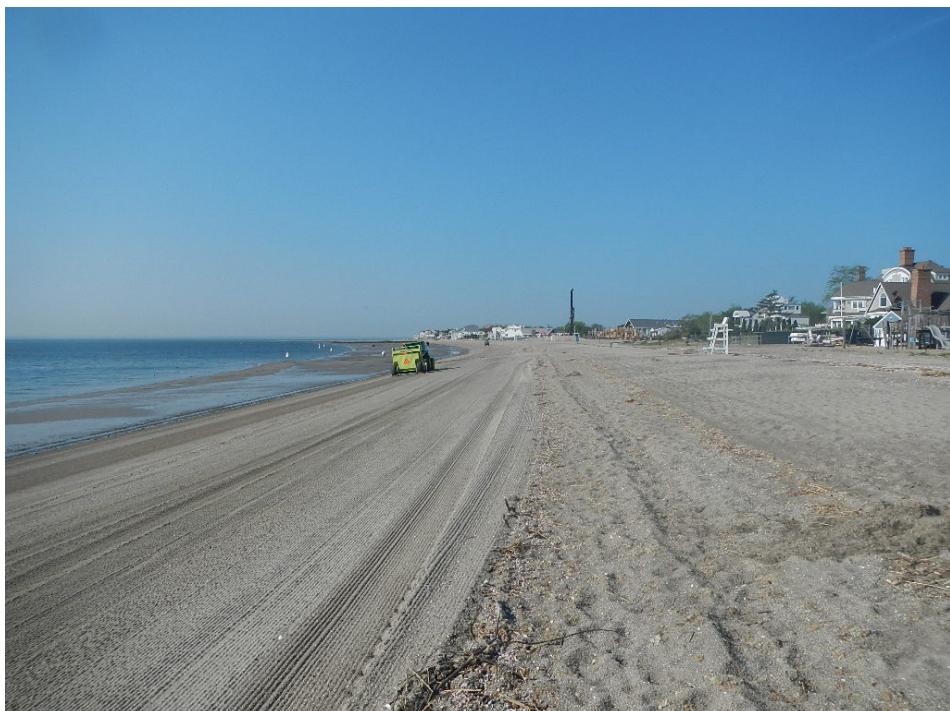


# Penfield Beach

## Resilient Design & Recommended Maintenance Program

Town of Fairfield, CT



April 26, 2017

Prepared by:



*Project No. 201644*

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## 1. Introduction

**RACE Coastal Engineering (RACE)**, at the request of the Town of Fairfield, CT, performed a coastal engineering study that included assessment of the existing site and characteristic environmental conditions at Penfield Beach and development of an engineered beach design and maintenance plan. The purpose of this plan is to increase the stability of the existing beach and contribute to continued recreational opportunities for Town residents and guests. This report is intended to provide the Town with a tool for planning and implementing future beach and backshore nourishment programs, necessitated by storm related damage, that will be eligible for FEMA disaster assistance. Such eligibility is based upon the Stafford Act, 42 USC 5121-5206, as amended, Sections 403 and 406 and CFR §§206.225, Emergency Work and CFR §§ 205.226, Restoration of Damaged Facilities.

This document provides the Town of Fairfield with a baseline Beach Plan, including characterization of the existing beach sand materials, identification of the sand size and type that will be needed for future nourishment programs, quantification of environmental load conditions (i.e. waves and water surface conditions), that are representative of a coastal storm with a 5-yr and 10-yr recurrence interval, and a design for the backshore and beach fill that are intended to meet FEMA requirements for future disaster assistance.

### 1.1. Study Objective

The fundamental purpose of the study was to provide the Town of Fairfield with a planning document that will allow the shoreline to continually be managed and maintained for recreational, flood protection, and habitat enhancement purposes. In addition, this document describes an engineered beach and backshore design and maintenance plan that meets the minimum standards established by FEMA that are intended to allow the Town to seek FEMA assistance for future sand replacements necessitated by a beach avulsion event.

### 1.2. Project Site

The Penfield Beach site is a 1,000± linear feet beach utilized by the public for recreational beach opportunities. The Fairfield Beach Club is located to the northeast and privately owned residential lots are located to the southwest. Geomorphologically, the site can be described as a sand beach. It is a dynamic coastal landform whose shape and form will be most strongly influenced by wave action. It remains in a natural state in spite of relatively high utilization and modest anthropogenic impacts.

It was originally formed in the post-glacial period when sand that was moved along the shoreline under the influence of waves and to some extent tidal currents was deposited at the terminus of the glacier that covered the area. The general vicinity of the project is shown on the



photograph included in the following section, Figure 1 – Aerial Photograph – Penfield Beach. The beach system in this area is a result of the complex interaction of glacial melting and consequential sea level rise that occurred as recently as 5,000 years ago and the sculpting effects of waves and stream flow that have impacted the site since that time. The sand material and the underlying gravel deposits that characterize the beaches and the tidal ponds of Long Island Sound originated in the glacial deposits of that past glacial recession. The current sand beach formation is dynamic in nature, varying in size with the complexities of sand deposition and erosion, and in geometry and orientation when impacted by storm waves and severe winds or the semi-diurnal flooding and ebbing of the tide.

The Connecticut Department of Energy and Environmental Protection (DEEP) recognizes the site as including valuable and protected natural resources comprised of *beaches and dunes*, and *intertidal flats* (Ref 1). Areas adjacent to the site are more developed and include a parking lot, pavilion building, road way, and residential areas.

To the casual visitor, Penfield Beach is a place for reflection, exercise, entertainment, sport, picnic gatherings, bird watching, fishing, and other such activities. It is a valuable asset to residents and guests and deserving of facilities that will maximize its use and serve to protect the infrastructure from storm damage, while protecting the neighboring resources.

The site is normally exposed to winds and waves originating from the easterly and southeasterly directions. The aerial photograph in Figure 1 is orientated with north to the top of the page. Additional photographs are provided in Appendix A. A site plan of the Penfield Beach project area, including topography, is provided in the construction drawings included as part of Appendix B.

The site is exposed to Long Island Sound and is subject to coastal flooding associated with storm conditions. Such conditions yield extreme stillwater elevations and wave conditions. The shoreline is subject to semi-diurnal tidal fluctuation and is subject to storm events, most typically associated with hurricanes and nor'easters.

## 2. Existing Site Conditions

Site investigations were performed by **RACE** to document the existing site conditions. The site investigation and findings are documented in the following sections.

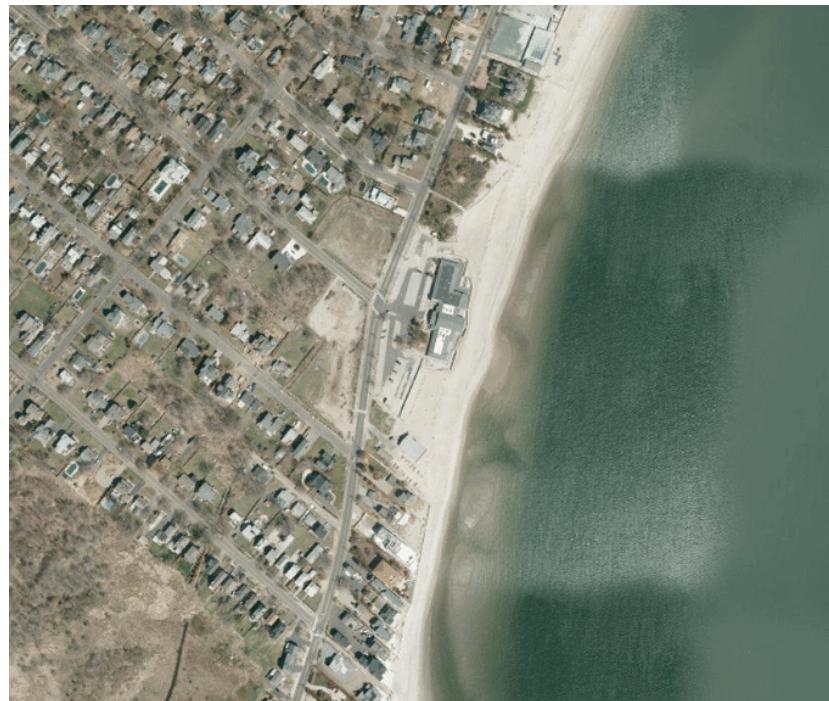
### 2.1. Site Investigation

A site field investigation was performed by **RACE** on May 25, 2016 during a period of low water to collect sediment samples and document the existing conditions. Base mapping was prepared, under subcontract to **RACE**, by Gesick & Associates P.C. from a series of field surveys that took



place from May 31, 2016 to June 10, 2016. Beach and backshore grades were measured along transects that were spaced at approximately 50' intervals and subsequently mapped so as to develop the site topography for this study. In addition, offshore hydrographic survey data to the depth of closure was collected by **RACE** on June 17, 2016 to optimally locate and position the required beach fill. The hydrographic survey was prepared such that offshore information on depths could be incorporated into a Site Plan showing depths and any obstructions to navigation which may exist on the site. The data collected during the field visit, site survey, and hydrographic survey were compiled to determine the baseline condition of the site. These data are compiled in Appendices A-C of this report.

At the time of the initial site investigations, the pavilion structure was under construction, and as such site information in the vicinity of the construction area could not be collected. Gesick & Associates P.C. preformed an as-built survey of the pavilion at a later date, and this survey was incorporated into the final construction drawings in April 2017.



*Source: ESRI World Imagery, 2011*

**Figure 1: Aerial Photograph – Penfield Beach**



## 2.2. Findings

The sandy foreshore slope of the beach was determined to vary from 1V:8H to 1V:12H which extends landward to a relatively flat planar sandy backshore area, ranging in elevation from approximately El. +8' to El. +12' (NAVD 88). There is a vegetated dune on the northern portion of the site landward of the planar backshore. The dune is interrupted by the pavilion structure which sits atop the flat planar backshore at approximately the center of the site. To the southwest of the pavilion is a playground, another building, kayak storage, and other ancillary structures. A paved parking lot is located immediately adjacent to the beach. A Site Plan, which includes this and more detailed topographic information, is included in the construction drawing set in Appendix B.

## 2.3. Beach Sand Characterization

Three (3) sand samples were collected from the site to determine the gradation of the existing beach sand. Sand was collected from mean low water (MLW), mid beach (El. +2'), and high beach (El. +8'). All samples from the site were described as gray beach sand with the Unified Soil Classification System (USCS) classification of a poorly graded sand (SP). A sieve analysis was performed and the results from the sieve analysis are graphically displayed in Figure 2.

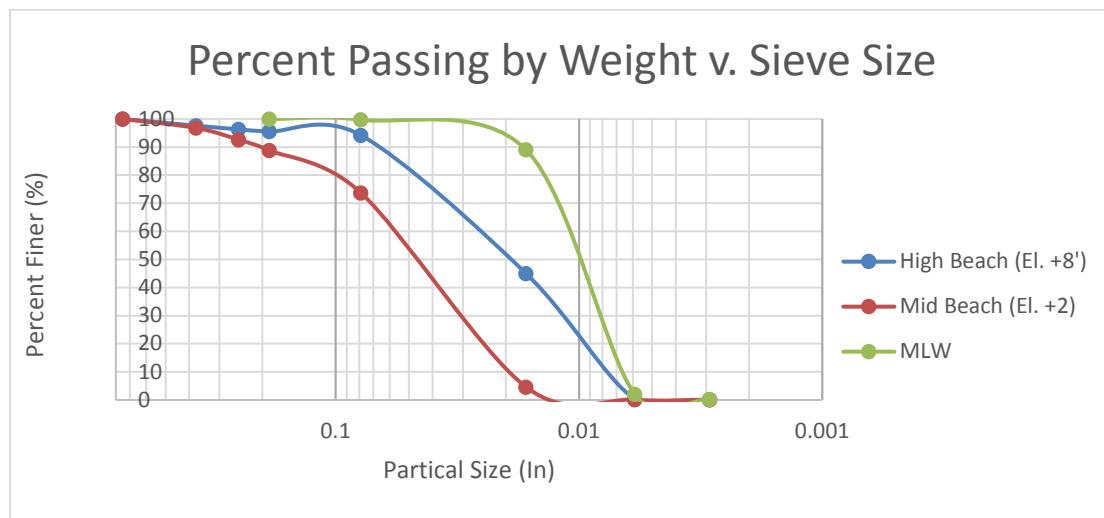


Figure 2: Percent Passing by Weight vs. Sieve Size

The average  $D_{50}$  of the samples was determined to be 0.026 inches (0.66 mm). The existing sediment information was used as input into RACE's coastal morphology model as well as to determine a specification for import material.



