayes Ave. On the west side of Hayes Avenue, the fixed floodwall will continue again along the northern side of Thayer Ave replacing the existing fence and acting as a barrier between the road and the parking/storage lot to the north. The proposed location for this wall is shown in Figure 7-2 below. To enhance visual appeal, the floodwall can be clad with a variety of finishes and potentially amendments to foster recreational co-use of the wall.

Figure 7-7-2 - Thayer Avenue Proposed Flood Wall

Figure 7-7-3 - Thayer Ave Flip Up Gates

The fixed floodwall along Thayer Ave will tie into the proposed floodwall at the northwestern corner of the intersection between Thayer and Mills Ave. Option 1 is a glass flood wall that can be used to protect the homes on and behind Mills Ave, while preserving river views for the residents. Alternatively, a fixed flood wall may be used in lieu of the glass as option 2. The glass flood wall will continue south along the western side of Mills Ave, along the same line where the existing barrier between Mills Ave and the water is currently located in Figure 7-4 below.

Figure 7-7-4 - Mills Ave Glass Flood Wall

The glass flood wall is proposed to run along the western side of Mills Ave until the intersection with Route 1A. Flip up gates will tie in to the glass flood wall along the water-side Mills Ave and run across the western half of Route 1A. See Figure 7-5. The flip ups will connect to the fixed flood wall proposed at the median of Route 1A.

Figure 7-7-5 - Mills Ave Route 1A Intersection Flip Up Gates

The last segment of Alignment A will consist of a fixed flood wall acting as a median between the western and eastern lanes of Route 1A as shown in Figure 7-6 below. The fixed flood wall will replace the existing highway median, serving as both and barrier between opposite traffic and a flood risk reduction measure. The fixed flood wall will continue down the center of Route 1A until the grade reaches + 11 ft.

Figure 7-7-6 - Route 1A Flood Wall as Median

7.2 Alignment B1

Alignment B1 will protect the eastern half of the peninsula. Like Alignment A, a variety of different flood risk reduction measures are proposed as shown in Figure 7-7. Along Rice Ave, dune protection is proposed along the shoreline, flip up gates will be used across streets to mitigate traffic disruptions, and fixed flood walls will be used in areas where vertical barriers currently exist. Due to site constraints, an Aquafence barrier is proposed at the western end of Rice Ave. Although the Aquafence barrier was defined as temporary measure in memorandum 3, it can also be used as part of a permanent flood alignment.

Figure 7-7-7- Alignment B1 Flood Risk Reduction Measures

Alignment B1 will begin at the end of Harrington Ave at the +12 ft contour on the northern side of the street. Flip up gates are proposed to run across Rice Ave to ensure traffic on Rice Ave is not obstructed. The flip up gates will tie into the eastern edge of Rice Ave. The first option in this area is to use engineered dunes along Rice Ave as shown in Figure 7-9.

Figure 7-7-8 - Harrington Ave Flip Up Gates

Option 2 in this area would be to raise the existing concrete seawall as shown in Figure 7-10 and create a fixed flood wall along the coastline. The dunes or fixed flood wall will continue north along the easter edge of Rice Ave and wrap around the tip of the peninsula until about station 3500 shown in Figure 7-7 above.

Figure 7-7-9 – Rice Ave Dune Protection

Figure 7-7-10 - Rice Ave Flood Wall

On the northern tip of the peninsula to the east and west of the Yacht Club parking entrance, a fixed flood wall is proposed. As shown in Figure 7-11, the flood wall would replace the existing fence. The fixed wall would tie into the flip up gates proposed in front of the Yacht Club parking entrance as shown in Figure 7-12 below. Flip up gates are necessary here to preserve traffic flow in and out of the parking lot.

Figure 7-7-11 - Rice Ave, East and West of Yacht Club Flood Wall

Figure 7-7-12 - Rice Ave Behind Yacht Club Flip Up Gates

In order to maintain access to the driveways of the two homes on the western end of Rice Ave, a deployable flood risk reduction measure is required. However, due to the location of these homes along Rice Ave, flip up gates are not feasible as the permanent posts would be located in the street, obstructing traffic along Rice Ave. Thus, a temporary deployable barrier such a Aquafence is proposed to be installed during a storm event behind these two homes as shown in Figure 7-13 below. The temporary deployable barrier would tie into the fixed flood wall along Rice Ave on either side of the two homes.

Figure 7-7-13 - Rice Ave Homes Aquafence

Alignment B1 ends at +12 ft just north of the intersection between Rice Ave and Lynnway. A fixed flood wall will tie in to the temporary deployable system on Rice Ave behind the two homes and run up the vegetated slope to the east of Route 1A shown on the left side of Figure 7-14.

