WATERFRONT PLANNING STUDY

CUMMINGS PARK & WEST BEACH WATERFRONT PLANNING STUDY

Prepared for:

STANTEC

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May 2015

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1.0 INTRODUCTION

Roberge Associates Coastal Engineers, LLC (RACE), is pleased to provide Stantec with the following report summarizing our findings and recommended improvements for West Beach, Cummings Beach and Cummings Marina. **RACE** was contracted by Stantec to aid in the planning of the waterfront for West Beach, Cumming Beach and Cummings Marina as a part of the Master Plan being developed for these waterfront facilities.

The following were performed as a part of the basic services at both Cummings and West Beach Park:

- Property survey
- Evaluation of existing park conditions
- Development of alternative improvement concepts
- Development of opinion of probable costs
- Preparation of a recommended park design concept
- Waterfront findings report

RACE was specifically tasked with performing a planning study of beach reinforcement and resiliency for both the Cummings and West Beach sites. These tasks included:

- Investigating the existing beach conditions
- Collecting sand samples
- Performing a beach stability assessment analysis
- Developing alternative beach improvement schemes
- Providing a recommended concept for implementation
- Preparing a findings report

In addition to the beach assessments, **RACE** was also tasked with reviewing and evaluating the existing marina and associated structures at Cummings Park. As part of this task **RACE** performed the following:

- A site investigation and condition assessment of the existing marina and associated structures
- Development of marina improvement alternatives
- Recommendation of a single marina improvement concept for implementation
- Opinion of probable cost
- A financial viability study
- Preparing a findings report

The following sections summarize our findings and recommended improvements for the Cummings Park Marina and the beaches at both Cummings and West Beach Park.

2.0 FACILITY DESCRIPTION

Cummings and West Beach Park are popular and highly utilized public parks located on the City of Stamford's shoreline adjacent to Westcott Cove. Both Parks are sheltered by Shippan Point to the west, Vincent Island to the south and Greenway Island to the East. Currently, entrances and exits to Cummings Park are located off Shippan Avenue as well as Soundview Avenue. West Beach Park has only one entrance off Shippan Avenue.
Cummings Park is comprised of approximately 79.3 acres of land containing park amenities including softball fields, baseball fields, tennis courts, basketball courts, parking lots, maintenance buildings, and

restrooms. As a result of its location, the Park naturally provides access to the waters of Long Island Sound via the marina and the beach. The beach is located along the southern edge of the property and has amenities including a concession stand, pavilion, a stone jetty, stone groin, and a timber fishing pier. The Cummings Marina is located north of the beach and is accessed via a navigation channel which bisects West Beach and Cummings Beach. The existing marina includes floating docks, timber anchor piles, stone seawalls, stone revetments, three deteriorated timber piers, a parking lot and a boat house. The Park, also includes the United States Army Corps of Engineers (USACE) Hurricane Barrier which provides protection for the City of Stamford during significant storm events.

West Beach Park includes approximately 31 acres of land containing baseball fields, soccer fields and parking lots. It also provides the public with access to the waters of Long Island Sound via the beach and the boat launch ramp. The beach is located along the southeastern edge of the property and has amenities including a playground, bath houses, and parking lot. There is an additional parking lot, at the north extent of the Park, which provides access to the public boat launch ramp. Along the northern edge of the ramp there is a floating dock system which services the launching and hauling of boats. The boat launch ramp allows boaters to access the navigation channel and the waters of Long Island Sound.

3.0 HYDROLOGIC REGIME

West Beach and Cumming Park are located along the shoreline of Westcott Cove in the City of Stamford. The Westcott Cove area is subject to coastal flooding and associated storm surge events most typical of hurricanes, nor'easters, and low pressure systems. The beach front, as well as the marina areas, is subject to semi-diurnal tidal fluctuations coincident with those of Westcott Cove and Long Island Sound. The following table provides a summary of tidal and statistically significant stillwater surface elevations at these sites.

Table 1. Stillwater Surface Elevations

Water Surface Event	Approximate Elevation NAVD 88
100-yr Flood [2]	+10.8-ft
50-yr Flood [2]	+10.1-ft
10-yr Flood [2]	+8.4-ft
Coastal Jurisdiction Limit (CJL) [3]	+5.5-ft
1-yr Flood [1]	+4.6-ft
Mean High Water (MHW) [1]	+3.3-ft
NAVD 88	0.0
NGVD 29	-1.1-ft
Mean Low Water (MLW) [1]	-3.9-ft

Sources: *1. U.S. Army Corps of Engineers, New England Tidal Flood Survey, 1988 (Converted to NAVD 88),*
2. Federal Emergency Management Agency Flood Insurance Study Number 09001CV001C Revised October 16, 2013
3. Connecticut Department of Energy & Environmental Protection Office of Long Island Sounds Program

The above referenced Stillwater Elevations are estimated stillwater elevations for a given storm event. In simple terms, during a 1 year period, a 1 year storm event, has 100% chance of the reference elevations being equaled or exceeded, a 10% chance for the 10 year storm event, a 2% chance for the 50 year and a 1% chance for the 100 year event. The stillwater elevations include the effects of storm surge and tidal influence, but not the influence of wave action, wave setup, or wave runup. The stillwater elevations are utilized by the Federal Emergency Management Agency (FEMA), to prepare Flood Insurance Rate Maps (FIRM) which identify potential storm impacts for buildings and associated structures within a flood zone. FIRMs take into account wave action, wave setup, and wave runup to determine areas susceptible to flooding during the design storm. These areas are defined as Special Flood Hazard Areas (SFHA) and are assigned a Base Flood Elevations (BFE). BFE is defined by FEMA as the computed elevation to which floodwater, extending to the crest of the 1% wave that can occur at the site, is anticipated to rise during a 100-yr return period event, or an event with a 1% chance of annually occurring. Table 2 includes the BFE's for the project areas.

Table 2: Base Flood Elevations

Park	Special Flood Hazard Areas (SFHAs)	Base Flood Elevation (BFE) (NAVD 88) [1]
Cummings Park	Zone VE	+15.0 ft
	Zone AE	+14.0 ft
	Other Flood Areas[1]	Protected by Hurricane Barrier
West Beach Park	Zone VE	+15.0 ft
	Zone AE	+14.0 ft
	Other Flood Areas	Protected by Hurricane Barrier

Sources: *1. Federal Emergency Management Agency Flood Insurance Rate Map Number 09001C0517G, Fairfield County, Connecticut (All Jurisdictions), Map Revised July 8, 2013*

The Stamford Hurricane Barrier is designed to protect upland structures from flooding during the design storm. Land located waterward of the Hurricane Barrier, such as Cummings and West Beach Park, are located within the Special Flood Hazard Area (SFHA) and are subject to inundation by the 1% storm event. Therefore, areas of the park that are located waterward of the Hurricane Barrier are required to be designed to meet or exceed the requirements of the City's regulations for the specified design flood as determined by the FEMA. A FIRMette showing the flood zone delineations is shown in Appendix D.

Specifically, Cummings Marina as well as the beaches of West Beach and Cummings Park are subject to coastal flooding with wave action. A SFHA in Zone VE is not only subject to flooding but is also subject to wave action with wave heights being equal to or greater than 3 feet. The area of West Beach Park that is located landward of the beach is in a SFHA Zone AE. This area is subject to coastal flooding as well as wave action with wave heights less than 3 feet. The northeastern portion of Cummings Park also falls within a SFHA Zone AE. While the Hurricane barrier provides protection from storm events that inundate the area, the upland areas of both parks are still noted by FEMA to be situated within an Other Flood Zone. This means, as stated on the FIRM, that if the Hurricane Barrier were to fail, the upland area of the parks would be flooded.

4.0 BEACH ASSESSMENT

The Cummings Park Beach and West Beach were assessed as a part of this study. Existing beach and foreshore topography was collected at each location to complement and update existing mapping. In addition, the size gradation and character of the sand on both beaches was evaluated so as to determine the existing beaches resiliency to storm events. Based on the collected data, computer models were utilized to analyze the beach conditions and how they will likely respond to wave action during defined storm events. The results were reviewed and evaluated as part of the process to determine the most resilient and sustainable alternative beach improvement scheme. The following paragraphs summarize **RACE's** findings for each beach.

It should be noted that for each of the alternatives that were investigated, the parks will be subject to flooding through the marina. In order to entirely protect the site from flooding, a barrier such as the Hurricane Barrier shown in Photograph 1 would need to be constructed. The primary attraction of the park is its access to the waterfront. A barrier structure would cut off access to the waterfront and change the character of the park and therefore was not considered to be a practical or necessary improvement.

The flood protection alternative described herein will not provide flood protection for facilities located waterward of the barrier. Structures located in these areas will need to be designed to sustain flood loads associated with storm events. The alternatives described below will not allow for any changes to the SFHA or alter the BFEs displayed on the FIRM. The FIRMette in Appendix D shows the flood line delineation. The alternatives described below were developed and evaluated based upon their functionality, maintenance requirements, and life cycle expectancy.