### 3. Environmental Settings

The Penfield Beach site is exposed to the waters of Long Island Sound from the north, northeast, and easterly directions and is subject to coastal flooding associated with storm conditions. Such conditions can yield extreme stillwater elevations and wave conditions which can cause beach and dune erosion, nearshore shoaling, and damage to near shore structures (Ref 3). Wind generated waves are defined by their height, length, and period. These characteristics can be measured at a given location and are determined by the following factors:

- Water depth (determined from stillwater elevation)
- Wind speed and duration
- Distance over which wind blows (Fetch)

Water depth, wind speed, duration, and fetch lengths, discussed in the following section, were used as design conditions to determine wave height, length, and period. Water depths, published in the Federal Emergency Management Agency's (FEMA) Flood Insurance Study (FIS), and wind speeds from FEMA's Engineering Library (Ref 4) were used to generate offshore waves with 10-yr and 5-yr return periods. These waves were transformed as they approached shore. The transformed wave heights and periods were used as input into the coastal morphology model that **RACE** used to evaluate the existing conditions and guide the design of the beach fill and nourishment schemes.

#### 3.1. Stillwater Elevation

Stillwater elevation is defined as the elevation of the water surface without the presence of wave action, but including storm surge as well as astronomical tides. The stillwater elevation reflects storm surge and tides typical of the Atlantic Ocean and, specifically, Long Island Sound. All elevations are referenced to the North American Vertical Datum of 1988 (NAVD 88) unless otherwise noted. The stillwater elevations, characteristic of the Penfield Beach site and associated with a range of return periods, are summarized in Table 1.

Return Period	Stillwater Elevation (ft)
100-yr	10.2
50-yr	9.5
10-yr	8
5-yr	6.8

**Table 1: Stillwater Elevations**

The 100-yr, 50-yr, and 10-yr tidal flood frequency information is referenced to Transect 39 from the Federal Emergency Management Agency (FEMA), Flood Insurance Study (FIS) No. 09001CV001C and dated October 16, 2013 (Ref 3). The 5-yr SWL was determined by interpolation. These stillwater elevations were used to determine water depths for the modeling and design of the proposed beach fill at the Penfield Beach site.



The modeling and design study was extended from the open water offshore of the site in a section of the reach where wave setup does not occur. Waves were transformed, utilizing the applicable Storm-Induced Beach Change model (SBEACH) described in subsequent sections, based on the fixed stillwater elevations described in Table 1 as they propagated landward.

### 3.2. Wind Climatology

The design wind condition for this site was based upon the recommended design wind speed from FEMA's Engineering Library (Ref 4). These wind speeds are based on a Peaks-Over-Threshold analysis of wind data collected from Sikorsky Airport in Stratford, CT. The published wind speed  $U_{100,hr} = 85$  mph is based upon winds with a 1 hour duration occurring at 30-ft above the water surface and a 100-yr recurrence interval (1% chance of occurring in any given year). This 100-yr wind speed was adjusted, based upon the guidelines of ASCE 7-05 (Ref 5), to generate wind speeds for both a 10-yr and a 5-yr event. These 1-hour duration wind speeds were then utilized as a basis for the determination of the design height, period, and length of the offshore wave(s) using the US Army Corps of Engineers *Wind Speed & Wave Growth* application of the *Automated Coastal Engineering System (ACES Version 4.03)* (Ref 6) as described in Section 3.3.

### 3.3. Site Wave Characteristics

The height and period of the offshore waves generated by the winds discussed in the previous section are dependent upon the length of the fetch over which the wind blows. Penfield Beach is exposed from a bearing of 20° from North to 190° from North. The exposure of each fetch from different directions at Penfield Beach is listed below in Table 2.

Bearing (deg)	Fetch (Miles)	Bearing (deg)	Fetch (Miles)
20	0.76	120	23.09
40	0.92	130	17.6
50	1.69	140	14.85
60	1.44	150	12.45
70	4.69	160	14.34
80	5.85	170	15.13
90	46.06	180	15.65
100	37.59	190	0.37
110	20.54		

Table 2: Fetch Radials



The direction and length of each fetch radial was input into the *Wind Speed & Wave Growth* application of the *Automated Coastal Engineering System (ACES)* and used to determine the 10-yr and 5-yr design wave height and wave period based off of the windspeeds and water surface elevations described above in Sections 3.1 and 3.2. The incident design wave was assumed to originate over the longest exposure at a bearing of 90° with a distance of 46.06 miles across Long Island Sound. The model results are displayed in Figures 3 and 4.

**Project: TOF**  
**Group: 10-yr Wave, 1hr Duration**

Case: Penfield					
Windspeed Adjustment and Wave Growth					
Breaking criteria	0.780				
Item	Value	Units	Wind Obs Type		
El of Observed Wind (Zobs)	30.00	feet	Shore (windward)		
Observed Wind Speed (Uobs)	71.40	mph	Deep restricted		
Air Sea Temp. Diff. (dT)	0.00	deg F	Restricted Fetch Geometry		
Dur of Observed Wind (DurO)	1.00	hours	#	Fetch Angle (deg)	Fetch Length (miles)
Dur of Final Wind (DurF)	1.00	hours	1	30.00	0.76
Lat. of Observation (LAT)	41.20	deg	2	40.00	0.92
Results			3	50.00	1.69
Wind Fetch Length (F)	40.67	MILES	4	60.00	1.44
Wind Direction (WDIR)	90.00	deg	5	70.00	4.69
Eq Neutral Wind Speed (Ue)	72.23	mph	6	80.00	5.85
Adjusted Wind Speed (Ua)	123.30	mph	7	90.00	46.06
Mean Wave Direction (THETA)	94.00	deg	8	100.00	37.59
Wave Height (Hmo)	9.02	feet	9	110.00	20.54
Wave Period (Tp)	5.72	sec	10	120.00	23.09
Wave Growth:	Deep		11	130.00	17.60
			12	140.00	14.86
			13	150.00	12.45
			14	160.00	14.34
			17	190.00	0.37

Figure 3: ACES Model Results for Offshore Design Wave 10-yr



Project: TOF  
Group: 5-yr Wave, 1hr Duration

Case: Penfield			
Windspeed Adjustment and Wave Growth			
Breaking criteria	0.780		
Item	Value	Units	
<b>El of Observed Wind (Zobs)</b>			
El of Observed Wind (Zobs)	30.00	feet	
<b>Observed Wind Speed (Uobs)</b>			
Observed Wind Speed (Uobs)	61.20	mph	
<b>Air Sea Temp. Diff. (dT)</b>			
Air Sea Temp. Diff. (dT)	0.00	deg F	
<b>Dur of Observed Wind (DurO)</b>			
Dur of Observed Wind (DurO)	1.00	hours	
<b>Dur of Final Wind (DurF)</b>			
Dur of Final Wind (DurF)	1.00	hours	
<b>Lat. of Observation (LAT)</b>			
Lat. of Observation (LAT)	41.20	deg	
<b>Results</b>			
Wind Fetch Length (F)	40.67	MILES	
Wind Direction (WDIR)	90.00	deg	
Eq Neutral Wind Speed (Ue)	61.86	mph	
Adjusted Wind Speed (Ua)	99.80	mph	
Mean Wave Direction (THETA)	94.00	deg	
Wave Height (Hmo)	6.83	feet	
Wave Period (Tp)	5.03	sec	
Wave Growth:	Deep		17
			190.00
			0.37

Figure 4: ACES Model Results for Offshore Design Wave 5-yr

The design offshore wave height and period were computed to be  $H_{mo} = 9.02$  ft and  $T_p = 5.72$  sec for the 10-yr case and  $H_{mo} = 6.83$  ft and  $T_p = 5.03$  sec for the 5-yr case. These wave heights and periods were compared to the computed wave heights and periods at the other four Fairfield Town beaches Jennings, South Pine Creek, Sasco, and Southport Beach. Since the wave height and periods of each of the beaches were within a few 100ths of each other for each beach, the maximum ( $H_{mo} = 9.04$  ft and  $T_p = 5.73$  sec for the 10-yr case and  $H_{mo} = 6.85$  ft and  $T_p = 5.04$  sec for the 5-yr case) was used as a conservative design wave such that there was consistency at each beach. The modeling methodology that was employed is typically acceptable for FEMA wave and flood analyses.

As waves travel over and through Long Island Sound they will be modified by the effects of reduced depths and variations in shoreline and bottom configurations. The effects of these physical constraints will transform the incoming waves and effectively change the incident wave height, length and direction at the nearshore site. These incident waves were further transformed as the waves propagate up and over the beach and backshore and continue inland. The numerical model SBEACH (Ref 7) was used to simulate the wave conditions as the waves moved inland.



### 3.4. Design Storm

The SBEACH modeling was employed to estimate the quantities and limits of anticipated beach and backshore erosion that will result during the simulated storm events. A synthetic storm was generated to simulate a Nor'easter for both the 5-yr and 10-yr storm using the design waves and water levels described above. The design synthetic storm surge took the shape of a cosine squared function ( $\text{COS}^2$ ) and was added on to normal tides experienced at the site expressed as a sine function. Mean high water (El. +3.2 ft NAVD 88), the mean tide level (El. – 0.2 ft NAVD 88), and mean low water (El. -3.6 ft NAVD 88) were obtained determined using information from the NOAA's Southport and Bridgeport Tide Station (Ref 2) and were used to generate the normal tide function. The time series of the synthetic storms for the 10-yr and 5-yr events are displayed below in Figures 5 and 6, respectively.

