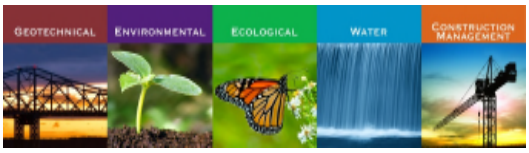

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November 3, 2020
File No. 18.0171674.04

Mr. David H. Knowlton, P.E.
City Engineer/DPS Director
City of Salem, MA
98 Washington Street, 2nd Floor
Salem, Massachusetts 01970

Re: Preliminary Design Summary Letter - Executive Summary
Columbus Avenue Seawall Reconstruction Project (EEA #258-2020-3)
Salem, Massachusetts

Dear Mr. Knowlton:

GZA GeoEnvironmental, Inc. (GZA) is pleased to submit this Executive Summary to our summary letter of preliminary design progress dated October 21, 2020 for the Columbus Avenue Seawall Reconstruction Project to the City of Salem (Client). This Executive Summary was prepared at the request of, and in response to, our conversations with you.

This Executive Summary is subject to the terms and conditions of our original agreement and the Limitations of our preliminary design summary letter dated October 21, 2020. Elevations provided are referenced to the North American Vertical Datum 1988 (NAVD88).

We thank you for the opportunity to work on this project and look forward to our continued involvement. If you have any further questions or require any additional information, please do not hesitate to call David Smith at 781-278-4806 or email at David.smith@gza.com.

Very truly yours,
GZA GEOENVIRONMENTAL, INC.

David A. Smith
Senior Project Manager

Enclosed: Executive Summary

BACKGROUND

GZA was retained by the City of Salem to provide design and permitting services for the replacement of the existing Columbus Avenue seawall. GZA understands that the City would like to replace the existing seawall with consideration to raise the height of the seawall for greater protection and resilience to wave surge/flooding conditions. In addition, the City would like to improve coastal resiliency of the area by implementing an improved living shoreline adjacent to the wall in areas of existing and deteriorated salt marsh habitat.

GZA's scope of services includes inspection, survey, design, permitting services, and bid solicitation phase services for the proposed Columbus Avenue Seawall Reconstruction Project located within Juniper Cove, Salem, Massachusetts. The preliminary design summary letter dated October 21, 2020, presents existing conditions, site investigations and assessment, coastal wave and flood analysis, and the proposed project design progress performed to date.

EXISTING CONDITIONS

The Columbus Avenue seawall is an older fieldstone and granite block masonry structure approximately 474 linear feet long, located along the northwestern portion of Juniper Cove in Salem, Massachusetts between the properties of 44 Columbus Avenue and 30 Bay View Avenue. The seawall provides foreshore protection to; the public roadway (Columbus Avenue), public sidewalk, utilities, and residential dwellings. The seawall is fronted by the publicly accessible 'Steps Beach' and an area of salt marsh vegetation along the southwest portion of the beach area. The seawall varies in elevation from approximately 10.1 feet NAVD88 at the southwestern corner to 8.5 feet NAVD88 at the northeastern corner. Neighboring private walls on each end are at the same approximate elevation as the adjacent Columbus Avenue seawall.

The seawall has never had the benefit of any ongoing, periodic preventative maintenance program but has received spot repairs from time to time especially after the damage that occurred during the 2018 Nor'easters. The seawall is vulnerable to the ever-increasing severity of coastal storms and higher water levels than previously experienced. If left as-is the structure is likely to experience additional degradation and potentially failure compromising the roadway, public access, utilities and residential dwellings.

SITE INVESTIGATIONS AND ASSESSMENT

GZA has performed investigations to document the existing conditions of the site and to assist in the development of proposed reconstruction and restoration designs including an updated topographic survey of the site, inspections of the seawall structure and limited ecological survey of the salt marsh habitat area.

- The Columbus Avenue seawall was observed to have minor to advanced defects and deterioration. The seawall is particularly susceptible to failure, due to age, existing deteriorated condition, lack of consistent maintenance, and lack of proper stone sizing and design.
- The salt marsh area was observed to be partly desiccated and degraded. Improvements and enhancement of the salt marsh area will help to stabilize the shoreline and reduce erosion, attenuate waves, and provide habitat for plant and animal species.

COASTAL WAVE AND FLOOD ANALYSIS

GZA has performed a metocean and wave analysis for the project site to determine design parameters for the proposed reconstructed seawall and living shoreline marsh restoration. **Table 1** presents the Stillwater elevations (flood level **without** wave height), total water level (flood level **with** wave height), and wave runup elevation (maximum water level reached by waves and swash along the seawall) for the 10-year, 50-year, 100-year recurrence interval flood events. That is, a 10-year flood event statistically has a 10-percent chance of occurring in any given year.