Figure 7-7-14 - End of Rice Ave Flood Wall

Based on this proposed alignment, there are a few houses that are left unprotected on the flood side. To provide flood protection, it is recommended to raise the buildings so that they are out of the flood plain. Based on the existing elevations shown in Figure 7-15, there are 10 homes that would need to be raised. It should also be noted that the existing Yacht Club would fall on the flood side of the alignment. It may be possible to protect the Yacht Club with building specific protection measures, however additional information is needed to further evaluate this possibility, including details regarding the building layout, presence/absence of a basement, and whether any flood protection measures currently exist.

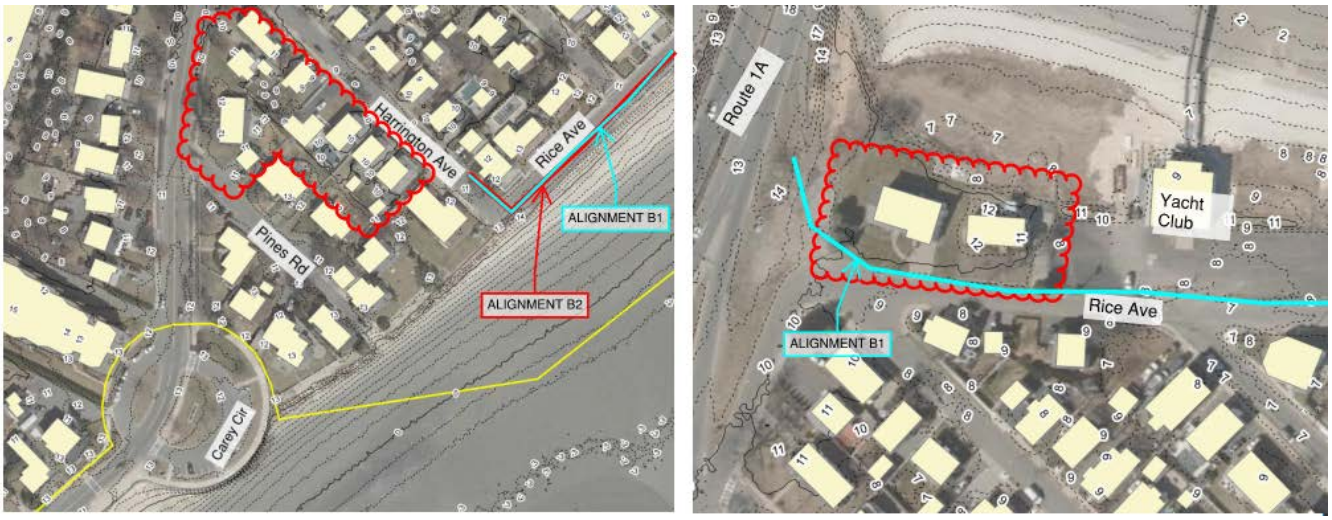

Figure 7-7-15 Residential Homes on Flood Side

7.3 Alignment B2

Alignment B2 is intended to protect about one third of the homes on the eastern half of the peninsula. This alignment was proposed as a shorter alternative to B1. The proposed flood risk reduction measures along the alignment are shown below in Figure 7-16. Alignment B2 will begin the same way as B1 with a flip up gate crossing Rice Ave at the end of Harrington. The flip up will tie into a dune or raised seawall along Rice Ave. Alignment B2 takes a different path from B1 at Alden Ave where flip up gates are proposed crossing Rice and along Alden until high ground of +12 is achieved. Based on the existing conditions along Alden Avenue, as shown in Figure 7-17 below, flip up gates are the only viable measure due to traffic, driveways and property line restrictions.

However, this alignment is likely not feasible due to constructability and the residential division that it causes. Installing flip up gates of this length would require a significant amount of construction and would have a large impact on the residences on both sides of Alden Ave. Furthermore, once constructed, the gates would only protect one side of the street. For the purpose of this study, Alden Ave was chosen as the dividing road, but the same issue would occur if the alignment turned up any of the side roads off Rice Ave. Therefore, for the purpose of this study alignment B2 was not studied further.