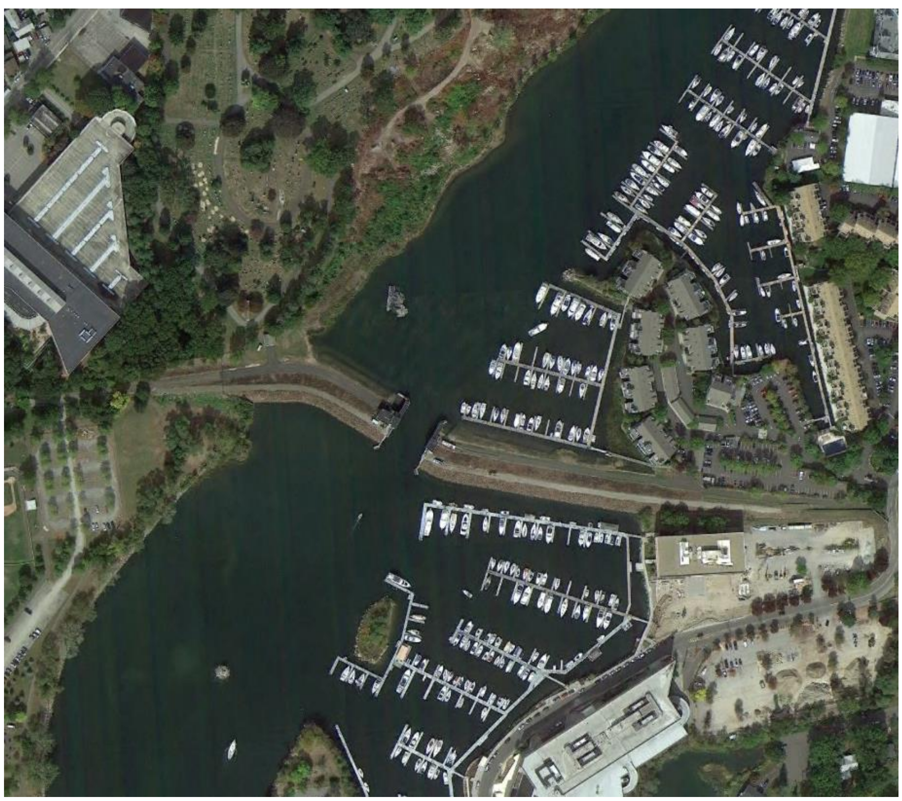

Figure 1: Hurricane Barrier

Sediment transport within the littoral zones at the parks was also investigated. The direction of sediment transport along Cummings Beach is predominantly to the northwest, while the sediment transport on West Beach is to the northeast based upon qualitative analysis of beach forms as shown on the historic aerial photographs. It is the opinion of **RACE** that this sediment transport is due to the effect of local topography on wave refraction. Refraction of waves in the nearshore region results in a predominant transport of beach materials towards the channel. This opinion, as noted, is illustrated by the annotated aerial photograph below which indicates sediment transport to the northeast on the west side of the cove and to the northwest on the east side of the cove. The indication of transport direction is demonstrated by the location of the sand depletion on the downdrift side of the visible groins.

Figure 2: Predominant Sediment Transport Regime of Westcott Cove

4.1. CUMMINGS BEACH

Cummings Beach is located in the City of Stamford, northwest of Shippan Point. The site includes a sandy beach, parking lot and related recreational facilities. There are ball fields, tennis courts, and a marina located landward of the beach. There is a groin located near the center of Cummings Beach and a jetty on the west side of the beach. The groin functions to trap sand being transported from the east as the accretion of beach material on the east of the groin is significantly greater than the amount of beach material on the west end of the groin. The jetty on the west side of the beach functions to maintain the navigation channel.

The site can be accessed from Shippan Ave or McMullen Ave. Topographic information was collected by **RACE** on August 18, 2014. While on site, **RACE** collected surface sediment samples using hand tools.

4.1.a. Beach Sand Characterization

Three sediment samples were collected from Cummings Beach and three samples were collected from West Beach. Cummings Beach was determined to have grain sizes with a d_{50} varying from 0.42 mm to 0.76 mm, while the West Beach sand was determined to have a grain size with a d_{50} ranging from 0.55 mm to 0.76 mm. For the purpose of the following analysis, a grain size of d_{50} = 0.55 mm was used to determine the beach stability. This was the grain size primarily found inland on both beaches. The sand in the intertidal zone was coarser.

4.1.b. Stability Analysis

As part of the beach assessment **RACE** was tasked to determine the existing beach grade stability. Based on the data collected during the site investigation, wave analyses were performed for the 1, 10, 50, and 100 year storm events. These data were utilized to determine the beach stability as a function of each of the storm conditions.

Cummings Beach is an unprotected area containing unconfined sand, exposed to open fetches extending through Long Island Sound. It is subject to winds, tides, currents, and waves. Storms have the potential to cause dramatic changes in the dynamics of the beach system resulting in changes in the beach profile that are not recoverable by natural processes. The existing site conditions and environmental settings described in the preceding sections were used to determine the wave heights and periods with the USACE ***Coastal Engineering Design & Analysis System*** (CEDAS)'s ***Automated Coastal Engineering System*** (ACES) model.

ACES was used to determine the maximum wave height and period based upon wind speeds for the given return periods. The 50-yr 3-second wind gusts at 33' as listed in the CT Building Code 2009 Amendment Appendix K was converted to the given return period using the ASCE 7-05 Table C6-7. As the wave propagated inland, the erosion potential of the dune, and the flooding potential of the proposed site was determined using the ***Storm-Induced Beach Change (SBEACH)*** model.

Two computational cross-section transects were taken perpendicular to the shore at Cumming's Beach. Waves were transformed along these transects as they propagated inland. The existing beach and each of the improvement schemes were modeled for each storm event.

It was determined that the existing Cummings Beach was stable during a typical 1-yr event, but susceptible to moderate erosion during a 10-yr event, and severe erosion during a 50- and 100-yr event. The erosion potential for the existing beach is described in the following section in Table 3: Erosion Potential at Cummings Beach.

4.1.c. Improvement Schemes

RACE reviewed several alternatives to improve the existing beach resiliency to storm events. These generic improvement schemes included:

- Do Nothing
- Beach Nourishment
- Grain Size Modification
- Addition of a Sand Dunes
- Sand Gradation Modification
- Offshore Wave Attenuators
- Offshore Feeder Bars

Using ***SBEACH***, the existing beach was shown to be resistant to storm conditions with a 1-yr return period. The site was shown to experience a potential of approximately 2.8 C.Y./lf of erosion during a 10-yr event, 6.4 C.Y./lf of erosion during a 50-yr event and a potential of 7.6 C.Y./lf during a 100-yr event. The total predicted volume of sand loss during each event at Cumming's Beach is displayed below:

Table 3: Erosion Potential at Cummings Beach

Return Period (Years)	Erosion Potential	
	Cubic Yards Eroded (C.Y.)	Unit Erosion (C.Y./ft)
1	Minimal	<1
10	3,750 ±	2.8
50	8,750 ±	6.4
100	10,000 ±	7.6

A broad range of alternatives for improving the beach are discussed in the following paragraphs. It should be recognized that a range of specific means and methods are available to the designer that could achieve same or similar results. For example: beach nourishment can be accomplished using sand imported to the site from a remote quarry or other source. Sand can also be reclaimed from dredging of the marina's navigation channel, or mined from the offshore sand deposits that are located in Long Island Sound, seaward of this site. Similarly, offshore wave attenuation can be achieved by mooring a floating wave attenuator, constructing a stone breakwater, or constructing an artificial reef offshore from the site.

The selection and recommendation of specific means and methods are typically dependent upon a broad range of characteristics, including, but not necessarily limited to: cost of construction; maintenance requirements and costs; technical effectiveness; regulatory restrictions; potential environmental impacts; constructability; impacts to navigation; impacts to benthic resources; and other issues of critical concern. The following sections describe the alternatives in relatively generic terms. Specific design requirements are the subject of more detailed engineering investigations.

4.1.c.i. Do Nothing

The "Do Nothing" alternative would involve leaving the existing beach in its current state. This alternative would preserve the existing character of the site, but would not include any amendments or add any protection. The initial cost would also be nothing to the City, although there would likely be damage to the beach, parking area, and upland facilities such as the pavilion, snack bar, etc. resulting from future storm damage.

This alternative is considered appropriate when structural and nonstructural alternatives are considered too costly and are not economically viable or where the regulatory climate and environmental restrictions dictate that no structural alternatives are not appropriate. This alternative would allow the character of the site to remain.

The primary drawback to the “Do Nothing” alternative is that the risk of flooding and wave damage to the beach, parking area and upland facilities will increase as erosion of the beach persists. While there are no initial cost, repair costs can accumulate if the site is battered by multiple storms. The site, the beach and facilities, will suffer cumulative damage. Upland structures properly designed to manage storm loads will be substantially less susceptible to damage and will incur substantially lower repair costs if properly designed.

The erosion potential remains the same as displayed above in Table 3. As storms pass by, if no repairs are performed, the erosion effects will be cumulative. This would result in accelerated rates of damage and a significant decline of the site character.

4.1.c.ii. Beach Nourishment

Beach nourishment involves placing sand on the beach to replace what was lost after a storm event or placing sand on the beach before a storm event in anticipation of storm induced erosion. The erosion potential of the site of the site would remain similar as displayed in Table 3, however by nourishing the beach after a storm event, the site’s vulnerability would not be cumulative as it would with the “Do Nothing” Alternative.