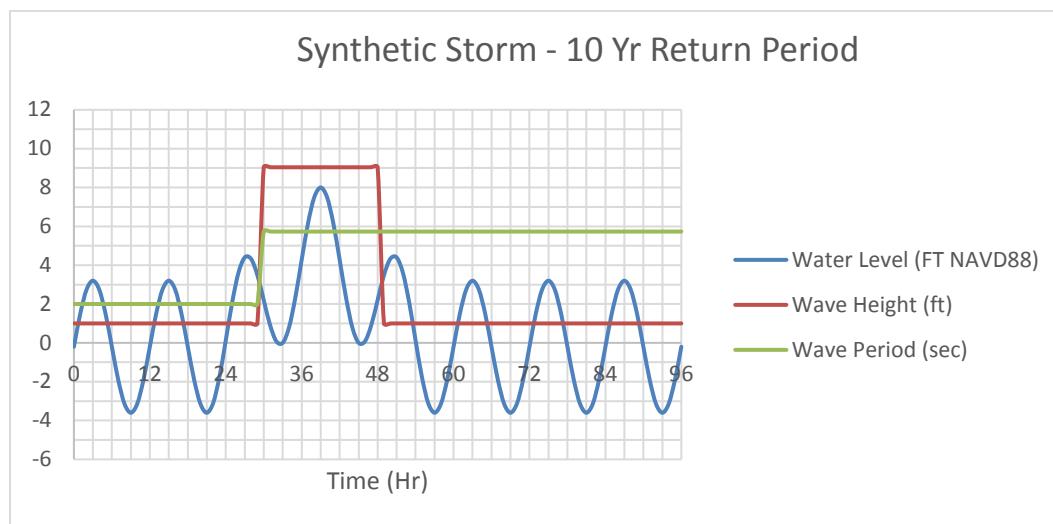


Figure 5: 10-yr Design Storm

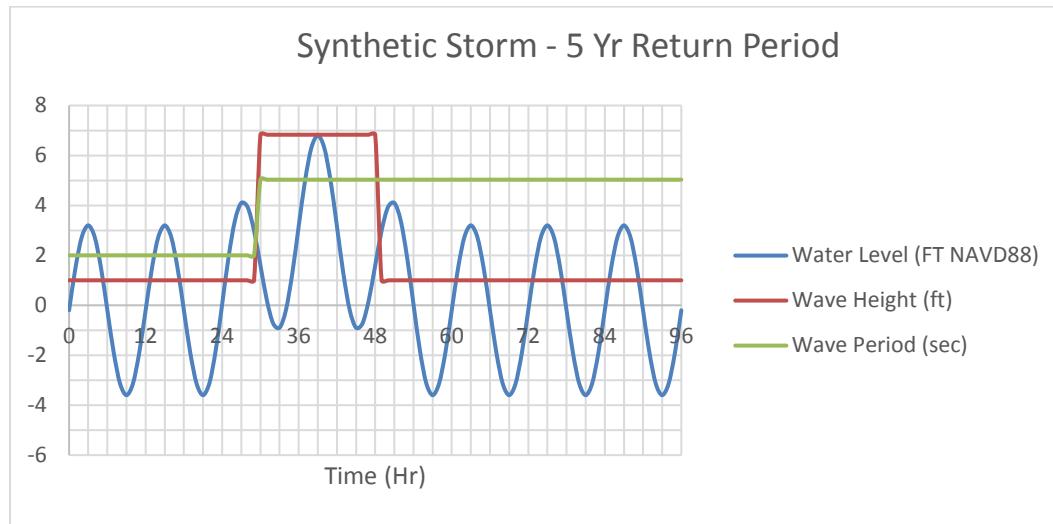


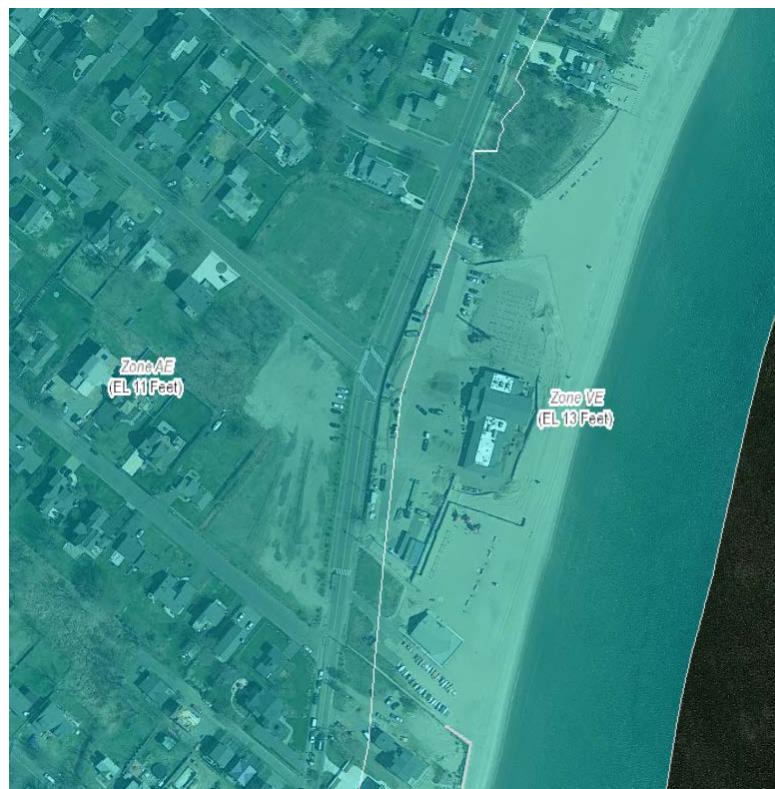
Figure 6: 10-yr Design Storm



The design storm was input into SBEACH along two transects across the site. The model transformed the storm waves along the profile and the results were used to assess the beach conditions and site resiliency during these events.

### 3.5. FEMA Flood Map Data

The currently effective FEMA Flood Insurance Rate Map (FIRM) Panel No. 90001C0438G, revision date July 8, 2013, shows the site to be primarily mapped as a Zone VE with a Base Flood Elevation (BFE) of El. +13' (NAVD 88). The upper reaches of the site are mapped as a Zone AE with a BFE of El. +11' (NAVD 88). These areas are shown on the segment of the FIRM panel included in Figure 7 (Ref 8).



**Figure 7: Flood Insurance Rate Map of Study Area**

The BFE and flood zone designations shown on the 2013 FIRM are based on beach and backshore/dune grade elevations that were available to FEMA at the time that the FIRM was produced. The effects of any beach morphology, i.e. erosion and accretion, since that time are not reflected on the FIRM. The entire site is considered by FEMA to be located within a Special Flood Hazard Area (SFHA) that can be inundated during storm events. Waves in excess of 3 ft in height with periods on the order of 6 seconds can and will impact this site during large return period events. Proper design, using appropriate coastal engineering tools, of any beach and/or backshore improvement at this site is critical to meeting the resilient, sustainable and environmentally responsible goals established by FEMA and other agencies.



## 4. Site Resiliency & Shoreline Design

The site is an unprotected beach composed of unconsolidated sand that is subject to the whims of winds, tides, currents, and waves. Storms have the potential to cause dramatic changes to the beach system resulting in changes in the beach profile that are not recoverable by natural processes. The Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), 42 U.S.C. 5121-5206, as amended, Sections 403 and 406; and 44 Code of Federal Regulations (CFR) §§ 206.225, Emergency work, and 206.226, Restoration of damaged facilities, authorized FEMA's Public Assistance (PA) Program to fund replacement of sand on damaged public beaches under the conditions that include (Ref 9):

### **Emergency Work:**

- Eliminate or lessen immediate threats to life, public health, or safety
- Eliminate or lessen immediate threats of significant additional damage to improved property
  - Immediate threat means that there is a threat of additional damage or destruction from an event which can reasonably be expected to occur within five years
  - Emergency work to eliminate or lessen immediate threats of additional damage to improve the property must be cost effective

### **Permanent Work:**

- The beach was constructed by the placement of imported sand (of proper grain size) to a designed elevation, width, and slope
- A maintenance program involving periodic nourishment with imported sand has been established and adhered to by the applicant
- The maintenance programs preserve the original design

### **4.1. Design of Beach Fill**

A variety of beach profiles and grain size distributions were analyzed in order to determine the optimal profile design for the Penfield Beach site. The Storm-induced Beach Change Model (SBEACH) was used to simulate potential cross-shore beach erosion of the representative beach profiles. The design storms, cross-shore topography, and grain size were input into the model. Winds, waves, and stillwater elevations that are typical of the 10-yr and 5-yr return periods were used to develop design storms as described in Section 3.4 and the effects these storms would have on cross section profiles were modeled.

The model also calls for additional parameters including maximum slope prior to avalanching, transport rate coefficient, overwash transport parameter, coefficient for slope-dependent term, and transport rate decay coefficient multiplier to be input. These parameters may be



manipulated such that the model may be calibrated for site specific cases. Site specific calibration of the model was difficult due to lack of pre-and post-storm profiles, and as such, these parameters were determined from the USACE's calibration of SBEACH based on field data in Duck, NC, Manasquan, NJ, Point Pleasant, NJ and Torrey Pines, CA. These parameters were determined to be the best available data (ref 7). As Jennings Beach is maintained, pre-and post-storm data for the site may become available, and model calibration may be improved. The SBEACH input is tabulated below in Table 3.

SBEACH Parameter	Value
Effective Grain Size	0.66 mm
Maximum slope prior to avalanching	30 deg
Transport rate coefficient	1.75E-06 m <sup>4</sup> /N
Overwash transport parameter (Kb)	0.005
Coefficient for slope-dependent term	0.002 m <sup>2</sup> /S
Transport rate decay coefficient multiplier	0.5
Water temperature	20 deg C
Topographic Data	Varies per transect

Table 3: SBEACH Parameters

The dimensions of the beach cross-sectional design profile and the volumes of sand required to obtain the design profiles are discussed in the following sections. The beach profile is defined to include the backshore / berm elevation, berm width, dune dimension, profile shape, and volume of cross-sectional fill (Ref 10).

#### 4.1.1 FEMA Considerations

In order for a permanent work site to be eligible for Emergency Assistance, the beach must be designed to include the placement of imported sand of a proper grain size to a designed elevation, width, and slope. A maintenance plan that involves the periodic nourishment to preserve the original design must also be in place for the site to be eligible for Emergency Assistance.

The Applicant must provide FEMA with design studies, plans, construction documents, and as-built record drawings for the original nourishment as well as for every subsequent nourishment operation. It is further necessary that documentation and a detailed description of the maintenance plan, including how the need for nourishment is determined and funded be provided to FEMA. The plan must include pre- and post- storm beach profiles that extend at least to the seaward edge of the sub-aqueous nearshore zone. In order to obtain FEMA funding, the beach must be continually monitored and maintained.



Only sand that is lost during a disaster event is eligible for funding. The cost to replace sand eroded prior to the disaster is not eligible for FEMA funding. “One-time” nourishments are not eligible for funding. The beach must be continually maintained. In addition, partial renourishments or “hot-spot” nourishments are not considered maintenance and therefore are not eligible for funding. Sand not selected to meet compatibility design criteria (i.e. sand from a channel maintenance project) is also not eligible (Ref 9).

#### 4.1.2 Engineering Analysis

Engineering analyses were performed to determine the optimum beach profile shape, backshore / berm and dune geometry, sand grain size distribution, and required volume of fill. The Storm-induced Beach Change Model (SBEACH) was used to simulate cross-shore transport of two profiles along the project site. These profiles are referred to as the Penfield Transect 1 (P-1) and Penfield Transect 2 (P-2). P-1 was located at the southernmost end of the beach and P-2 was taken at the northern end of the beach. The locations of these transects are displayed on the Site Plan included in Appendix D. Wind, waves, and stillwater elevations that are typical of the 10-yr and 5-yr return periods were modeled to gain an understanding of the beach system’s response to storms with these return periods. The results of the SBEACH model simulations are also provided in Appendix D.

The SBEACH modeling demonstrated that Transects P-2 was most susceptible to damage during the design storms. Transect P-1 performed well during the design storms, and was chosen as the design profile. It is common practice to determine the design profile by mimicking a beach profile that is performing well during design storms. A design profile may be planned by translating an average profile shape from a healthy beach condition (Ref 10).

#### Grain Size

The median grain size of sand found on the beach was 0.66 mm. Mean grain size influences the generalized beach slope. Coarser grain size is generally seen on beach profiles with steeper beach slopes, while beaches with more mild slopes tend to have finer grain sand (Ref 11).

It is preferred that fill material used in a beach nourishment program be as similar in grain size to the native beach as possible (Ref 11). Borrow material, i.e. sand borrowed from sources other than the beach, for beach fill that is identical to the natural material is usually not available. After a source of borrow material is identified, the design volume of fill is typically adjusted by a “fill” and/or “nourishment” factor. Essentially, these factors allow the designer to estimate the relative performance of borrow materials with respect



to the native materials. Volume factors are used to calculate a required overfill to compensate for the volume of undersized borrow material that will be lost due to erosion, following both initial placement and to increase project longevity. Essentially, larger grain sand remains on the beach longer than fine sand. The construction documents in Appendix B take this into account, and require the contractor to submit grain size of import material to the engineer for approval.

### **Berm**

The *Coastal Engineering Manual* (Ref 10) recommends that the elevation of the nourished berm or backshore area correspond to the natural berm crest. Field observations and measurements at the site revealed that the natural berm crest at the Penfield Beach site varied from approximately in elevation from El. +8' to El. +12' (NAVD 88). The higher section of berm or backshore was found in the general vicinity of Transect P-2.

The model results show that, during the 5-yr and 10-yr events, the parking lots, pavilion, and other structures located on the flat planar berm will not likely be damaged as a result of erosion and that the current berm width is sufficient to manage the effects of the design storm events. The engineering plans enclosed have been designed to minimize the amount of fill necessary and to avoid placing sand below mean low water as this would be subject to stricter regulatory requirements, and as such, do not extend the width of the berm. A broader berm width may be desired by the Town to protect from storms of a greater intensity or for complementary reasons such as providing a more spacious beach for public enjoyment. It should be noted that even structures that are located outside of the potentially eroded berm area may be susceptible to scour imposed damage if they are lower than the 100-yr total water level.