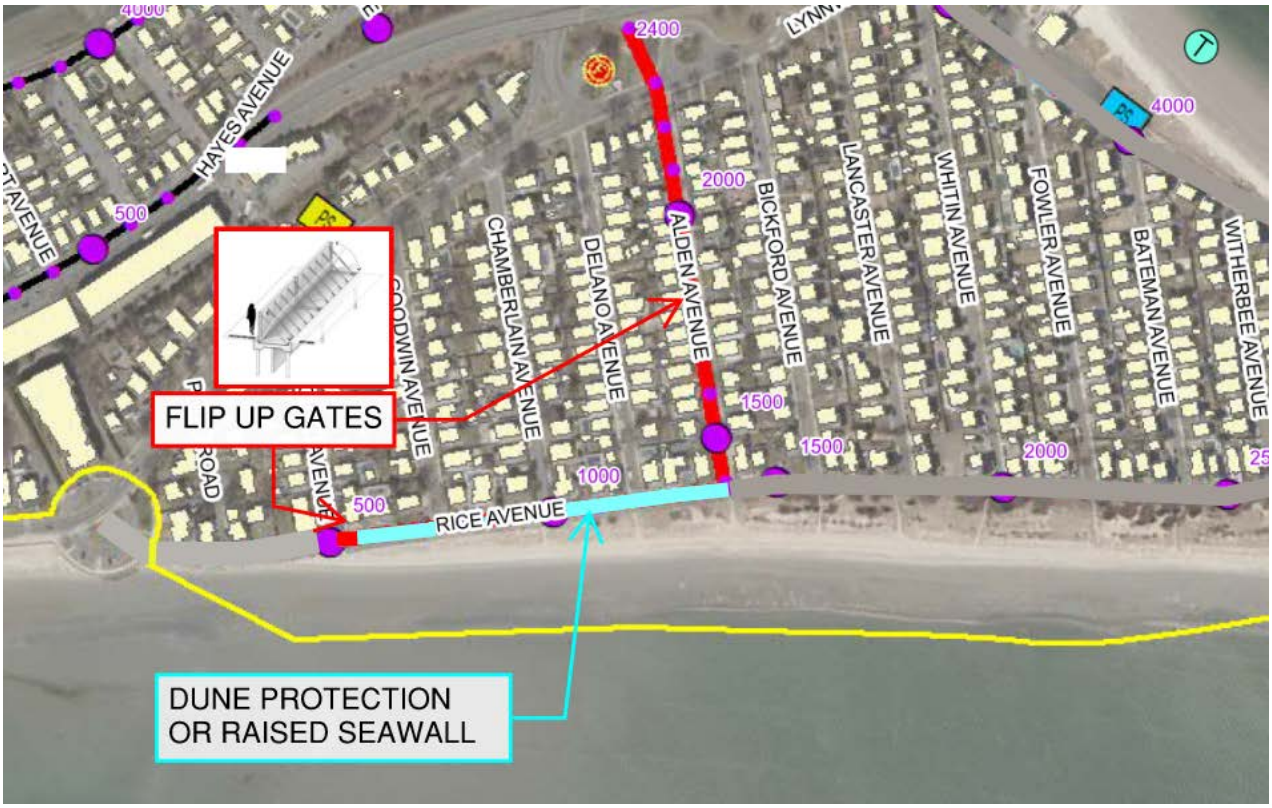

Figure 7-7-16 - Alignment B2 Flood Risk Reduction Measures

Figure 7-7-17 Alden Ave

7.4 Alignment C

To protect the residential areas along Revere Beach Boulevard on the southeast side of Route 1A, the proposed recommendation is to replace the median of Route A with a fixed floodwall as shown in Figure 7-18 below. On the northern side, this floodwall would connect as a continuation of the median floodwall in Alignment A with a flip up gate at the Mills Ave crossing to maintain egress. Due to the lack of existing high ground in the southern

project area, to reach high ground, the floodwall would have to be continued slightly northwest of the project area limits.

Figure 7-18 - Southern Route 1A Floodwall as Median

7.5 Critical Buildings

The Fire Station is not in the 2020 100-year storm flood plain and therefore does not require additional flood protection measures. Fire Station

7.5.1 Wastewater Pump Station

The wastewater pumps station, shown in Figure 7-18, is located to the east of Route 1A. Based on the size of the pump station, the proposed recommendation is to lift and floodproof/elevate the building or rebuild it in the same location at a higher elevation.