This beach improvement scheme would require the City to maintain the beach after a damaging storm occurs. A template, i.e. specific optimum grades and slopes, would be created based on existing conditions and engineering design. The beach would need to be maintained to this template. Periodic surveys would need to be performed in order to provide an estimate of the amount of nourishment necessary to maintain the beach. This alternative would allow the City to seek federal funding for future repairs and re-nourishment should the beach be damaged in a storm event.

To maintain the beach, nourishment would have to take place every few years. It is estimated that approximately 2,460 C.Y. of sand would be necessary every nourishment event, however this quantity is subject to variation. A significantly greater volume of material would be required if a larger and more intense storm hits the site or the volume could be nothing if the site is spared from storms. Regular monitoring of the beach, to determine the sand that is lost during a regular time interval, is an important component to this nourishment scheme. The conceptually designed nourishment scheme is estimated to have a 10-yr lifespan.

Beach nourishment is not intended to provide ultimate protection against storms as much as provide a formal program to restore the beach following a significant storm event. Annual monitoring and maintenance would be required by the City to maintain the existing lines and grades.

Per The City of Stamford's Operations Manager with the department of Parks & Facilities, the site is currently maintained with daily grooming from April 1st to September 30th. Sand that migrates upland during storm events is screened and placed back on the beach.

Beach nourishment would preserve the existing characteristics of the site, as well as add a buffer against storm damage. Beach nourishment would also prevent any cumulative damage from occurring.

The primary drawback to nourishment is that it would provide minimal protection from flooding and wave attack. The more substantial the nourishment the more protection from waves the site would get. Regardless of the size of the nourishment project, the park would still be susceptible to flooding through the inlet.

4.1.c.iii. Grain Size Modification

The third alternative considered focused on changing the grain size of the sand that is distributed on the beach. This could be done, and would most efficiently be done, in conjunction with a beach nourishment program as described above. The median grain size, d_{50}, of the sand that is currently on Cummings Beach varies from 0.42 mm to 0.76 mm. Based on the existing sand gradation, engineering modeling indicates that the beach will be stable when exposed to a 1-yr storm event and susceptible to moderate erosion during a 10-yr event. The site would experience severe erosion during a 50- and 100-yr event. By modifying the sand, the beach could become more resilient, i.e. less erosion, to larger storm events. As noted, sand modification could be done in conjunction with a beach nourishment program. It would involve adding and blending coarser grain sand into the beach using earth moving equipment, tow-behind rakes, and graders.

A benefit to this option is that the coarser the grain size is less susceptible the beach would be to erosion. The larger sediment is more resistant to movement by waves. By increasing the d_{50} at Cumming's Beach to 0.75 mm or greater, it would be possible to make the beach stable during the 10-yr event, however the site would still be susceptible to erosion from the 50-yr and 100-yr event.

The most significant drawback to a sand blending program involves the difficulties in locating a sediment source that would satisfy the design gradation. Most common sources of nourishment materials come from upland quarries or from maintenance dredging. If these local sources offer a suitable gradation, then sand grain modification during nourishment is a viable option. If a local source of sediment is not available, this alternative may quickly become cost prohibitive.

Additionally, coarser grain size may not have the same 'feel' as finer sand, changing the character of the site resulting in complaints from patrons. Such concerns are often remedied by adding a sand veneer of a finer grain size over the technically optimized base layer. Such a veneer would be subject to seasonal erosion and require annual replenishment. In addition, upland structures would still be susceptible to wave attack and flooding. to implement a veneered beach system over the entire Cummings Beach site, a 1-ft thick cover of sand composed of a coarse grain size sand sub-base including approximately 2,520 CY of coarse sand and 1,540 CY of fine sand veneer would have to be placed.

4.1.c.iv. Sand Dunes

Another alternative which was considered for beach improvement was the addition of sand dunes to the site. A sand dune, extending across the landward side of the beach, would consist of a mound of sand finished at El. +13-ft (NAVD 88) or approximately 5-ft higher than the existing nominal grade along the upper beach. The dune would have a crest width of approximately 30-ft and would be approximately 90-ft wide at the toe. Approximately 11,000 CY of sand would be necessary for dune construction. Because of the limited space on site, constructing such a dune would be challenging. It is significant to note that the modeling indicates that erosion at the site is occurring predominantly on the foreshore slope of the beach and not on the upper backshore or beach crest. Wave energy is simply dissipated on the beach face, allowing no natural opportunity for the erosion of the artificial dune and subsequent feeding of the sand onto the beach face. In addition, there is no room for a berm in front of the dune to be constructed because the parking area, located immediately landward of the beach severely restricts any beach expansion.

The dune would primarily function to provide a stockpile of sand that could be used to mechanically re-nourish the beach in the event of a storm event. The sand dune aids in protecting the landward structures and park on site from wave attack, but does not protect the site from flooding. Water can inundate the site from around the sides of the dune and through the inlet.

The primary drawback to the dune is that to provide functionality, the dune would have to cover the majority of useable beach area, including the volleyball courts. Another disadvantage is that predictions from the ***SBEACH*** modeling show that the dune will most likely migrate landward. Based on the model, sand will inundate the parking area and potentially the marina and will not provide any measurable benefit to beach stability or resiliency. This could be mitigated by moving the dune landward, but this would require the parking lot to be relocated.

Additional concerns associated with constructing a dune are impacts to view and restricting access to the beach. The dune's height would prevent the public from easily seeing the Sound from their cars as well as create a potential safety concern as police would not be able to see the beach as they drive through the parking lot. The public would have to walk up and over the dune to access the beach and there would be little room for sitting on the beach.

4.1.c.v. Beach Slope Modification

An additional alternative considered for Cummings Beach would require changing the grade of the beach. Beach slope modification would involve altering the grade of the beach face to a shallower or flatter slope.

The flatter sloped beach will absorb wave energy as the waves approach shore and translate up the beach. Through the ***SBEACH*** modeling, it was determined that a slope of 1V:40H would be ideal for this site. In order to achieve this grade, a significant amount of sand would need to be added to the beach.

The new slope would enhance wave damping by causing the waves to break further away from the parking lot and structures. It would also allow for the breaking of waves to be more gradual as there would no longer be a sharp change from the floor of the Sound and the beach. This would result in a dissipation of wave energy over a broader area, decreasing the amount of erosion on the beach. Changing the grade on the beach would make the site resistant against erosion during the 10-yr event and less susceptible to major damage during the 50- and 100-yr event. In addition, the modification would widen the beach and provide recreational benefits.

The primary drawback to this alternative is that in order to achieve a functional design, a significant amount of sand would be necessary. Approximately 71,000 C.Y. of sand would be required. This would be very costly and the extension of the beach into Long Island Sound, below MLW would be contrary to current regulatory policy. It is significant to note that the CT DEEP is in the process of assessing such beach improvements and is considering modification of their historic opposition to waterward encroachment. In addition, the modified beach slope would need to be maintained over time. As noted with the other alternatives, flooding would still occur through the inlet.

4.1.c.vi. Offshore Wave Attenuator

Reduction of the heights of waves that travel from the open fetch(s) of Long Island Sound and onto the site would significantly reduce the potential for sand movement and erosion of the beach systems. Traditional methods to achieve such a condition involve the installation of a wave attenuator structure. Wave attenuation structures can vary from ***deep draft floating dock***; ***an offshore stone breakwater***, ***a timber or steel wave fence***, ***a submerged artificial reef***, and a broad range of variations and combinations of such structures. The objective of such installations is to reduce the wave energy that impacts the shoreline, i.e. beach, to encourage the stability of the beach, and where littoral materials are naturally available, to encourage deposition and growth of the beach.

This treatise is not intended to develop a specific design of any such wave attenuator systems, but it is of interest to note that a wave attenuator installation located offshore of Cummings Beach would be on the order of 900-ft long. It would be positioned at or just inside the ordinary surf zone and it would likely require complementary beach nourishment. It is also important to realize that the success or lack of success of such structures is highly dependent upon identifying the proper height and geometry so as to effectively attenuate wave energy.

The normal tide range at the Westcott Cove site is approximately 7.2-ft and the 100-yr stillwater elevation can be 14.7-ft above MLW. Design of a fixed structure, whether it is a stone breakwater or a submerged artificial reef, must accommodate these significant water surface elevation variations. Any such structure will be large and obtrusive. Alternatively, a floating wave attenuator would likely require a floating dock assembly with a draft of 8-ft or more and a width of more than 30-ft. Mooring lines or fixed anchor piles would support such a system and the initial construction cost would be costly. Fixed and flexible gravity structures would be less expensive. Attenuator systems also present a significant hazard to navigation. Breakwater structures, artificial reefs, and floating wave attenuators would impact the natural bottom, resulting in as much as 6-acres of direct and permanent impacts to benthic resources.

It is essential to appreciate that the installation of any type of wave attenuation system in the area offshore of Cummings Beach and West Beach will ***not*** reduce the risks to flooding of the marina or upland areas of the Park.

4.1.c.vii. Offshore Feeder Bars

An offshore feeder bar was also considered, but ruled out during the preliminary assessment as it involved a considerable amount of sand, and was not as effective to this location as other alternatives. The feeder bar would do little to break waves as water levels rise. In addition, the feeder bar would do nothing to protect from the site against flooding. There was additional concern that this alternative would increase the sand accretion rate within the channel.