### **Dune**

Dunes protect upland property against waves, erosion, and flooding during storm events. The natural dune system at the Penfield Beach site crest is terminated when the pavilion intersects the dune. It is recommended that the Town considers extending this dune. The recently constructed pavilion, is elevated, and as such a dune may be constructed beneath this structure. The engineering plans enclosed have been designed to minimize the amount of fill necessary, and as such do not include specifications for dune construction. Should the Town choose to enhance the dune, a reconstructed dune in this area should have a finished crest at El. +15' to El. +20' NAVD 88 with a minimum width of 30' and 1V:5H side slope. Such a dune system would provide a large volume of sand that would compensate for future storm induced erosion and aid in protecting upland structures from waves. The practicality of an extensive dune should be investigated.



#### 4.1.3 Beach Profile Design

In a situation where the median grain size of the fill material is the same as that of the native beach sand, the beach profile may be obtained by translating an average profile shape from a healthy beach condition (Ref 10). Sand must be placed to nourish the entire profile extending waterward to the depth of closure. The depth of closure is generally considered to be the seaward limit of the littoral zone. Kraus, et al. (Ref 11) more generally describe the depth of closure for a characteristic time interval to be the most landward depth, seaward of which there is no significant change in bottom elevation and no significant net sediment transport between the nearshore and the offshore. The depth of closure was determined for the Penfield Beach system using the *Coastal Engineering Manual* (Ref 10) Eq. III-3-9. The depth of closure for the 5-yr event was conservatively determined to be 13.1'. This depth corresponds to El. -6.3'. This closure analysis shows that the two profiles are healthy sections of the beach, exhibiting minimal offshore movement of sand.

The SBEACH analysis demonstrated that the profile of P-1 behaves most favorably under 5-yr and 10-yr conditions. It is, therefore, recommended that this profile be translated throughout the site and established as the optimal design profile. Extending this optimum nourishment profile template across the entire  $1,000 \pm$  linear feet of Penfield Beach could be accomplished by regrading the beach. The design template included in the construction drawings requires approximately 100 CY of material to be imported. The beach should be nourished every few years to maintain this profile. Import material shall match the grain size of the native beach sand per the specifications on the construction drawings. A maintenance plan is detailed below in section 4.2.

For the case where the median grain size of the sand material from a borrow site that is not identical to the natural beach's median grain size, the volume of sand used to nourish the beach must be adjusted by a fill factor such that the equilibrium profile is that which is desired (Ref 12). The contractor shall inform the engineer if import material differs from native beach sand. A fill factor can be determined using the *Beach Nourishment Overfill Ration and Volume* module of the *Automated Coastal Engineering System (ACES)*.

### 4.2. Operation and Maintenance Plan

As part of this study, vertical and horizontal control was established at the site. These include three (3) monuments with brass disc and punch set into the ground in accordance with land survey standards. Documentation of these benchmarks is included in Appendix C of this report. Maintenance and periodic confirmation of these benchmark stations should be performed.

Regular maintenance of beach nourishment projects is important to maintain the beach profile and prevent erosion and damage. The level of protection in the aftermath of a major storm will



be decreased if proper maintenance is not performed. Beaches that have eroded to a critical condition are not eligible for FEMA funding. The beach must be maintained through scheduled renourishments (Ref 9). Maintenance includes periodic nourishment, advance nourishment, and emergency maintenance. The SBEACH model simulations demonstrated that a modest amount of sand will be lost during storm events and that will need to be replaced.

The volume of import material will need to be adjusted by the fill factor based upon the grain size determination of the borrow material. The necessary volume of import sand should be adjusted as the monitoring program continues and an historical record of the actual beach response is established.

It is critical to the successful operation and maintenance of the Penfield Beach management plan that a monitoring plan be established that will serve as a basis for determining when and how much maintenance is required (Ref 10). The quantity of sand that is eligible for FEMA funding for replacement is limited to the volume lost during a disaster event. It is essential that pre- and post-storm profiles of the beach be determined by survey so as to establish a basis for claims to FEMA.

The pre- and post- storm profiles are used to determine the volume of sand (Ref 9) that is lost. In order to establish a pre- storm profile, it is recommended that, as a minimum, the beach be surveyed and mapped biennially or more frequently if conditions warrant. The design beach profile, described in the body of this report, should be established as a baseline to be reestablished after any major storm event. Monitoring and historical record keeping is an essential part of the Operation and Maintenance Plan so the Town can evaluate the volume of sand necessary for historical maintenance and that volume may be adjusted.

In addition to biennial beach monitoring surveys, hydrographic surveys of the subtidal area located seaward of Penfield Beach should be performed at nominal three year intervals. These surveys will allow the Town to determine the fate of sand that is eroded during storm events and to verify the depth of closure.

## 5. Conclusions & Recommendations

Penfield Beach is a sandy beach site exposed to the waters of Long Island Sound. The site is dynamic in nature and is subject to erosion that results from wind and wave action during storms that frequent the region. The field studies and engineering analysis described herein demonstrate that the beach is in a fairly healthy state and that a modest beach maintenance program will serve to provide added protection against coastal storms as well as maintain the beach for recreational use by residents and visitors.

The studies, performed by **RACE** and described herein, establish a clear basis for specific recommendations and actions regarding Penfield Beach. These include:



- The Town of Fairfield should establish a Penfield Beach Management Program to be implemented on a biennial basis and in response to significant storm events;
- It was demonstrated that the Management program should accommodate a beach profile sufficient to manage a coastal storm with a typical 10-year return period;
- The Management Program should establish the P-1 Profile, as determined by these analyses, as the optimum design profile to be maintained along the approximate 1,000 linear feet of Penfield Beach;
- The Town should regrade Penfield Beach, based upon the latest topographic survey of the beach and backshore, to establish the P-1 Profile geometry throughout the project area of Penfield Beach. Import material, should it be necessary, shall be properly sized per the construction drawing specifications. If grain size of native material cannot be matched, fill amounts shall be adjusted with a properly designed fill factor;
- The Management Program should focus on the beach and backshore / berm areas and NOT include the establishment of a dune system at this site. The dune may be enhanced should the Town want additional protection from wave action;
- The Town should establish, as a part of the Penfield Beach Management Program, a beach monitoring program to include, but not necessarily be limited to (1) a biennial survey of Penfield Beach to assess beach resiliency and variations of the beach profile(s) from the optimum design profile, (2) post-storm event beach survey(s) to assess the impact of the storm on the beach profile, and (3) periodic hydrographic surveys of the area seaward of Penfield Beach to identify and quantify the fate of sand that is eroded from Penfield Beach;
- Anticipate that periodic nourishment of Penfield Beach will be necessitated by the cumulative erosion of the beach caused by storm events.



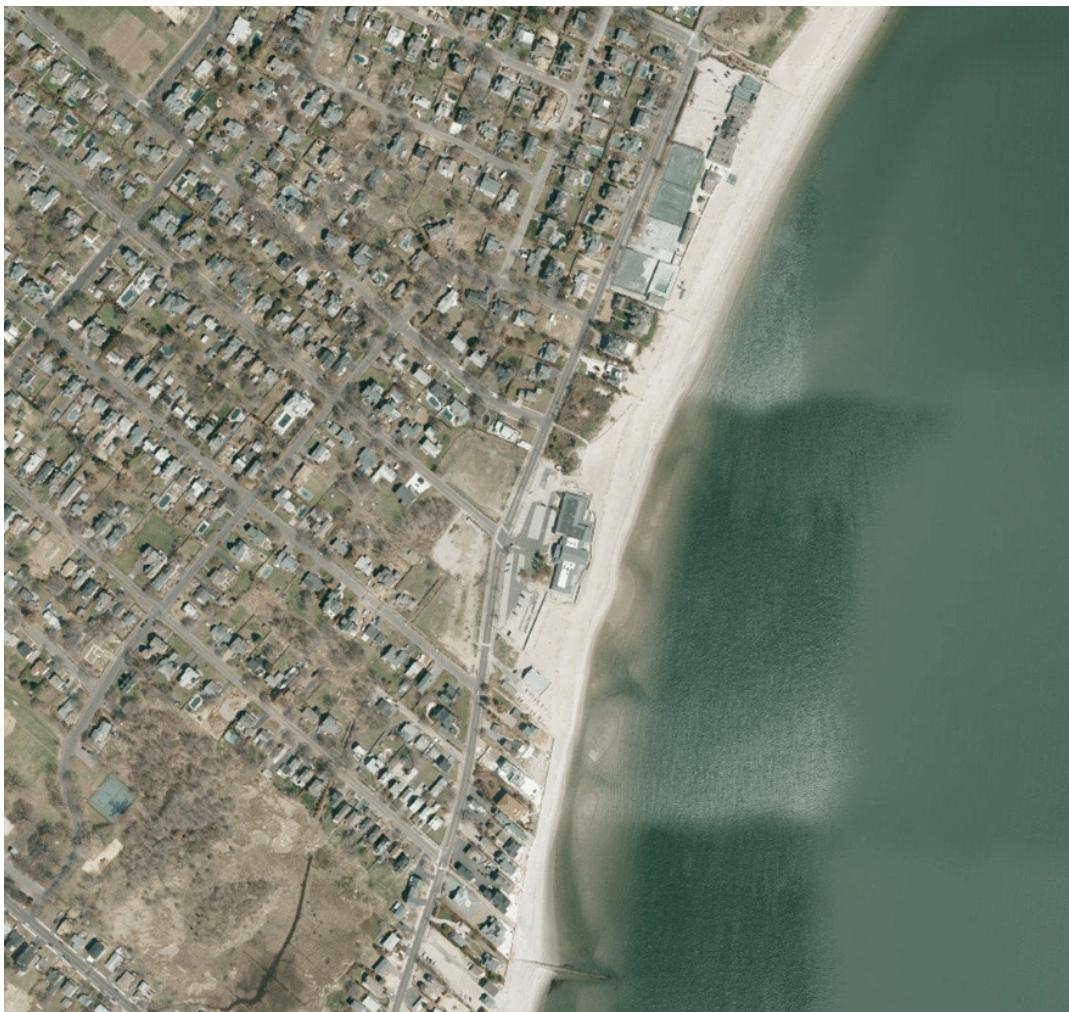
## References

1. Connecticut Department of Energy & Environmental Protection, *Coastal Policies and Use Guidelines, Planning Report No. 30*. Hartford, CT, December 1979.
2. National Oceanic and Atmospheric Administration (NOAA), "NOAA Tides and Currents." *NOAA Tides and Currents - Home*. Web. 2013.
3. Federal Emergency Management Agency (FEMA), *Flood Insurance Study No. 09001CV001C*. October 16, 2013.
4. Federal Emergency Management Agency (FEMA), *Fairfield\_Summary\_9\_26\_11*. Sept 26, 2011.
5. American Society of Civil Engineers (ASCE), *Minimum Design Loads for Buildings and Other Structures*. ASCE 7-05, 2006.
6. "Automated Coastal Engineering System (ACES)" in "Coastal Engineering Design & Analysis System (CEDAS)." Version 4.03. Vicksburg, MS, 2013.
7. Larson, et. Al. "SBEACH: Numerical Model for Simulating Storm-Induced Beach Change- Report 2" Department of the Army – Waterways Experiment Station. Vicksburg, MS, May 1990.
8. Federal Emergency Management Agency (FEMA), *Flood Insurance Rate Map No. 090001C0438G*. July 8, 2013.
9. Federal Emergency Management Agency (FEMA), Memorandum: *Disaster Assistance Fact Sheet DAP9580.8 Eligible Sand Replacement on Public Beaches*, October 1, 2009.
10. U.S. Army Corps of Engineers. "Coastal Engineering Manual." Vicksburg, MS, 2002.
11. Kraus, N.C., Larson, M. and Wise, R.A, "Depth of Closure in Beach-fill Design," Coastal Engineering Technical Note CETN II-40, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, March 1998.
12. Donald K. Stauble, Ph.D., PG, "A Review of the Role of Grain Size in Beach Nourishment Projects." U.S. Army Research and Development Center Coastal Hydraulics Laboratory. Vicksburg, MS.