Table 1: Summary of Flood Elevations

Storm Event Return Period	Stillwater Elevation (SWL) (ft, NAVD88)[1]	Total Water Level (TWL) (ft, NAVD88)[2]	Runup Elevation Along Seawall (ft, NAVD88)[3]
10-year (10-percent)	8.4	8.4 to 10.7	8.4 to 12.8
50-year (2-percent)	9.4	10.7 to 11.9	11.9 to 14.2
100-year (1-percent)	10.0	11.2 to 13.2	12.7 to 15.0

[1]FEMA Stillwater elevations
[2]Total Water Level (TWL) equals the Stillwater elevation plus wave heights
[3]Calculated by EurOtop Manual (2018)

The existing seawall varies in elevation from approximately 8.5 feet NAVD88 at the northeastern corner to 10.1 feet NAVD88 at the southwestern corner. The existing seawall provides some flood protection against the Stillwater elevations of a flood event but provides lesser flood protection against high water plus wave height and wave runup/overtopping along the seawall.

RELATIVE SEA LEVEL RISE

The relative sea level rise at the project site was estimated using the USACE sea level rise calculator and the NOAA sea level rise projection at NOAA Boston tide station. Assuming the NOAA Intermediate sea level rise projection, sea level rise for the year 2070, relative to 2020 is approximately 2 feet. Sea level rise will increase the wave and flood risks at the site.

BREAKWATER ANALYSIS

At the entrance to Juniper Cove there is an existing deteriorated breakwater approximately 750 feet seaward of the seawall. The breakwater extends approximately 120 feet perpendicular from existing bedrock outcrops at the northern shoreline of Juniper Cove, at the approximate property of 72 Bay View Avenue. The existing breakwater was observed to have a crest at approximate elevation 0 feet NAVD88 and the armor stones were observed to be raveled in some areas where it appears the bedrock core of the breakwater was exposed.

Significant wave heights were estimated for increased breakwater heights. **Table 2** presents the estimated wave height reductions along the seawall for the 10-year, 50-year, and 100-year recurrence interval flood events.

Table 2: Summary of Wave Height Reductions along Seawall[1]			
Storm Event Return Period	**Breakwater Height 5 feet (El. 5 ft-NAVD88)**	**Breakwater Height 8 feet (El. 8 ft-NAVD88)**	**Breakwater Height 10 feet (El. 10 ft-NAVD88)**
10-year (10-percent)	0 to 0.5 feet	0 to 1.4 feet	0 to 1.2 feet
50-year (2-percent)	0.1 to 0.3 feet	0.4 to 0.7 feet	0.5 to 0.7 feet
100-year (1-percent)	0 to 0.4 feet	0.4 to 1.3 feet	0.5 to 1.4 feet

[1]Significant wave heights were estimated using the SWAN (Simulating WAves Nearshore) model

If the breakwater crest was raised 5 feet, the wave heights at the seawall would be reduced by less than approximately 0.5 feet for the 10-year, 50-year, and 100-year recurrence interval flood events. If the breakwater crest was raised 10 feet, the wave heights at the seawall would be reduced by less than approximately 1.5 feet for the 10-year, 50-year, and 100-year recurrence interval flood events.

PROPOSED PROJECT DESIGN

The reconstructed seawall is proposed with an increased height ranging from approximately 1.5 feet to 3 feet, up to a consistent elevation of 11.5 feet NAVD88, roughly at the approximate top of the existing planter/pillars. The reconstructed seawall will provide improved flood protection against the Stillwater elevations up to a 500-year recurrence interval flood event (elevation 11.4 feet NAVD88) and will provide increased flood protection against high water plus wave height and wave runup/overtopping along the seawall. An elevation of 11.5 feet NAVD88 was chosen to balance the desired level of protection with cost, practicality, and aesthetics.

The proposed salt marsh enhancement design aims to stabilize the shoreline and reduce erosion, attenuate waves, and provide habitat for plant and animal species. A healthy salt marsh may reduce wave heights by up to approximately 30 to 40 percent as shown from the Metocean and Wave Analysis.

The proposed project seawall reconstruction and living shoreline salt marsh enhancement designs will provide a holistic improvement with increased shoreline stabilization and coastal storm/flood protection and resiliency. Specific site improvements of the proposed project include:

- Reconstructed seawall with large cut granite stone wall founded on a reinforced concrete footing to provide increased protection to the roadway, public walkway, dwellings, utilities, and other landside features.
- A more resilient structure and shoreline area less prone to degradation from wave surge/flooding conditions and design elements that help dissipate wave energy.
- Increased protection and flood prevention with a reduced access opening, flood protection barrier, landing improvements, and beach access improvements.
- Promotion of nature-based and natural elements to provide a more resilient shoreline able to provide increased storm damage prevention and flood control.
- Minimized maintenance to the seawall and associated costs.
- Reconstruction within same wall footprint.