4.1.d. Opinions of Probable Cost

The following are opinions of probable costs (OPC) that were performed for each improvement. These OPC’s are based upon RS Means as well as comparable projects performed in the general geographic region in the past several years. These do not represent a firm quote and are subject to change based upon actual design. These costs are intended to provide a basis for decision and not for the development of project budgets. The OPC for the beach improvement schemes for Cummings Beach are listed below. For a description of the alternative please refer the corresponding section listed in the right hand column of the table.

Table 4: Cummings Beach OPC

Alternative	OPC (2015 USD)	Report Section
Do Nothing	0	4.1.c.i
Beach Nourishment	$ 308,000	4.1.c.ii
Grain Size Modification	$ 496,000	4.1.c.iii
Dune	$ 1,652,000	4.1.c.iv
Beach Slope Modification	$ 3,311,000	4.1.c.v
Wave Attenuator	$ 4,482,000 [1,2]	4.1.c.vi

Notes: 1. OPC's for the various alternative wave attenuator systems range to as much as $8,000,000. Actual construction costs will vary.
2. Provided cost is based on a floating wave attenuator system with anchor piles.

4.2. WEST BEACH

West Beach is located west of Cummings Beach in Stamford, CT. The site includes a sandy beach, parking lot and ancillary recreational facilities. A jetty, oriented perpendicular to the beach is located on the northeast end of the beach and nominally parallel to the navigation channel that services the Cummings Marina Basin, Halloween Yacht Club, and private berthing facilities. The timber jetty is effectively trapping sand that is being transported from the beaches and offshore sand deposits that are located to the west of the site. This is clearly evident by the buildup of beach material to the west of the jetty. This accretion is significantly greater than that on the linear shoal that extends along the interior or east side of the jetty. This linear shoal was likely formed by sand that overtops the jetty and/or migrates around the waterward end of the jetty. It is clear that the direction of sediment transport on West Beach is in the opposite direction, i.e. easterly, of that on Cummings Beach. The sediment transport of the beaches are discussed in Section 4.0.

The West Beach site can be accessed from Shippan Ave. Topographic information was collected by **RACE** on August 18, 2014. While on site, **RACE** collected surface sediment samples using hand tools.

4.2.a. Beach Sand Characterization

Three distinct sediment samples were collected from West Beach. As noted in Section 4.1.a, three samples were also collected from Cummings Beach. Cummings Beach was determined to have grain sizes with a d_{50} varying from 0.42 mm to 0.76 mm, while the West Beach sand was determined to have a grain size with a d_{50} ranging from 0.55 mm to 0.76 mm. For the purpose of the following analysis, a grain size of d_{50} = 0.55 mm was used to assess the beach stability of both beaches. Finer grain sand is typically more susceptible to erosion, so it is suggested that using the smaller d_{50} should be considered to be more conservative and thus allow for more conservative estimates of erosion rates and volumes.

4.2.b. Stability Analysis

As part of the assessment of West Beach and identical to that performed for Cummings Beach, **RACE** was tasked to determine the existing beach grade stability. Based on the collected data from the site investigation wave analysis were performed for the 1, 10, 50, and 100 year storm events. These data were utilized to determine the beach stability as a function of each storm condition.

The site is an unprotected area comprised of unconfined sand and exposed to the open fetches of Long Island Sound. It is subject to environmental loads such as winds, tides, currents, and waves. Storms have the potential to cause dramatic changes in the dynamics of the beach system resulting in changes in the beach profile that are not recoverable by natural processes. The existing site conditions and environmental settings described in the preceding sections were used to determine the wave heights and periods with the USACE's ***Coastal Engineering Design & Analysis System*** (CEDAS)'s ***Automated Coastal Engineering System*** (ACES) model.

ACES was used to determine the maximum wave height and period based upon wind speeds for the given return periods. The 50-yr 3-second wind gusts at 33' as listed in the CT Building Code 2009 Amendment Appendix K was converted to the given return period using the ASCE 7-05 Table C6-7. As the wave propagated inland, the erosion potential of the dune, and the flooding potential of the proposed site was determined using the ***Storm-induced Beach Change (SBEACH)*** model.

One computational cross-section transect was taken perpendicular to the shore. The wave was transformed along the transect as it was propagated inland and sediment transport was analyzed. The existing beach and each of the improvement schemes were modeled for each storm event.

4.2.c. Improvement Schemes

RACE reviewed several alternatives to improve the existing beaches resiliency to storm events. These generic improvement schemes, similar to those discussed for the Cummings Beach site, include:

- Do Nothing
- Beach Nourishment
- Grain Size Modification
- Addition of a Sand Dunes
- Sand Gradation Modification
- Offshore Wave Attenuator
- Sand Back-passing
- Offshore Feeder Bars

The existing beach was shown to be resistant to storm conditions with a 1-yr return period. West Beach behaved similarly to Cummings Beach because of its similar cross section and exposure. It was estimated that West Beach could experience erosion of approximately 3.2 CY/ lf of beach during a 10-yr event, 6.3 CY/ lf during a 50-yr event and 7.6 CY/ lf during a 100-yr event. The total predicted volumes for West Beach are displayed below.

Table 5: Erosion Potential at West Beach

Return Period (Years)	Erosion Potential	
	Cubic Yards Eroded (C.Y.)	Unit Erosion (C.Y./ft)
1	Minimal	<1
10	2,550 ±	3.2
50	5,950 ±	6.3
100	6,800 ±	7.6

As discussed for Cummings Beach, a broad range of alternatives for improving West Beach are discussed in the following paragraphs. These too should be considered to be general descriptions and are in no way intended to describe specific designs or methods. Implementation of a final scheme will require additional and detailed engineering analyses.

4.2.c.i. Do Nothing

The "Do Nothing" alternative would leave the existing beach in its current state. This alternative would preserve the existing character of the site, but would not include any amendments or add any protection. There would be no initial cost to the City, although this beach and adjacent areas would likely be damaged during significant storm events.

This alternative is considered appropriate when structural and nonstructural alternatives are considered too costly and are not economically viable or environmental restrictions preclude the implementation of structural alternatives. This alternative would allow the characteristic of the site to remain.

The primary drawback to the "Do Nothing" alternative is that the risk of flooding and wave damage to the beach, parking area, and facilities increase as erosion at the site persists. While there is no initial cost, repair costs can accumulate if the site is battered by multiple storms. The site, the beach and facilities will experience cumulative damage. Upland structures properly designed to manage storm loads will be substantially less susceptible to damage and will incur lower repair costs.

The erosion potential remains the same as displayed above in Table 5, however as each storm passes, if no repairs are performed, the erosion effects will be cumulative. This would result in accelerated rates of damage and significant decline of the site character.

4.2.c.ii. Beach Nourishment

Beach Nourishment involves placing sand on the beach to replace what was lost after a storm event or placing sand on the beach before a storm event in anticipation of storm induced erosion. The erosion potential of the site of the site would remain similar as displayed in Table 5, however if sand is replaced after it is lost, the site's vulnerability will not be cumulative as it would with the "Do Nothing" alternative.

This beach improvement scheme would require to the City to maintain the beach after a damaging storm occurs. As with Cummings Beach, a template would be created based on existing conditions and engineering design. Once designed, the beach should be maintained to this template. Periodic surveys should be performed in order to provide an estimate of the amount of nourishment necessary to maintain the beach. This alternative would allow the City to seek federal funding for future repairs and re-nourishment should the beach be damaged in a storm event. It should be expected that nourishment would have to take place every few years.

It is estimated that approximately 1640 C.Y. of sand would be necessary every nourishment event, however this quantity is subject to vary. A significantly greater volume of sand would be required if a larger and more intense storm impacts the site or the volume could be minimal if the site is spared from intense or frequent storms. Regular monitoring of the beach, to determine the volume of sand lost, is an important component of this nourishment scheme. The conceptually designed nourishment scheme is estimated to have a 10-yr lifespan.

Beach nourishment is not intended to provide ultimate protection against storms as much as provide a formal program to restore the beach following a significant storm event. Annual monitoring and maintenance would be required by the City to maintain the existing lines and grades. Per The City of Stamford's Operations Manager – Parks & Facilities, the site is currently maintained with daily grooming from April 1st to September 30th. Sand that migrates off the beach and upland during storm events is screened and placed back on the beach. There is currently no nourishment plan in effect for the beach.

The primary drawback to nourishment is that it would provide minimal protection from flooding and wave attack. The more substantial the nourishment the more protected from waves the site would get. Regardless of the size of the nourishment project, the site would be susceptible to flooding through the marina inlet. Another concern with beach nourishment of West Beach is that sand migrates into the navigation channel. There is already a large amount of sand built up against the jetty on the northeast side of the site. Any substantial nourishment of the western beach could accelerate sand transport around the timber jetty and into the navigation channel.