## **Appendix A: Site Photographs**





*Source: ESRI World Imagery, 2011*

**Photo 1: Aerial Photograph – Penfield Beach**





**Photo 2: Site Looking North**



**Photo 3: Site Looking South**





Photo 4: Construction Area May 2016

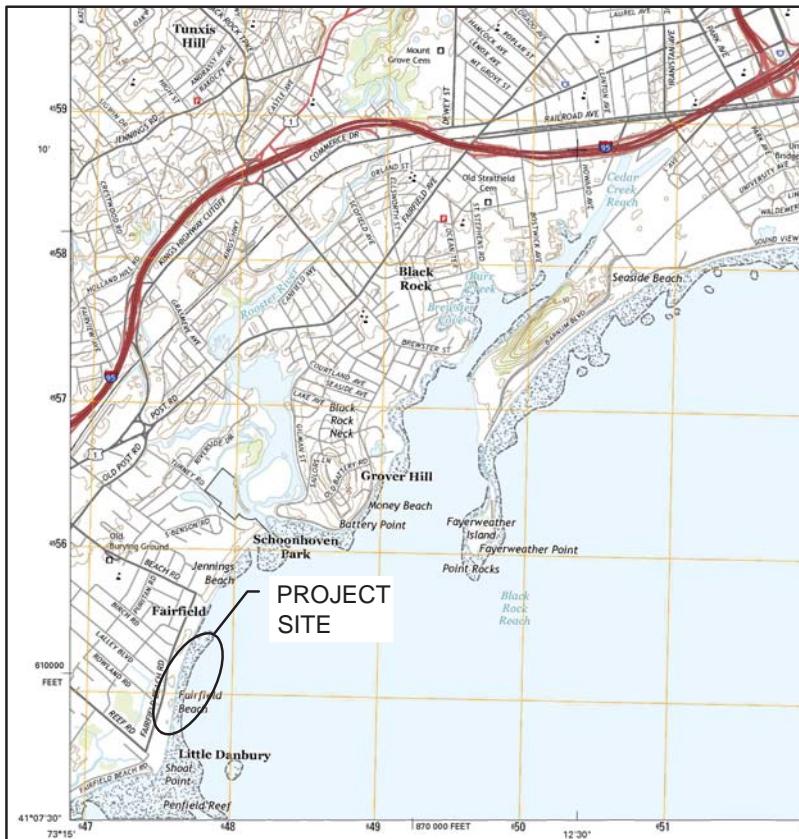


## **Appendix B: Construction Drawings**

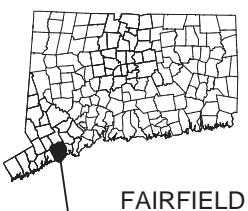


# PENFIELD BEACH ENGINEERED BEACH DESIGN FAIRFIELD BEACH ROAD FAIRFIELD, CT

04/12/2017



## VICINITY MAP



AERIAL PHOTO

## LIST OF DRAWINGS

DRAWING NO.	DRAWING NAME
1	TITLE SHEET, DRAWING LIST & VICINITY MAP
2	PROJECT NOTES
3	SITE PLAN
4	GRADING PLAN
5	SECTIONS

611 Access Road Stratford, CT 06615  
Tel: 203-377-0663 [www.racecoastal.com](http://www.racecoastal.com)

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REARED FOR:  
CONSERVATION DEPT  
TOWN OF FAIRFIELD  
725 OLD POST RD  
FAIRFIELD, CT 06434

PROJECT:  
PENFIELD BEACH  
ENGINEERED BEACH DESIGN  
FAIRFIELD BEACH ROAD  
FAIRFIELD, CT

**DRAWING:**

Designed By:	Date:
JAP	04/12/2017
Drawn By:	Scale:
JAP	As Noted

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725 OLD POST RD  
FAIRFIELD, CT 06824

1

PENFIELD BEACH  
ENGINEERED BEACH DESIGN  
FAIRFIELD BEACH ROAD  
FAIRFIELD, CT

1

## SITE PLAN

NOTE: UNDERGROUND UTILITY, STRUCTURE AND FACILITY LOCATIONS DEPICTED AND NOTED HEREIN HAVE BEEN COMPILED, IN PART, FROM RECORD MAPPING AND LIMITED FIELD MEASUREMENTS. THESE LOCATIONS MUST BE CONSIDERED AS APPROXIMATE IN NATURE. ADDITIONALLY, OTHER SUCH FEATURES MAY EXIST ON THE SITE. THE SIZE, LOCATION AND EXISTENCE OF ALL SUCH FEATURES MUST BE FIELD DETERMINED AND VERIFIED BY THE APPROPRIATE AUTHORITIES PRIOR TO CONSTRUCTION. CALL BEFORE YOU DIG 1-800-423-1455.

**SITE PLAN**

SCALE: 1" = 40'-0"

REduced copy - DO NOT SCALE

PROPERTY LINE (TYP)

MONUMENT WITH BRASS DISK & PUNCH SET #20  
N = 609871.05  
E = 864400.44  
ELEV = +3.84'

UTILITY POLE (TYP)

REBAR FOUND

OVERHEAD WIRE

PAVED AREA

WATER SPIGOT PILE (TYP)

FLAG POLE

GUY LINE

ROCK WALL (TYP)

BENCH MARK CORNER OF CONCRETE WALL  
ELEV. = +9.90'

CONC. WALL

REBAR FOUND

PILE (TYP)

GRILL (TYP)

SIGN (TYP)

SWING SET

EXISTING UTILITY (WATER MAIN, TYP) (SEE NOTE)

EXISTING UTILITY (ELECTRICAL, TYP) (SEE NOTE)

EXISTING UTILITY (GAS, TYP) (SEE NOTE)

EXISTING UTILITY (TELEPHONE, TYP) (SEE NOTE)

GUARD STATION

PARKING AREA

PARKING AREA

CURB (TYP)

MONUMENT WITH BRASS DISK & PUNCH SET #22  
N = 610604.85  
E = 864660.12  
ELEV = +5.82'

VEGETATION LINE

BOARDWALK

FENCE (TYP)

VEGETATION LINE

WOOD POST WITH ELECTRICAL BOX

GRILL (TYP)

LOCATION OF SAND GRAB SAMPLE (TYP)

C.J.L. EL. +5.2'

HTL EL. +4.7'

MHW EL. +3.2'

MLW EL. -3.6'

EBB FLOOD

NOTE: UNDERGROUND UTILITY, STRUCTURE AND FACILITY LOCATIONS DEPICTED AND NOTED HEREIN HAVE BEEN COMPILED, IN PART, FROM RECORD MAPPING AND LIMITED FIELD MEASUREMENTS. THESE LOCATIONS MUST BE CONSIDERED AS APPROXIMATE IN NATURE. ADDITIONALLY, OTHER SUCH FEATURES MAY EXIST ON THE SITE. THE SIZE, LOCATION AND EXISTENCE OF ALL SUCH FEATURES MUST BE FIELD DETERMINED AND VERIFIED BY THE APPROPRIATE AUTHORITIES PRIOR TO CONSTRUCTION. CALL BEFORE YOU DIG 1-800-922-4455.

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## PREPARE

CONSERVATION DEPT  
TOWN OF FAIRFIELD  
725 OLD POST RD  
FAIRFIELD, CT 06824

## PROJECT

PENFIELD BEACH  
ENGINEERED BEACH DESIGN  
FAIRFIELD BEACH ROAD  
FAIRFIELD, CT

## DRAWING

## GRADING PLAN

NOTES:

1. BLEND PROPOSED CONTOURS INTO EXISTING CONTOURS BEFORE STA. -0+65 AND AFTER STA. 4+34.
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6. GRADING SHALL REMAIN ABOVE MLW.
7. BLEND PROPOSED CONTOURS AROUND EXISTING BUILDING.
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4 of 05

PROPERTY LINE (TYP)

REBAR FOUND

WORKING POINT #1 MONUMENT WITH BRASS DISK & PUNCH SET #20 N = 609871.05 E = 864400.44 ELEV = +3.84'

PAVED AREA

WATER SPIGOT

CONC. WALL

KAYAK STORAGE (SEE NOTE 5&6)

BENCH MARK CORNER OF CONCRETE WALL ELEV. = +9.90'

CONC. WALL

CYL EL. +5.2' HTL EL. +4.7'

AR AND

EXISTING CONTOURS (TYP)

SEE NOTE 1

370'-7"

363'-4"

343'-6"

329'-8"

332'-3"

336'-6"

370'-7"

363'-4"

343'-6"

329'-8"

332'-3"

336'-6"

PROPERTY LINE (TYP)

SEE NOTE 1

STA -0+85

STA -0+44

STA 0+00

STA 0+35

STA 2+63

STA 4+14

STA 7+52

STA 8+23

STA 9+39

UTILITY POLE (TYP)

EXISTING UTILITY (WATER MAIN, TYP) (SEE NOTE 2)

EXISTING UTILITY (ELECTRICAL, TYP) (SEE NOTE 2)

OVERHEAD WIRE

LIGHT

ROCK WALL

PARKING AREA

FLAG POLE ON CONCRETE PAD

SWING SET

PLAYGROUND

UTILITY POLE GUY LINE

WOOD PAD WITH SHOWER

PILE (TYP) (SEE NOTE 5)

GRILL (TYP) (SEE NOTE 5)

SIGN (TYP) (SEE NOTE 5)

EXISTING BUILDING

EXISTING UTILITY (GAS, TYP) (SEE NOTE 2)

CURB (TYP)

VEGETATION LINE

WOOD POST WITH ELECTRICAL BOX

BOARD-WALK

FENCE (TYP)

VEGETATION LINE

SEE NOTE 1

PROPOSED CONTOURS (TYP)

MLW EL. -3.6'

15' MIN

42'-6" (TYP)

36' (TYP)

60' (TYP)

15' MIN

NOTES:

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## GRADING PLAN

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SCALE: 1" = 80'-0"

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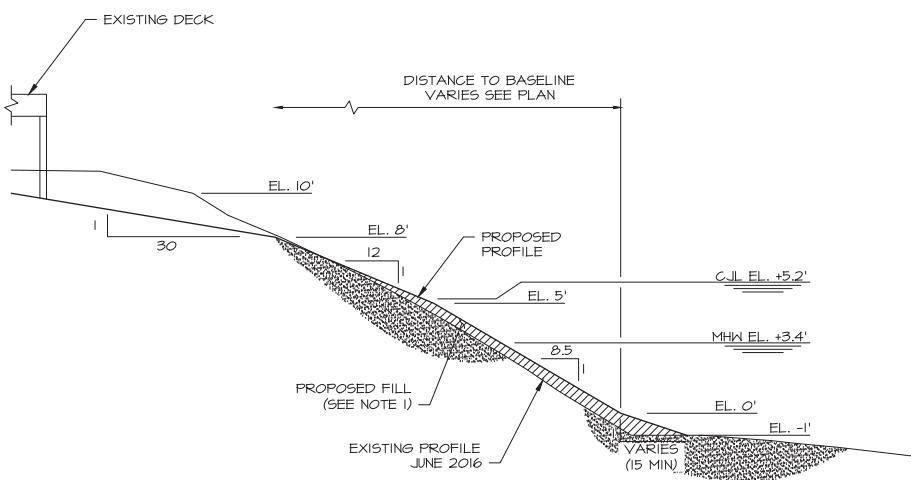
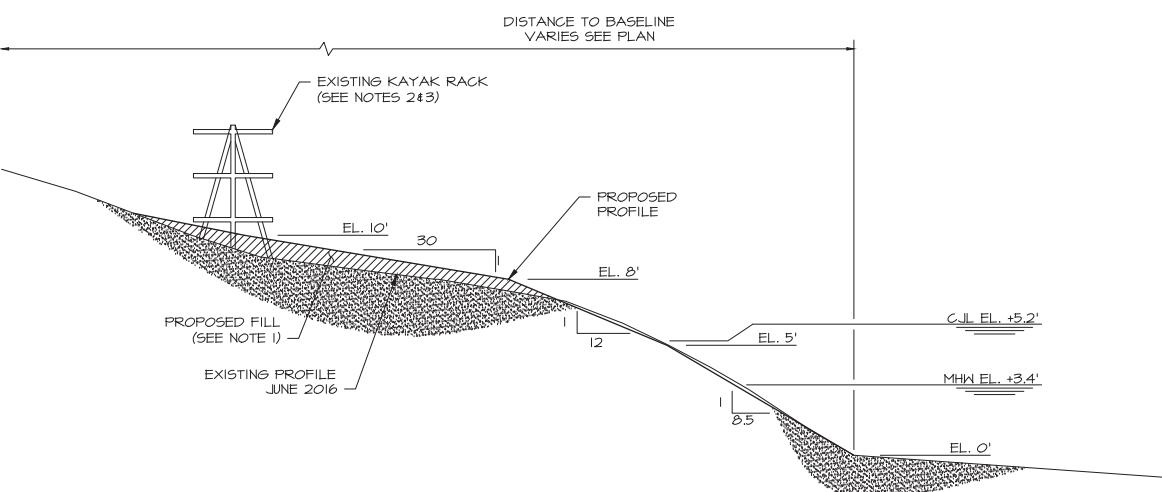
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PROJECT:

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ENGINEERED BEACH DESIGN  
FAIRFIELD BEACH ROAD  
FAIRFIELD, CT

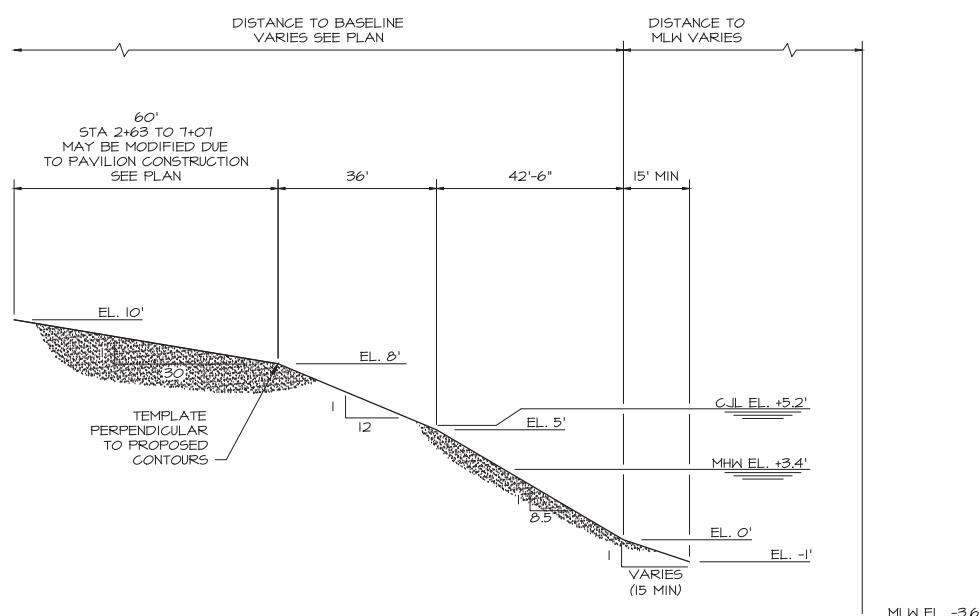
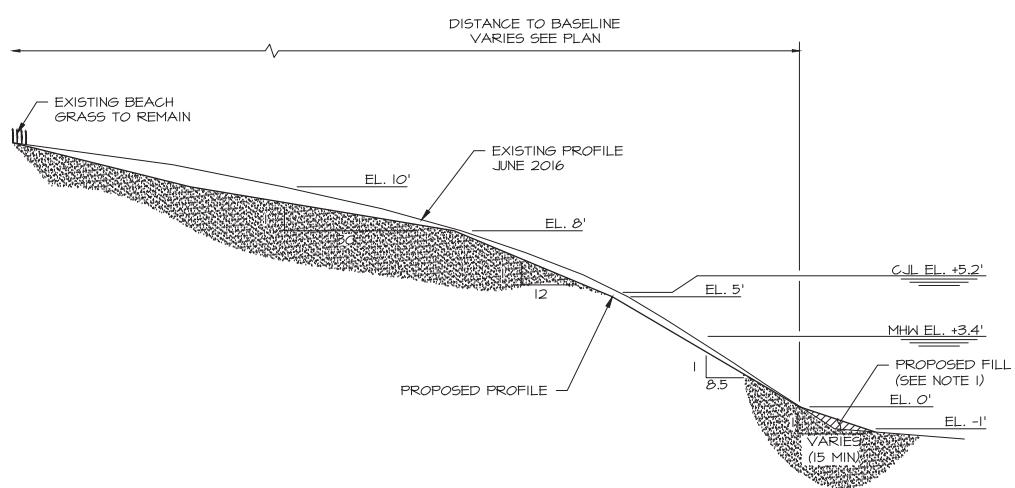
DRAWING:

SECTIONS



SECTION 1  
VERTICAL SCALE 1"=4'- HORIZONTAL SCALE 1"=20'

SECTION 2  
VERTICAL SCALE 1"=4'- HORIZONTAL SCALE 1"=20'



SECTION 3  
VERTICAL SCALE 1"=4'- HORIZONTAL SCALE 1"=20'

PROPOSED TEMPLATE  
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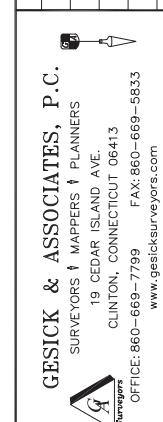
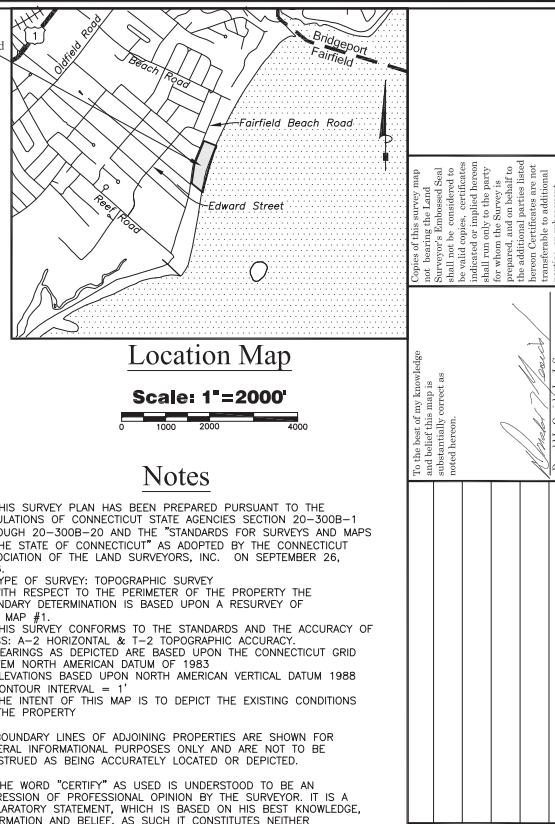
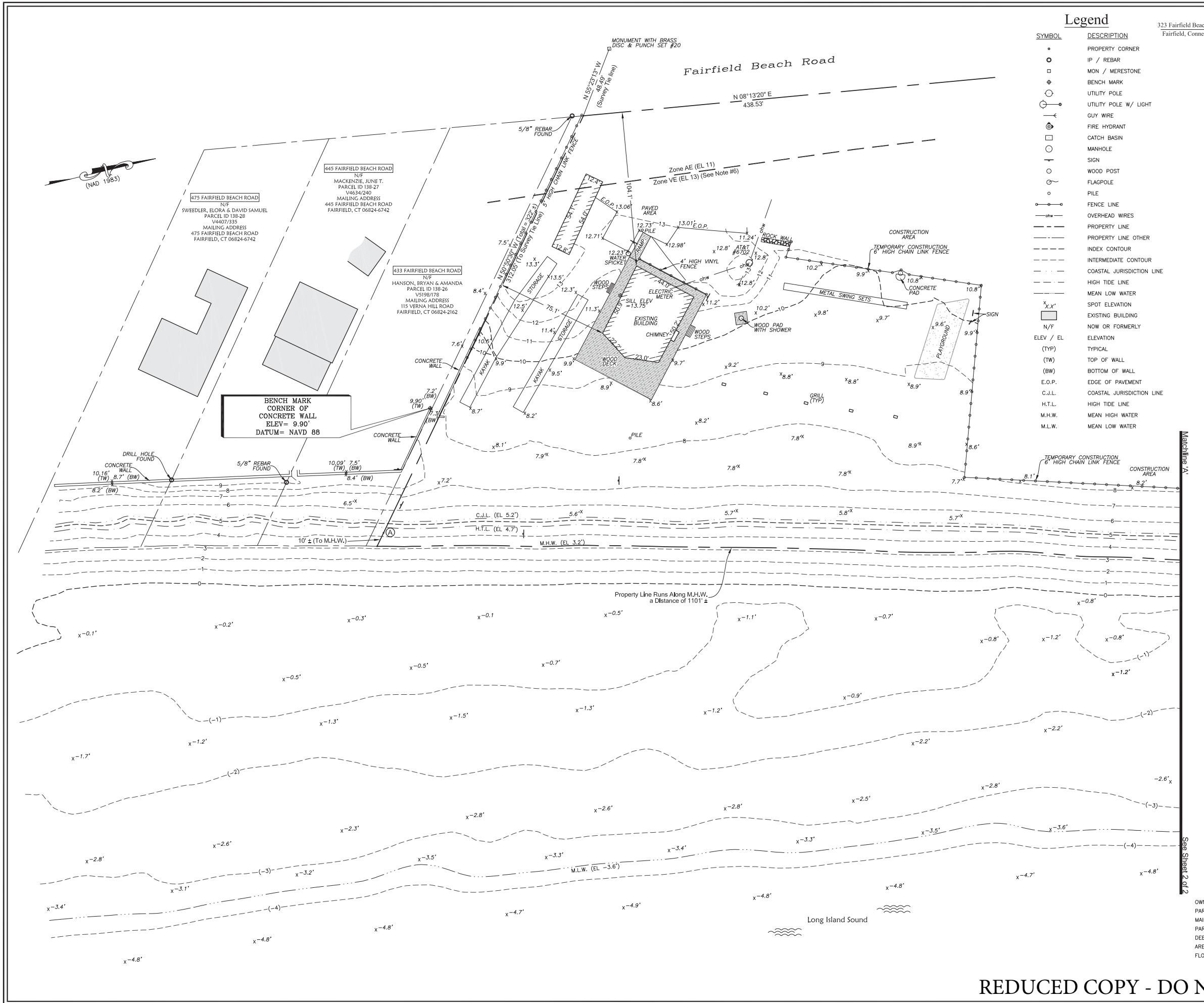
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Checked By:	ADS	Project Number:	201644
CAD File:	PENFIELD - REPORT DRAWINGS.DWG	Drawing No.:	
			5 of 05

## **Appendix C: Survey**





## Preference Maps

"TOWN OF FAIRFIELD DEPARTMENT OF PUBLIC WORKS PENFIELD  
PAVILION REPAIR FAIRFIELD BEACH ROAD FAIRFIELD CONNECTICUT"  
PREPARED BY TOWN OF FAIRFIELD DEPARTMENT OF PUBLIC WORKS  
DATED MAY 27, 2013 SCALE 1" = 40'

Topographic Survey

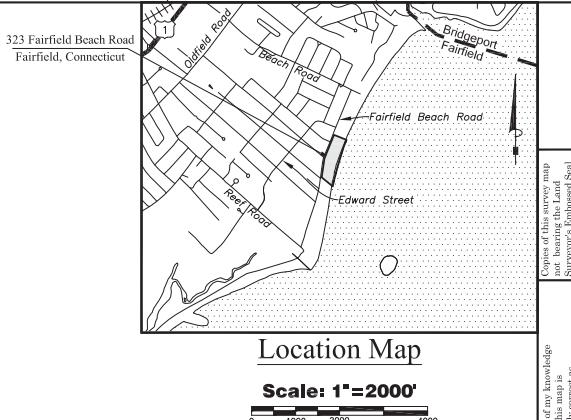
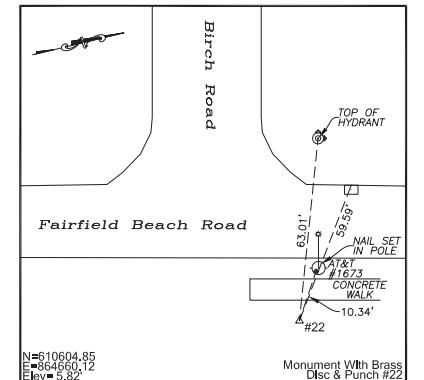
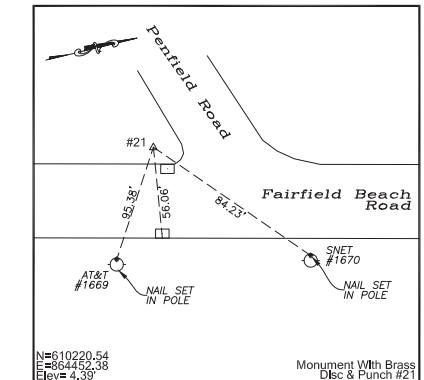
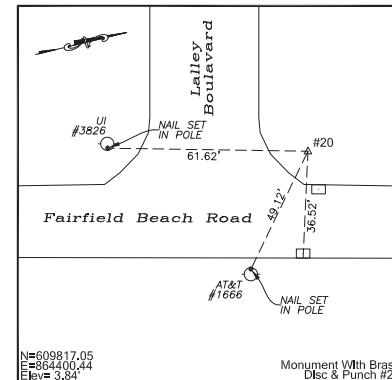
- 1 -

### Subject Parcel Information

Subject Parcel Information  
OWNER: THE TOWN OF FAIRFIELD  
PARCEL ADDRESS: 323 FAIRFIELD BEACH ROAD FAIRFIELD, CONNECTICUT 06824  
MAILING ADDRESS: 725 OLD POST ROAD FAIRFIELD, CONNECTICUT 06824  
PARCEL ID: MAP 138 LOT 23  
DEED: VOLUME 616 PAGE 496  
AREA: 332,540.32 SQ. FT. ± OR 7.63 ACRES ±  
FLOOD ZONE: ZONES AE (EL 10) & VE (EL 13) PER FIRM MAP  
COMMUNITY PANEL #09001C0438G DATED JULY 8, 2013  
DATUM = NAVD, 1988 (S.F.F. NOT #6).