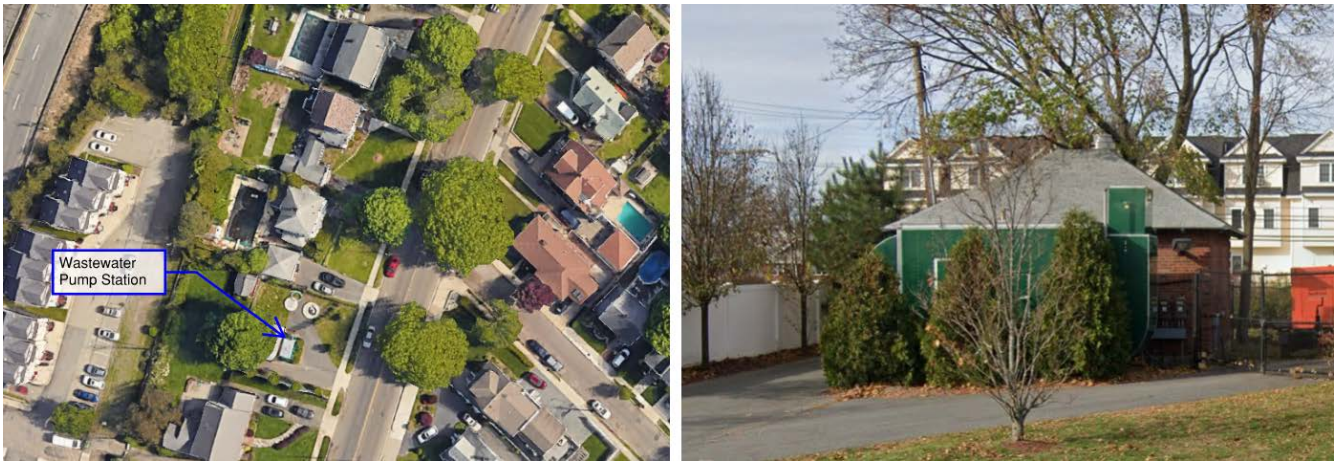

Figure 7-7-19 Wastewater Pump Station

7.5.2 Stormwater Pump Station

The stormwater pump station, shown in Figure 7-19 below, is located to the North of Mills Ave. Based on the size of the stormwater pump station, the proposed recommendation is to lift and floodproof/elevate the building or rebuild it in the same location at a higher elevation.

Figure 7-7-20 Stormwater Pump Station

7.5.3 Adult Day Care Center

The adult day care center, shown in Figure 7-20 below, is located at the Northern end of the Peninsula. Based on its size, the proposed recommendation is to create an alignment around the perimeter of the building and parking lot. The alignment would consist of a fixed wall on three sides and flip up barriers along the fourth side to allow for access in non-storm conditions.

Figure 7-7-21 Adult Day Care Center

7.6 Cost

A high-level cost estimate was prepared for each of the proposed alignments and critical infrastructure buildings based on the FEMA 100-year storm DFE. Alignment A Option 1 includes the glass floodwall option along Mills Ave, while Alignment A Option 2 includes the concrete floodwall option. Alignment B1 Option 1 includes the concrete floodwall option along Rice Ave, while Alignment B1 Option 2 includes the dune protection option. This estimate was based on costs from other projects and was created as a planning level estimate and is not a construction cost estimate. Assumptions were used for geotechnical conditions and permitting was not included. Due to the lack of existing information, a -30% +50% contingency was applied. This estimate has been escalated to 2023 costs and is summarized in Table 7-1 below.

Table 7-1 Cost Estimate

Flood Protection	Cost Min	Cost Max
Alignment A Option 1	9.4 M	20 M
Alignment A Option 2	7 M	15 M
Alignment B1 Option 1	6.8 M	14.5 M
Alignment B1 Option 2	5.9 M	12.5 M
Alignment C	6 M	13 M
Critical Buildings	4.6 M	10 M

8. Summary

A variety of tools may be needed to increase the resilience of the Study Area, including barrier measures that control future floodwaters predicted to occur due to climate change which are costly and challenging to permit, as well as smaller stormwater management measures such as Green Infrastructure which may add additional co-benefits such as habitat and water quality improvement . An initial evaluation of implementation of the tools identified as most feasible for protecting residential areas and other critical assets in the Study Area was completed and will be further refined as part of the Final Task 6 Feasibility Report for the project, based on discussion and input from the City of Revere. Based on DFE analysis above, protection measures for the future predicted conditions in 2030 is only feasible for the 10-year storm and protection for storms larger than the 10 -year storm in 2030, as well as flooding predictions for 2050 and 2070, may not be possible without a larger-scale tool that expands beyond the existing study area.

9. Acronyms

ACEC	Area of Critical Environmental Concern
ASCE	American Society of Civil Engineers
BLSF	Bordering Land Subject to Flooding
CZM	Coastal Zone Management
DEP	Department of Environmental Protection
DFE	Design Flood Elevation
EEA	Executive Office of Energy and Environmental Affairs
EIR	Environmental Impact Report
ENF	Environmental Notification Form
FEMA	Federal Emergency Management Agency
Ft. or ft	Feet
HOI	Height of Intervention
In. or in	Inches
LAND	Local Acquisitions for Natural Diversity
LSCSF	Land Subject to Coastal Storm Flowage
MassDFW	Massachusetts Division of Fisheries and Wildlife
MC-FRM	Massachusetts Coastal Flood Risk Model
MEMA	Massachusetts Emergency Management Agency
MEPA	Massachusetts Environmental Policy Act
MESA	Massachusetts Endangered Species Act
MVP	Municipal Vulnerability Preparedness
NFWF	National Fish and Wildlife Foundation
NGVD	National Geodetic Vertical Datum
PARC	Parkland Acquisitions and Renovations for Communities
PoP	Point of Pines
SRF	State Revolving Fund Loan

USACE	United States Army Corps of Engineers

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