4.2.c.iii. Grain Size Modification

The third alternative for West Beach that was considered included changing the grain size of the existing sand. This could be done most effectively in conjunction with a beach nourishment. The median grain size, d_{50}, of the sand that currently covers West Beach varies from 0.55 mm to 0.76 mm. Based on the existing sand gradation, the modeling performed by **RACE** indicates that the beach will be stable when exposed to a 1-yr event and susceptible to moderate erosion during a 10-yr event. The site would still experience severe erosion during a 50- and 100-yr event. By modifying the sand, the beach could become more resilient to larger storm events. As noted previously, sand modification could be done in conjunction with a beach nourishment program. It would involve adding coarser grain sand to the beach and blending the new sand with the existing sand.

The primary benefit to this option is the modified beach would be less susceptible to erosion. The larger sand grain will be more resistant to movement by waves. By increasing the d_{50} at West Beach to 0.75 mm or greater, it would be possible to make the beach stable during the 10-yr event, however the site would still be susceptible to erosion from the 50-yr and 100-yr event.

The most significant drawback to a sand blending program, as noted in Section 4.1.b.iii involves the difficulties in locating a sediment source that would satisfy the design gradation. Most common sources of nourishment materials come from an upland quarries or from maintenance dredging. If these local sources offer a suitable gradation, then sand grain modification during nourishment is a viable option. If a local source of sediment is not available, this alternative may quickly become cost prohibitive.

It is important to note that coarser grain size may not have the same 'feel' as finer sand. The sand blending would change the character of the site which might result in complaints from patrons. Such concerns are often remedied by adding a sand veneer of a finer grain size over the technically optimized base layer. Such a veneer would be subject to seasonal erosion and require annual replenishment. In addition, upland structures would still be susceptible to wave attack and flooding.

Installing a veneered beach surface at West Beach would require placing a 1-ft thick cover of sand including, approximately 1,680 CY of coarse sand and 1,030 CY of finer sand veneer-over the entire beach surface.

4.2.c.iv. Sand Dunes

As discussed regarding Cummings Beach, a sand dune extending across the landward side of the West Beach consisting of a mound of sand finished at El. +13-ft (NAVD 88) could provide a reservoir of sand for use in restoring beach grades following storm events. The dune would have a crest width of approximately 30-ft and would be approximately 90-ft wide at the base. Approximately 7,500 CY of sand would be necessary for dune construction on West Beach. Installation of such a dune would be very difficult due to the limited beach area. The area is restricted by the adjacent parking area along the upper backshore area. It is important to note that the modeling, performed by **RACE** indicated that most of the erosion that occurs on West beach is on the foreshore slope of the beach. Restoration of the foreshore would require the mechanical movement of sand material from the dune to the face of the beach. Very little natural nourishment from the dune would occur.

The dune would, essentially, function as a stockpile of sand that could be used to re-nourish the beach following a storm event. The sand dune would serve to protect the site from wave attack, but would not protect the site from flooding. Flood water from LIS could inundate the site around the ends of the dune and through the inlet.

The primary drawback to the installation of a dune focuses on the extent of the dune, i.e. footprint, which by necessity would be so large that it would impact the functional area of the recreational beach. ***SBEACH*** model revealed that the dune would likely migrate landward under the influence of storm induced elevated water surfaces and accompanying waves. Ultimately, the dune materials, following a storm event would be transported to the parking lot along with the marina.

Additional concerns associated with constructing a dune include impacts to view and restricting access to the beach. The height of the dune would restrict the public view of LIS as well as create a potential safety concern for police. They would not be able to observe activities on the beach from the perspective of the parking lot. In addition, pedestrians and beach users would have to walk up and over the dune to access the beach.

4.2.c.v. Beach Slope Modification

Beach Slope Modification was considered for West Beach. This would include changing the grade of the beach. Beach slope modification would involve altering the grade of the beach face to a shallower or gentler slope.

The modified slope will absorb wave energy as the waves approach shore and travel up the beach. The ***SBEACH*** modeling performed by **RACE**, demonstrated that a slope of 1V:40H would be optimum for this site. In order to achieve this grade, a significant amount of sand would need to be added to the beach.

The new slope would enhance wave damping by causing the waves to break further away from the parking lot and structures. It would also allow for wave breaking to be more gradual as there would no longer be a sharp change from the floor of LIS to the beach. This would result in a dissipation of wave energy over a broader area and decrease the amount of erosion on the beach. Changing the grade on the beach would make the site less vulnerable to erosion during the 10-yr event and less susceptible to major damage during the 50- and 100-yr event. In addition, the additional nourishment would provide recreational benefits that would result from widening the beach.

The primary drawback to this alternative is that in order to achieve a functional design, a significant amount of sand would be necessary.

Approximately 48,300 C.Y. of sand would be spread over the entire beach area. This would involve a large cost as well as regulatory issues as the sand would need to be placed below MLW in order to be effective. In addition, the sand could potentially migrate in to the channel creating navigation hazard. Both the beach and channel would need to be maintained over time. Another drawback to this alternative is that it would do nothing to raise the crest of the beach, so there would be no mitigation to flooding. As with the other alternatives, flooding would still be able to occur.

4.2.c.vi. Offshore Wave Attenuator

Reduction of wave energy at the face of the beach could be effectively achieved with the installation of an offshore wave attenuator system. This alternative is discussed in Section 4.1.b.vi. of this report. A wave attenuator system would serve to modify the wave environment at both West Beach and Cummings Beach. As noted, the costs for such a system are relatively high and the incidental impacts to views in addition to navigation can be significant or unacceptable.

4.2.c.vii. Sand Backpassing

A sand backpassing operation would involve periodic maintenance dredging of sand from the face of the fillet and/or the channel shoal area near the timber jetty at West Beach. The purpose of this activity would be to transport the sand back to the west end of the beach. It is important that this sand be introduced back into the active littoral zone so that it can again migrate from the west and remain within a recirculating “cell” that is the face of West Beach . The backpassing procedure reverses the natural transport of the sand. Sand would be harvested from the natural accretion zones on the west side of the timber jetty and the shoal that forms between the jetty and the navigation channel. The harvested sand would be relocated to the up drift erosion zones at the west end of the beach. Based on historic permit research, this procedure has been performed in the past under COP No. 92-040-LG.

This alternative would not only benefit West Beach but facilities that utilize the adjacent navigation channel. Backpassing would artificially widen the western portion of West Beach creating additional spaced for public use and reduce sand migration into the navigation channel. Periodic surveys would have to be performed to monitor the beach geometry and sand volume to determine when backpassing should occur.

The primary drawback to this alternative is that it would require ongoing maintenance to the beach such that design grades are maintained.

4.2.c.viii. Offshore Feeder Bars

An offshore feeder bar was also considered, but ruled out during the preliminary assessment since it requires a considerable amount of sand, and was shown to be ineffective for this area. The feeder bar would do little to break waves as water levels rise. In addition, the feeder bar would not to protect from the site against flooding. Sand migration into the channel was also a concern with this alternative.

4.2.d. Opinion of Probable Cost

The following Table summarizes opinions of probable costs (OPC) that were developed for each of the alternative West Beach improvements discussed in the previous sections. These OPC's are based upon RS Means historical cost data as well as comparable projects performed in the general geographic region in the past several years. These do not represent a firm quote and are subject to change based upon formal design. These costs are intended to provide a basis for decision and not for the development of project budgets.

Table 6: West Beach OPC

Alternative	OPC (2015 USD)	Section
Do Nothing	0	4.2.c.i
Beach Nourishment	$ 224,000	4.2.c.ii
Grain Size Modification	$ 335,000	4.2.c.iii
Dune	$ 1,119,000	4.2.c.iv
Beach Slope Modification	$ 1,755,000	4.2.c.v
Wave Attenuator	$ 1,520,000 [1,2]	4.2.c.vi
Backpassing	$ 95,000 [3]	4.2.c.vii

Notes: 1. OPC's for the various alternative wave attenuator systems range to as much as $2,600,000. Actual construction costs will vary.
2. Provided cost is based on a floating wave attenuator system with anchor piles.
3. Periodic cost.

4.3. RECOMMENDATIONS

Based upon the assessments of the alternatives described in the previous sections of this report, **RACE** recommends that the City seek to improve and maintain the resiliency of both Cummings Beach and West Beach by regularly nourishing the beach on an "as needed" basis as determined by regular beach surveys <u>and</u> incorporating a sand backpassing operation at West Beach.

Left unmaintained, the character and functional beach areas of both Cummings Beach and West Beach will steadily deteriorate as a result of erosion by waves and flooding. Every significant storm that hits the area will contribute to this steady and inevitable decline. By maintaining the beach after each significant event, the damage caused by storms will be mitigated and the character of the site will be preserved.

These sites are low lying sites. There are no practical or economical means to eliminate the potential flooding of either West Beach or Cummings Beach. The noted alternatives, such as the construction of a dune, optimizing the beach slopes, or even the grain size of the beach sand would change the dynamics and functionality of the sites. Such options are also more costly than the recommended beach nourishment of both beaches and sand backpassing at

West Beach. A wave attenuator option would be costly to the city and would be strongly opposed by regulatory agencies.

A proper beach maintenance plan would require annual in additional to possibly post-storm beach surveys and periodic beach nourishment for Cummings Beach and West Beach. West Beach in addition to the beach maintenance plan would also have a backpassing plan for transporting the beach sand from the east side of the beach back to the western side. This as previously mentioned would only occur periodically. The backpassing operation would aid in minimizing sediment transportation into the navigation channel.