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Scale: 1"=30'



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Donald L. Gesick, Jr., L.S.  
Reg. No. 18417

### Notes

1) THIS SURVEY PLAN HAS BEEN PREPARED PURSUANT TO THE REGULATIONS OF CONNECTICUT STATE AGENCIES SECTION 20-300B-1 THROUGH 20-300B-20 AND THE "STANDARDS FOR SURVEYS AND MAPS IN THE STATE OF CONNECTICUT" AS ADOPTED BY THE CONNECTICUT ASSOCIATION OF THE LAND SURVEYORS, INC. ON SEPTEMBER 26, 1996.

A. TYPE OF SURVEY: TOPOGRAPHIC SURVEY  
B. WITH RESPECT TO THE PERIMETER OF THE PROPERTY THE BOUNDARY DETERMINATION IS BASED UPON A RESURVEY OF REF. MAP #1.  
C. THIS SURVEY CONFORMS TO THE STANDARDS AND THE ACCURACY OF CLASS: A-2 HORIZONTAL & T-2 TOPOGRAPHIC ACCURACY.  
D. BEARINGS AS DEPICTED ARE BASED UPON THE CONNECTICUT GRID SYSTEM WITH AMERICAN DATUM OF 1983.  
E. ELEVATION BASED UPON NORTH AMERICAN VERTICAL DATUM 1988  
F. CONTOUR INTERVAL = 1'.  
G. THE INTENT OF THIS MAP IS TO DEPICT THE EXISTING CONDITIONS OF THE PROPERTY.

2) BOUNDARY LINES OF ADJOINING PROPERTIES ARE SHOWN FOR GENERAL INFORMATIONAL PURPOSES ONLY AND ARE NOT TO BE CONSTRUED AS BEING ACCURATELY LOCATED OR DEPICTED.

3) THE WORD "CERTIFY" AS USED IS UNDERSTOOD TO BE AN EXPRESSION OF PROFESSIONAL OPINION OF THE SURVEYOR. IT IS A DECLARATORY STATEMENT WHICH IS BASED ON HIS BEST KNOWLEDGE, INFORMATION AND BELIEF, AS SUCH IT CONSTITUTES NEITHER GUARANTEE NOR WARRANTY, EXPRESSED OR IMPLIED, OF ANY INFORMATION CONTAINED HEREON. NO CERTIFICATION IS EXPRESSED OR IMPLIED ON ANY ORIGINAL OR ANY DUPLICATE OF THIS MAP UNLESS IT BEARS AN ORIGINAL STAMP OR SEAL AND ORIGINAL SIGNATURE OF THE INDIVIDUAL WHOSE REGISTRATION NUMBER APPEARS HEREON.

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5) BASE MAPPING PREPARED BY GESICK & ASSOCIATES P.C. FROM A 5/31/2016 THRU 6/10/2016 SURVEYS.

6) THE FLOOD ZONE BOUNDARIES SHOWN WERE DERIVED UTILIZING FLOOD INSURANCE RATE MAPS. THE FLOOD ZONE BOUNDARIES WERE DIGITIZED AND ARE TO BE CONSIDERED AS APPROXIMATE ONLY AND FOR INFORMATIONAL PURPOSES ONLY.

7) UNDERGROUND UTILITY, STRUCTURE AND FACILITY LOCATIONS DEPICTED AND NOTED HEREON HAVE BEEN COMPILED, IN PART, FROM RECORD MAPPING AND LIMITED FIELD MEASUREMENTS. THESE LOCATIONS MUST BE CONSIDERED AS APPROXIMATE IN NATURE. ADDITIONAL FEATURES NOT SHOWN ON THIS MAP INCLUDE THE EXISTENCE OF WHICH ARE UNKNOWN TO GESICK & ASSOCIATES, P.C. THE SIZE, LOCATION AND EXISTENCE OF ALL SUCH FEATURES MUST BE DETERMINED AND VERIFIED BY THE APPROPRIATE AUTHORITIES PRIOR TO CONSTRUCTION, CALL BEFORE YOU DIG 1-800-922-4455.

8) SURVEY TIE LINE FOR MATHEMATICAL CLOSURE OF SURVEY, NOT PROPERTY LINE. SURVEY TIE LINE @ N 16°29'40" E = 1097.21'

GESICK & ASSOCIATES, P.C.  
SURVEYORS & PLANNERS  
19 CEDAR ISLAND AVE.  
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www.gesicksurvivors.com

### Topographic Survey

(Partial)  
Penfield Beach Road  
Fairfield, Connecticut  
Prepared for  
Roberge Associates Coastal Engineers, LLC

#### Legend

DESCRIPTION	SYMBOL	DESCRIPTION
PROPERTY CORNER	○	FENCE LINE
IP / REBAR	—○—	OVERHEAD WIRES
MON / MERESTONE	—■—	PROPERTY LINE
BENCH MARK	——	PROPERTY LINE OTHER
UTILITY POLE	——	INDEX CONTOUR
UTILITY POLE W/ LIGHT	——○—	INTERMEDIATE CONTOUR
GUY WIRE	—·—	COASTAL JURISDICTION LINE
FIRE HYDRANT	—·—	HIGH TIDE LINE
CATCH BASIN	——	MEAN LOW WATER
MANHOLE	○	NOW OR FORMERLY
SIGN	N/F	ELEV / EL
WOOD POST	(TYP)	ELEVATION
FLAGPOLE	(TW)	TOP OF WALL
PILE	(BW)	BOTTOM OF WALL
SPOT ELEVATION	E.O.P.	EDGE OF PAVEMENT
EXISTING BUILDING	—	COASTAL JURISDICTION LINE
	—○—	HIGH TIDE LINE
	—○—	MEAN HIGH WATER
	—○—	MEAN LOW WATER

Date: June 14, 2016  
Drawing: 16-053a  
Drawn: P.H.  
Sheet 2 of 2

## Appendix D: SBEACH Model Results



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REVISIONS:

NO.	DESCRIPTION	BY	DATE

NOT VALID WITHOUT ENGINEER'S SEAL:



CLIENT REVIEW ONLY  
NOT FOR CONSTRUCTION

PREPARED FOR:

CONSERVATION DEPT  
TOWN OF FAIRFIELD  
725 OLD POST RD  
FAIRFIELD, CT 06824

PROJECT:

PENFIELD BEACH  
ENGINEERED BEACH DESIGN  
FAIRFIELD BEACH ROAD  
FAIRFIELD, CT

DRAWING:

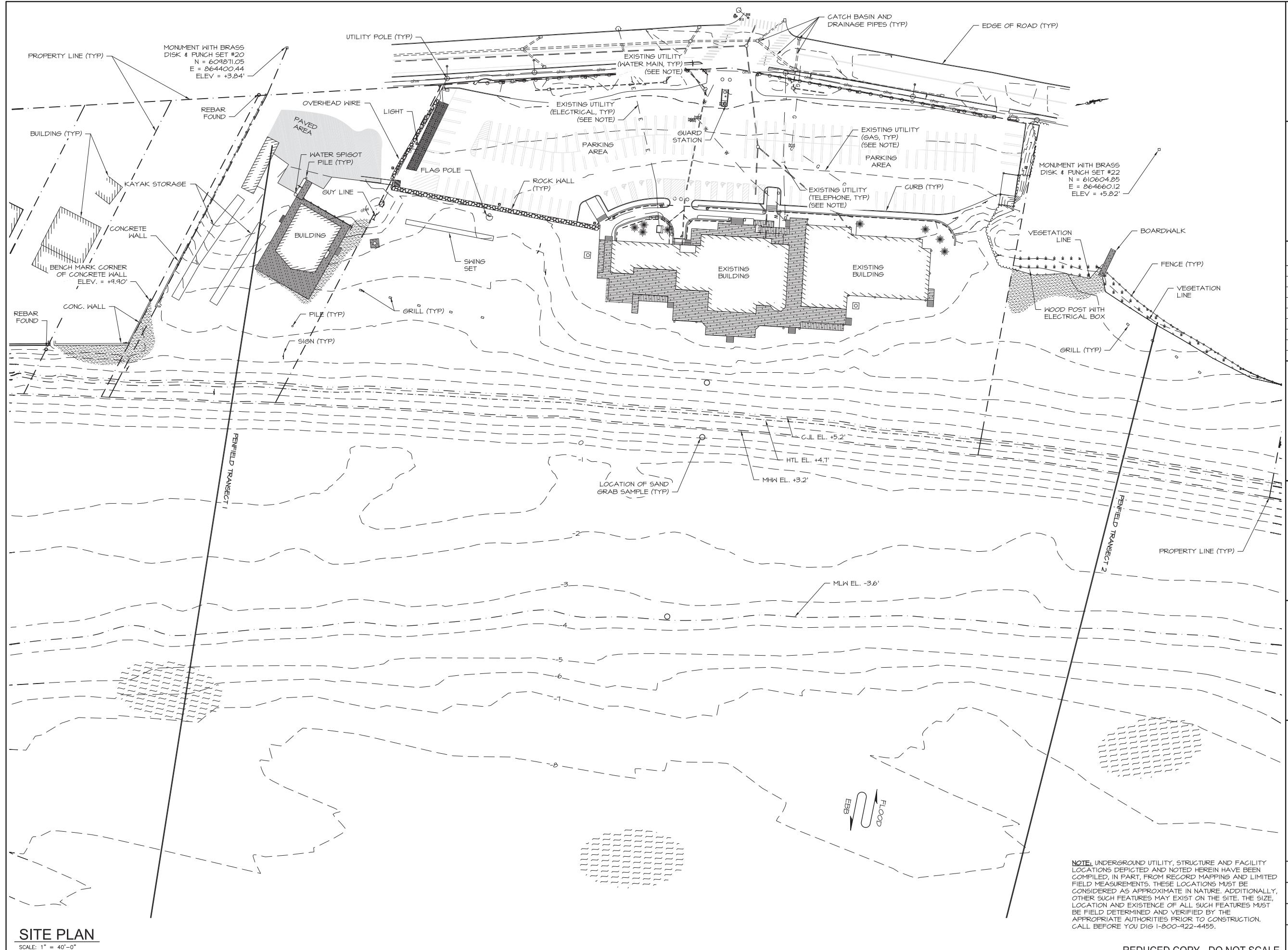
SITE PLAN

NOTE: UNDERGROUND UTILITY, STRUCTURE AND FACILITY LOCATIONS DEPICTED AND NOTED HEREIN HAVE BEEN COMPILED, IN PART, FROM RECORD MAPPING AND LIMITED FIELD MEASUREMENTS. THESE LOCATIONS MUST BE CONSIDERED AS APPROXIMATE IN NATURE. ADDITIONALLY, OTHER SUCH FEATURES MAY EXIST ON THE SITE. THE SIZE, LOCATION AND EXISTENCE OF ALL SUCH FEATURES MUST BE FIELD DETERMINED AND VERIFIED BY THE APPROPRIATE AUTHORITIES PRIOR TO CONSTRUCTION. CALL BEFORE YOU DIG 1-800-422-4455.