5.0 MARINA ASSESSMENT

An assessment of Cummings Marina was performed by **RACE** as an integral part of the facility planning being performed by Stantec. The marina assessment consisted of visually observing and measuring the existing structures that currently are part of and service the Cummings Marina Boat Basin. In addition, the boat ramp and associated structures at West Beach were also observed as part of this work.

Cummings Marina is located within Cummings Park. It is bound by the federal channel to the west and north and roadways, parking facilities as well as open space lawn areas to the east. A marina office (boat house) is located in the adjacent parking area.

There are a total of three marinas in and adjacent to Cummings Park. These include: Cummings Marina, Halloween Yacht Club and a private marina. Cummings Marina is located on the south side of the basin while Halloween Yacht Club is located to the North. The private marina is located along the western shoreline of the entrance channel. This entrance channel is a federally authorized channel that connects the basin to Westcott Cove and the waters of Long Island Sound.

As part of this marina assessment, **RACE** performed two site visits. The first visit was performed on the 7th of August 2015 and included observations and documentation of the conditions at Cummings Marina. The second site visit included observations and documentation of the conditions at the West Beach boat ramp on the 18th of August 2015. The following is a list of specific structures and ancillary items that were observed and documented at these sites.

<u>Marina & Ancillary Structures:</u>

- Timber piers
- Pier utilities
- Aluminum gangways
- Floating docks
- Timber float anchor piles
- Shoreline stabilization structure
- Boat ramp & ramp floats

5.1. SITE INVESTIGATION

The purpose of these site investigations was to observe, document, and develop an engineering opinion regarding the existing conditions of the aforementioned structures. All visual observations were performed above Mean Low Water (MLW). No underwater observations were performed as part of this work.

RACE employed steel measuring tapes, Real Time Kinematic (RTK), Global Positioning System (GPS), and a data collector to perform site specific measurements of grade and position throughout Cummings Marina. This equipment was used to determine dimensions, locations, and elevations of the existing structures specific to the marina. A temporary reference benchmark was established by Rocco D'Andrea, Inc. to provide both vertical and horizontal spatial reference. This allowed the supplemental information to be precisely incorporated into the Cummings Parks A-2 / T-2 survey. The following paragraphs describe the findings of the **RACE** assessment.

5.1.a. Timber Piers

Cummings Marina consists of three similarly constructed 5-ft wide timber piers of varying length. The piers, identified as Pier A, B, and C historically provided access to floating docks that extend into the basin. Pier A and its associated floating docks are located in the northern portion of the basin and Pier C is located in the southern most extent of the basin. For simplicity, the report will reference these piers as pier A, B or C respectively.

Pier A is approximately 65-ft in length and is supported by six pile bents. Each bent includes two timber foundation piles. The piles in each bent are spaced approximately 10-ft apart and are connected by timber split caps. The pile bents are spaced at approximately 10-ft on center and support stringers, timber decking and guard rails. It was noted that the landward end of the pier is founded on a concrete pad which is supported by a loose stacked stone wall. The pier is secured to the foundation with steel angles and partially deteriorated bolts. The top of the pier decking was noted to be at El. +7.5-ft (NAVD 88).

Pier B is approximately 44-ft long and is supported by four timber pile bents. Each bent includes two timber foundation piles. The piles in each bent are spaced approximately 10-ft apart and are connected by timber split caps. The pile bents are spaced at approximately 11-ft on center. As with Pier A, Pier B is also founded on a concrete pad which is supported by a dry stacked stone wall that extends along the western shoreline of the basin. The connection of the pier structure to the concrete pad is unknown. There is an approximately 6-ft long ramp at the landward end of Pier B that extends into the parking lot. The top of the pier decking was noted to be El. +6.5-ft (NAVD 88).

The overall length of Pier C was estimated to be approximately 40-ft. A 16-ft gap between the top of the revetment and the landward end of the pier restricted access to the timber pier. The pier is supported by five timber pile bents, each bent comprised of two timber foundation piles and a timber split cap. The foundation piles in each bent are spaced approximately 10-ft apart and the bents are spaced at 10-ft on center. It was noted, remnants of a timber bulkhead are evident in the vicinity of Pier C. It is apparent that this bulkhead was, at some point in time, removed and replaced with a stone revetment. The top of the pier decking was noted to be El. +5.9-ft (NAVD 88).

The foundation piles which support the timber piers are approximately 12" (nom.) in diameter and appear to be treated with a creosote preservative. All the piles were noted to have minor marine growth and only a few were witnessed to have minor abrasion damage. It was recorded that the top 12" to 18" of all the timber foundation piles had significant rot, with some exceeding 25% loss of section. The bolted connection securing the spilt cap to the pile at each pile location, extend through the rotted section of pile. A hammer was used to test the piles soundness. A select number of piles were tested at 2-ft above the mud line with the hammer. This was to determine if there were any specific areas that sounded hollow. No hollow spots were recorded on any of the piles which were tested. In addition, a steel probe was utilized to determine if the pile had any soft spots. The selected piles were probed in a few locations and it was determine that the piles appeared to be sound excluding the pile tops. Out of the 30 timber pier foundation piles, approximately 5 were observed to have what appeared to be marine borer damage. No coring or selective demolition was performed as part of this task.

As noted above, all the piers appear to be constructed in a similar manner. Secured to the timber foundation piles with ¾" diameter bolts are 3" by 10" split caps spanning approximately 10-ft. It appeared as though the split caps have the same creosote preservative as the foundation piles. The split caps provide support to the sistered 2" by 10" stringers which also span approximately 10-ft. The stringers appear to have a pressure treatment preservative similar to a CCA treatment and are connected to the split caps with 2x4 or 2x6 timber tie downs. The tie downs are connected to the split caps and stringers with a variation of screw and nail patterns. There are 3 stringers spaced at 2'-6" on center which support the 2" by 6" timber decking. The timber decking is nailed to each stringer with approximately 2 nails.

All the timber piers have an approximately 3-ft high timber guard which do not meet the requirements of the Connecticut State Building Code. The guard posts are constructed from 2" by 6" timber and are spaced at 5-ft on center. The posts are connected to the exterior stringers with two ½" diameter carriage bolts. There are two 5/4" by 6" intermediate rails connected to the timber post. One is located at mid height of the guard and the second provides support to the top 2" by 4" top rail. A 2" by 6" strut is connected to the underside of the top rail and connects to the split cap. The guard supports are at each split cap location. There are two ½" diameter bolts which connect the strut to the split cap and screws which secure the strut to the top rail. Excluding post connection to the stringer, the timber guard system is connected with wood screws.

When the marina was operational, the timber piers provided the public access to the floating docks within the marina basin. In order for a boater to gain access to the floating dock they were required to pass through a locked security gate. The security gates consists of steel pipe welded together to create a door as well as a door frame and chain link fence to fill the openings. Each security gate is approximately 10-ft tall by 12-ft wide and overhangs its respective pier by approximately 4-ft on either side. Three strands of barbed wire extend beyond the gate on the left, upper and right sides. The gate is connected to the timber pier on either side of the doorway with a steel plate and four ½" diameter bolts.

Overall the fixed timber pier structures appear to be in poor condition. The guard system is not code compliant, the timber sizes and spans are of concern, as well as the rot witnessed in the piles. It is recommended that the existing piers be replaced.

5.1.b. Floating Docks

Currently within the Cummings Marina there is only one approximately 4-ft wide by 36-ft long timber floating dock which appears to be in fair condition. Based on conversations with the City of Stamford, the Cummings Marina was significantly damaged during Hurricane Sandy, specifically the floating dock system. Due to the extent of the damage, the City of Stamford was unable to repair the floating docks and they were removed from the water and disposed of.

The Cummings Marina has been closed since 2012 but based on historic data provided by the City, the marina once berthed a total of 134 boats. Cummings Marina had a total of 38 slips for vessels 17-ft or less, 83 slips for vessels between 17-ft and 22-ft, and 13 slips for vessels between 22-ft and 25-ft.

The existing marina based on surveys and aerials images, had approximately 880 linear feet of main dock with approximately 56 finger docks. Pier A allowed boaters access to an approximately 180-ft long floating dock system with 8 fingers. This row of floating docks was located on the northwestern point of the marina. Once in the basin, the remainder of the floating docks were configured in a “U” shaped pattern. Pier B allowed access to another approximately 160 linear feet of floating docks which had 8 fingers and the remaining section of docks were accessed from Pier C.

Based on the existing condition, or lack of floating docks, it is recommended that a new system be installed to meet the requirements of the City as well as the public.

5.1.c. Float Anchor Piles

The timber float anchor piles which remain in the marina basin were utilized to secure the Cummings Marina floating dock system which has since been removed. There are a total of 18 approximately 12” diameter timber piles.

The piles appear to be in fair condition with minimal to no abrasion damage and minor marina growth. It was noted that one pile, on the east side of the basin across from Pier B, was significantly out of plumb. It is presumed that the pile was damaged during Hurricane Sandy. In addition to the condition of the piles, the elevation of pile tops were recorded.

It was determined, based upon the measurements, that the top of the piles varied in elevation from approximately El. +8.9-ft to El. +15.9-ft North American Vertical Datum of 1988 (NAVD). On average, the top of pile elevation is approximately +10.2-ft. Comparing the top of pile elevations to the still water elevations found in Table 1 under Section 3.0, the average top of pile is approximately at the 50-year storm still water elevation. Therefore, during a storm event that exceeds the 50-year or 2% recurrence interval, the floating dock system would break free of the anchor piles. Typically, marinas will be designed to meet or exceed site specific lateral loads. The lateral loads applied are typically derived from the wind, wave and boat loads acting on the floating dock system which transfers the loads to the piles. Depending upon the marinas location and requirements it can be designed to withstand a storm event as appropriate for the area. Based on the above elevations, it appears as though the pile are too short and it is recommended that they be replaced.

5.1.d. Utilities

The existing clubhouse is powered by overhead power lines. The only lights within the marina appear to be supplied by the light poles which are located on the eastern edge of the marina's parking lot. In addition to the light poles, it was noted that conduit protrudes from the ground at each pier location.

Pier A was witnessed to have two black plastic water lines protruding from the ground on the southern edge of the pier. One line was approximately 1" diameter the other was approximately 1-1/2" in diameter. The 1" line crossed underneath the timber pier and extends along the northern edge to the piers terminus while the 1-1/2" diameter pipe is capped at the first pile bent. It was noted that small ½" diameter lines were tapped into the larger diameter pipe, hang down to the mudline and extend out to where the floating docks were once installed. Overall it appears as though the lines are in poor condition and should be updated.

Pier B was noted to have four pipes protruding from the ground on the southern edge of the pier. Two appeared to be black water lines, one approximately 2" in diameter and the other approximately 1" in diameter. The other two appeared to be electrical conduits, one is 2-1/2" in diameter and the other is 1-1/2" in diameter. The large diameter water line was capped at approximately the first pile bent and had small diameter black lines tapped into it. The small lines extend towards where the floating dock were once installed. The smaller electrical conduit was damaged and wires were exposed. As for the larger diameter conduit it extend towards the waterward terminus of the pier. The utilities on this pier appeared to be in poor condition and need to be replaced.

Pier C had two black lines with the same diameter as the ones seen at Pier A and one 3" diameter conduit. The 3" conduit as well as the larger diameter black line were capped while the smaller black line was not. Although the lines protruding from the ground were not connected to anything it was noted that the pier had piping remnants extending to the waterward terminus. There was a larger diameter waterline attached to the north landward side of the pier which had smaller diameter lines tying into it. The smaller lines extend out towards the location were the floating docks were once installed. As with the other piers, the existing lines appear to be in poor condition and should be replaced.

5.1.e. Water Depths

The City of Stamford contracted Hydro Data, Inc. to perform a hydrographic survey of the Cummings Park Marina Basin on the 22nd of March 2013. Based on the provided data from the City of Stamford, the marina basin at its deepest has a depth of approximately -9.0-ft Mean Low Water Datum (MLW) with the entrance to the marina basin at an average depth of approximately -6.0-ft MLW and the southern boundary at approximate -3.0-ft MLW.

Required water depths vary largely between marinas and are determined based upon the size of the vessels the marina is seeking to accommodate. Following is Table 7 which provides vessel length verses minimum recommended water depths:

Table 7: Recommended Marina Depths

Vessel Length (ft)	Type	Depth (ft) [1]	Depth (ft) [2]
Minimum	Power / Sail	4	N/A
30	Power	7	8
	Sail	9	
35	Power	8	8
	Sail	10	
40	Power	8	10
	Sail	11	
45	Power	8	10
	Sail	12	
50	Power	8.5	12
	Sail	13	
55	Power	8.5	12
	Sail	14	

Notes: 1. Marinas and Small Craft Harbors (MSCH) Second Edition, by Bruce Tobiasson, P.E. and Ronald Kollmeyer Ph.D.
2. Planning and Design Guidelines for Small Craft Harbors, 3rd edition By American Society of Civil Engineers

It is explained in the Planning and Design Guidelines for Small Craft Harbors, basin depths should be adequate for both power boats and sailboats. A safety clearance under the keel will depend upon the substrate condition but should be between 2 and 3 feet. The US Army Corps of Engineers recommend a minimum safety clearance of 2-ft for soft bottoms such as sand or silt and a minimum of 3-ft for hard bottoms such as rock or coral.

As discussed with the City of Stamford, Cummings Marina when in operation had vessels which ranged in length up to approximately 25-ft. Based on the recommended marina depth and comparing it to the hydrographic survey, Cummings Marina had adequate depth in the past.

Currently the City is seeking to improve Cummings Marina. Through discussions with the City and based upon public comments, the City is seeking to increase the size of the vessels from 25-ft to approximately 30-ft. Per the recommended depths, a marina servicing boats up to 30-ft in length should have a minimum of 7-ft of water depth for power boats and 9-ft for sail boat. Comparing this to the hydrographic data provided by the City of Stamford, the water depths within the marina are adequate but access to the marina during periods of low water may limit some deep draft sailing vessels.

5.1.f. Stone Revetment

Stone revetments as well as stone walls provide protection to the earth embankment around Cummings Marina. A majority of the Cummings Marina eastern shoreline is stone revetment. There are two section within the eastern shoreline that are not revetments. One section is a grouted stone wall and the other is a dry-stacked stone wall. These two section are explained in section 5.1.g. The revetment section have been separated into northern, middle and southern sections as depicted in Figure 3.

Figure 3: Revetment Locations

The northern section of revetment, which is located north of Pier A, extends around the point and is approximately 160 linear feet. The stones vary in size with an average stone approximately 2'-6" in diameter. The riprap does not appear to extend to the top of the slope and sections of the embankment appear to have eroded throughout the years. The riprap appears to have been placed on the embankment without any filter layer or foundation layer. It was also noted that there are numerous voids throughout the revetment. Overall this section appears to be in poor condition and too low to provide protection for the embankment. It is recommended that this section of revetment be repaired.

The middle section of revetment, which is located south of Pier A, extends from the southern edge of the pier to the northern edge of Pier B approximately 132-ft. Based on the supplemental survey the slope of the stone revetment is 1 vertical to 2.25 horizontal. The average stone used throughout this section of revetment is approximately 6-ft by 4-ft by 18". The large stones in some areas appear to overlay some bedding stone but on average the bedding stone has been washed away and the earth embankment is exposed. Stones throughout the revetment appear to have shifted or settled. Along this entire stretch of revetment the toe stones appear to be undermined which causes an unstable condition for the revetment. Overall this section of revetment is in poor condition and it is recommended that it be repaired.

The southern revetment which is in the vicinity of Pier C, is approximately 150-ft in length and appears to have been installed recently. It was noted that a timber bulkhead was installed in this location but has since been replaced. The stone revetment is sloped at approximately 1 vertical to 1.8 horizontal and has an average stone size of approximately 18”. Overall the revetment appears to be in good condition.

5.1.g. Stone Seawalls

Stone seawalls are the dominate structure protecting the marinas shoreline. There are a variety of construction types seen throughout this site from vertical dry-stacked stone walls, to battered dry-stacked stone walls, to partially grouted stone walls all with the varying average stone sizes. Figure 4 below depicts the stone wall location as well as the construction type.

Figure 4: Stone Wall Locations

As depicted in Figure 4, south of Pier B is a 2-ft wide partially grouted stone wall which extends approximately 15-ft and ties into a dry-stacked stone wall. The partially grouted stone wall is installed were the old boat ramp once resided. It was noted at the north end of the wall, at the intersection between the partially grouted stone wall and the dry-stacked stone foundation for Pier B, is a pile of loose 6" stone which fills an approximately 4-ft by 4-ft hole. There were no voids noted in the wall and the grouted joints appeared to be in good condition. Overall this section of wall appears to be in good condition.

Continuing south, the partially grouted stone wall ties into an approximately 4-ft wide dry-stacked stone wall which extends approximately 116-ft. On average the stones utilized in the wall are approximately 5-ft long by 2-ft tall. The depth of the stones are estimated to be 4-ft but underneath the top layer it is unknown. Smaller stones were used to chink the interstitial spaces. It was noted that an 18-ft section of wall near mid-span appears to have settled significantly and stones are bulging from the face of the wall. At the southern terminus of the dry-stacked stone wall there is a partially grouted return. The return is approximately 2-ft wide and extends approximately 10-ft landward from the dry-stacked stone wall. The top 2-ft of the stone wall is grouted and founded on dry-stacked stone. This appears to have been recently completed and is in good condition.

The remaining stone wall on the eastern side of the marina basin is in the southwest corner and is a grouted stone wall. The wall is approximately 2-ft wide and is approximately 108-ft long. The wall terminates at a battered dry-stacked stone wall which extends along the southern extent of the marina basin. The grouted wall varies in height from approximately 4-ft to 8-ft. A 20" diameter reinforced concrete pipe outfall penetrates the wall approximately 10-ft from the southern corner. The pipe has an invert El. +1.22-ft NAVD 88 and appears to be in fair condition. Stacked stones above the pipe appear to have shifted and should be restacked. Overall this section of wall appears to be in fair condition.