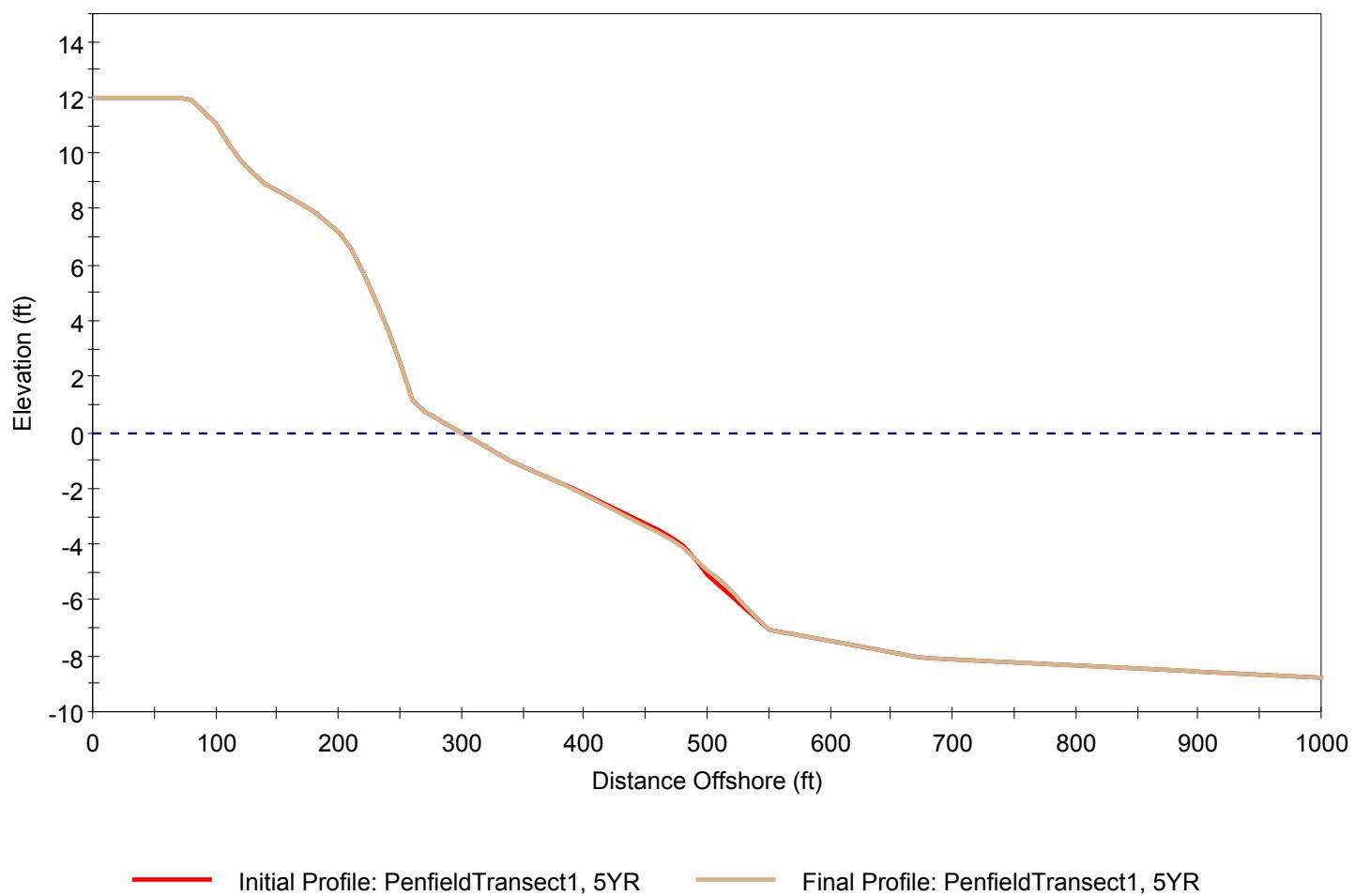
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Drawn By:	JAP	Scale:	As Noted
Checked By:	ADS	Project Number:	201644
CAD File:	PENFIELD - REPORT DRAWINGS.DWG	Drawing No.:	

REDUCED COPY - DO NOT SCALE

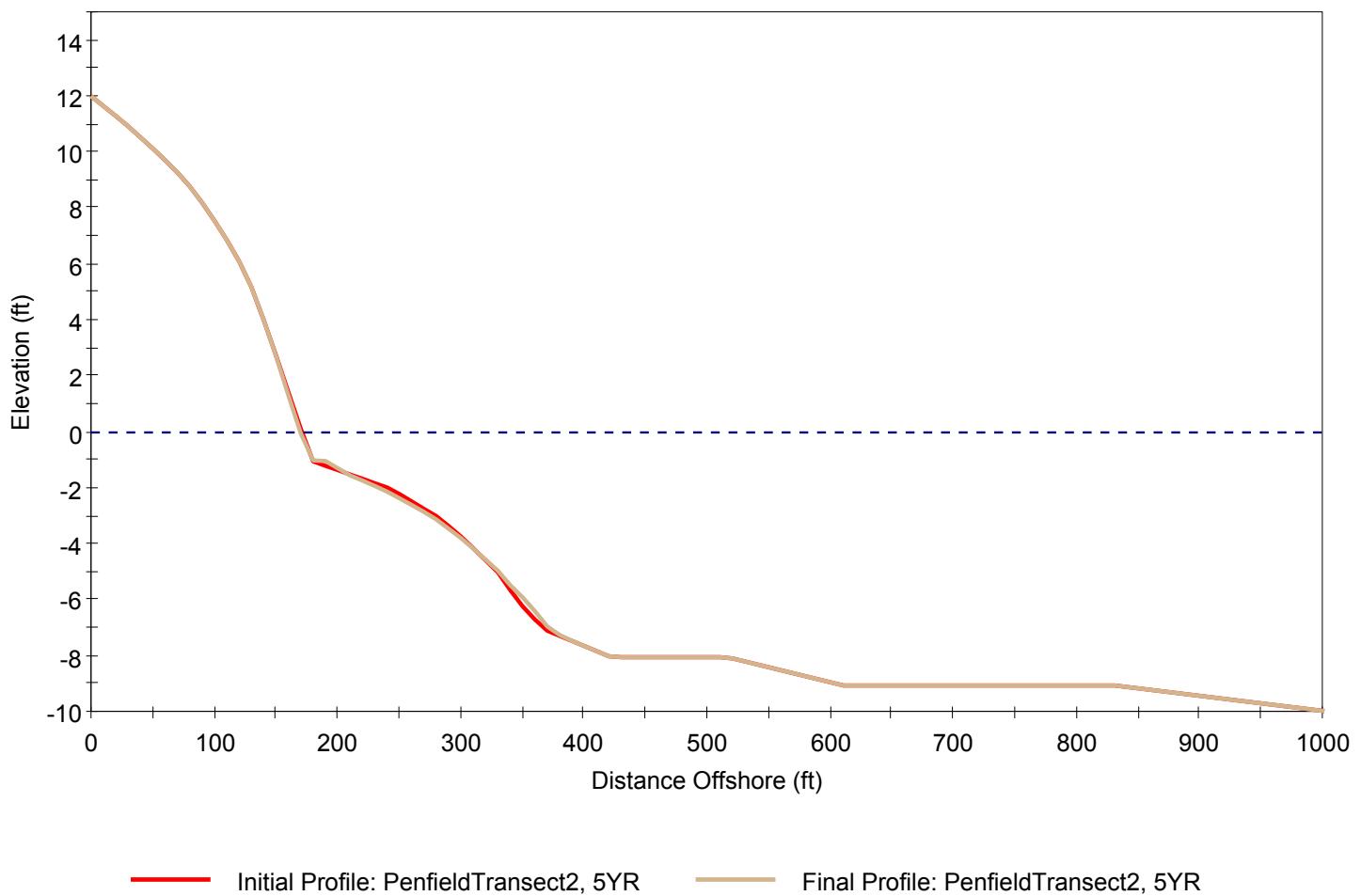
1 of 01



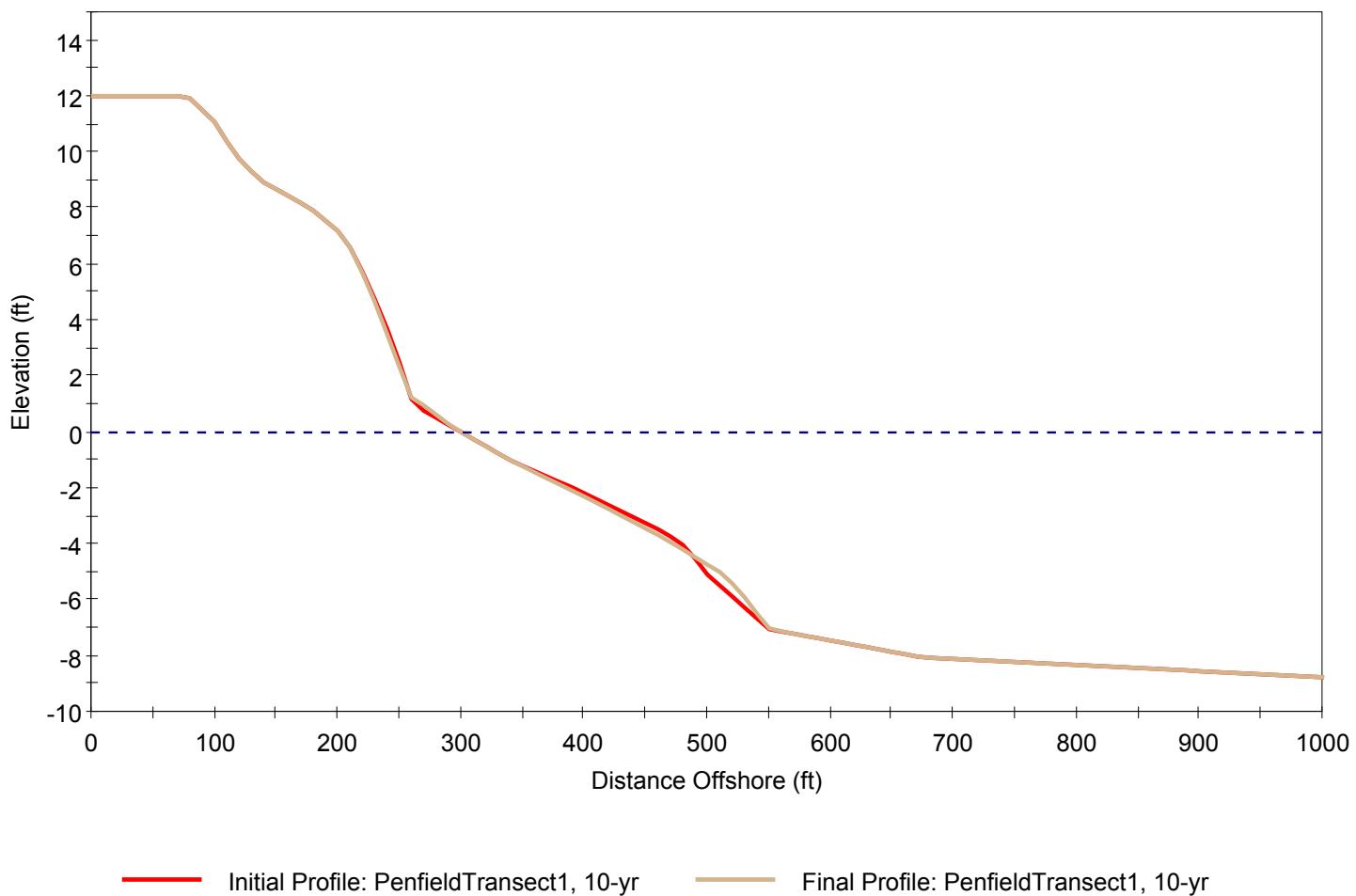
### **5-Yr Storm**



### **5-Yr Storm**



### **10-Yr Storm**



### **10-Yr Storm**