The battered dry-stacked stone wall retains soil along the southern terminus of the marina basin. The wall is approximately 7-ft in height and is angled at approximately 26 degrees from vertical. The wall extends approximately 210-ft along the entire southern edge of the marina basin. Overall, the wall appears to be in fair condition with minor deficiencies. There is an approximately 2-ft wide section 10-ft from the western corner which appears to have failed. Continuing east, approximately 45-ft from the western corner, protruding through the wall is a 20" diameter reinforced concrete pipe. The pipes invert is located approximately 2-ft below the top of wall. A bulge in the wall was also observed over a 5-ft section. The bulge is located approximately 100-ft from the western corner. Minor voids were also noted throughout the wall.

The eastern perimeter of the marina basin is a partially grouted stone wall. The section which was observed extended from the concrete box culvert to the battered stone wall which is approximately 1,150 linear feet. The wall height varies over the length of the wall from approximately 1'-6" to 7-ft with the top approximately 2-ft being grouted. Overall it is in poor condition with significant voids, missing foundation stones and sections which have failed. It was noted that there were two areas where the wall has collapsed. One section of wall was noted to be approximately 80 linear feet while the other section is approximately 15 linear feet. Areas were the toe stones were missing revealed the founding soils. The wall appeared to be founded only on grade. There were three outfalls noted along this section of wall. One was a 12" diameter corrugated plastic pipe, the other was a 48" diameter reinforced concrete pipe and the last one was an 18" diameter reinforced concrete pipe.

Along the waterward edge of the seawall, located adjacent to the concrete box culvert, some geotextile fabric was witnessed along approximately 180 linear feet of the shoreline. The fabric extends approximately 15-ft waterward from the wall. It was noted that vegetation was growing through the fabric in a few locations. It appears as though this area was utilized as a living shoreline repair. Currently this area is in poor condition and it is recommended that improvements be performed to enhance the growth of tidal vegetation.

5.1.h. Boat Ramp

Located at West Beach, north of the beach area, is an approximately 30-ft wide by 65-ft long concrete boat ramp. The boat ramp is constructed from approximately 18" wide by 14.5-ft long planks. It was noted that there are approximately 3" gaps filled with crushed stone between each plank as well as extending down the center of the ramp. At the landward edge of the ramp there is an 8" headwall which defines the start of the ramp as well as 8" curbing extending along the edges.

Based on field measurements the ramp is estimated to be pitched at 1 vertical to 6.5 horizontal or approximately 9 degrees. Also, based on the estimated edge of ramp measurement, it was noted that the ramp has at least 2-ft of water depth during periods of low water. Overall the ramp appears to be in fair condition excluding the depth restriction during periods of low water.

A timber floating dock system aids boaters in the launching and hauling their boats. The floating dock system is located along the north side of the boat ramp. The existing system is approximately 6-ft and 150-ft long. A 110-ft section parallels the boat ramp then turns 90 degrees to the north for an additional 40-ft. The existing docks and seven float anchor piles appear to be in good condition.

5.2. MARINA IMPROVEMENTS

The existing marina components as described above need improvements and/or repairs. The City of Stamford is seeking to improve the existing marina and create a more accessible facility for both the general public and boaters. It is recommended that along with the following recommendations that the facility seek to become compliant with the Americans with Disabilities Act (ADA) as well as safe and operational. Following are the improvements **RACE** recommends to have a safe and operational marina facility.

5.2.a. Timber Piers

The existing timber piers overall are in poor condition. While the timber decking is in fair condition the stringers, caps, foundation piles, and guard rail are in poor condition. A preliminary review of the stringers and caps were analyzed against the intended use loading as specified in the International Building Code (IBC). It was determined that the existing stringers and caps are not adequate to support the applied load and therefore need to be strengthened.

In addition to the pier structural elements, it was noted that the timber guard is not code compliant and therefore would need to be replaced. Specifically, the timber guard openings, connections and posts were noted to be insufficient. It is recommended that a code compliant guard be installed which meets or exceeds the requirements set forth in the Connecticut State Building Code.

The existing two aluminum gangways, located at Pier B and C, were noted to be in poor condition. The gangways which remain in place appear to be for a light duty use and not adequately size for commercial use. The length of the gangways also appear to be too short and did not provide an adequate slope for traversing between the piers and docks during periods of low water. It is recommended that the existing gangways be replaced with an adequately sized gangway design to support public/commercial use as well as be meet the ADA guidelines.

It is recommended that the existing timber piers and aluminum gangways be replaced. Due to their location and exposure to wave impact, the timber piers should be designed to withstand the site specific lateral loads as well as the proposed gravity loads. In addition, the aluminum gangways should be designed to meet or exceed the loading requirements for commercial use.

5.2.b. Floating Docks

Currently there is only one floating dock within the Cummings Marina. It is recommended that this floating dock be removed and a new floating dock system be installed. The new floating docks systems should be designed to withstand the loads applied from an applicable storm event for this area.

In addition to the floating docks systems, to improve safety within the marina, it is recommended that a safety pedestal with fire suppression and a life ring be installed on the docks at a minimum of 75 feet on center. Dock ladders should also be installed for marina safety.

It is also recommended that the floating dock system have a de-icing system to minimize ice damage to the new facility. The de-icing system would continually move the water such that is does not freeze around the docks or associated anchor piles. Also if the marina was to be used for wet storage a de-icing system would be highly recommended.

5.2.c. Float Anchor Piles

The existing embedment of the float anchor piles, based on conversations with the City of Stamford, is unknown. In addition, as discussed in Section 5.1.c, the float anchor piles are too short when compared the still water elevations of storm events in the Stamford area.

Since the City of Stamford is seeking to improve the marina layout, the existing piles are too short, and the embedment depth of the existing is unknown, it is recommended that the piles be removed and replaced. The replacement piles should be designed such that they extend to a suitable elevation as well as able to withstand lateral loads applied from the floating dock system.

5.2.d. Revetment Improvements

As discussed in Section 5.1.f, there are three existing revetment conditions. The northern section along the point needs repair. The stones should be restacked at a minimum, although a better repair would be to remove the existing stone, install a filter layer and then reinstall the armor stone.

The second section, between Pier A and B, needs repair. The existing toe of the slope has been damaged or is missing which is allowing the slope to erode. This erosion is undermining the upper section of the slope and causing the large stones to be unstable. The slope should be repaired by installing new toe stones as well as installing a filter stone layer with geotextile fabric underneath the armor stones. This would stabilize the slope and minimize potential damage to the existing parking lot. It would also provide stabilization to future upland improvements in this area.

5.2.e. Seawall Improvements

Partially grouted and dry-stacked stone walls in addition to the stone revetments line the shoreline and provided stabilization to the upland areas. Along the western shoreline in the vicinity of the boat house, the dry-stacked stone wall is in fair condition. An approximately 18-ft long section was noted to have settled and appears as though repairs are required to minimize continued settlement or movement. It is recommended that this existing section be deconstructed, a new foundation stabilizing the wall be installed and the stones be restacked.

The existing seawall along the southern shoreline is in fair condition and only requires minor repairs with chinking and filling of voids as well as deconstructing and reconstructing an approximately 2-ft wide area.

The stone seawall along the eastern shoreline requires repairs. Large sections of the wall have collapsed and other sections appear as though they in poor condition. Voids throughout the wall were noted as well as toe stones missing throughout a majority of the wall. Based on the visual observation it did not appear as though the wall had a foundation. It is recommended that the partially grouted seawall be removed and replaced.

5.2.f. Water, Electric, and Waste Utilities

The existing water and electric utility services at the marina are in poor condition. Based upon the visual observations made by **RACE**, Pier B is the only pier with electric service. All of the piers have waterlines which are damaged and not functional. It is recommended, that new water and electrical services be installed and that each of the piers be fit with proper safety lighting. The marina should also be upgraded to provide power and water to each slip. Based on Eaton Corporation, a power management company which provides energy efficient solutions, the following power supply should be provided at each slip.

Table 8: Recommended Electrical Supply

Boat Length (ft)	Electrical Service Quantity and Capacity		
	Minimum	Acceptable	Preferred [1]
Up to 20	None	1 – 20 Amp	1 – 20 Amp
21 - 25	1 – 30 Amp	1 – 30 Amp	1 – 30 Amp
26 - 30	1 – 30 Amp	1 – 30 Amp	2 – 30 Amp
31 - 37	1 – 30 Amp	2 – 30 Amp	2 – 30 Amp
38 - 45	1 – 30 Amp	2 – 30 Amp	1 – 30 Amp & 1 – 50 Amp

Note: 1. Recommended by Eaton Corporation, PLC

It is further recommended that the utilities be enclosed within the docks and that pull boxes and access ports be installed at appropriate spacing to provide access for maintenance and service modifications. Power pedestals, including water service connections and hose bids should be installed at each double slip such that water as well as power is provided at each vessel slip.

In addition to power and water service upgrades, **RACE** recommends that a sewage pump out station be installed on the northeastern floating dock system. Resident boaters and slip holders, as well as transient vessels, would be encouraged and able to use the pump out system to remove sewage from their on-board storage tanks. Based on historic permits, specifically Permit SD-89-173, there is an existing 4” ductile iron sanitary sewer line tying into the existing dockmaster building. This permit also authorized a sanitary pump-out facility which tied into the sanitary line. While the existing condition of the sanitary line is unknown, it is recommended that a new pump out system be tied into the parks sanitary lines. Alternatively, a sewage hold tank could be installed and periodically emptied by a transport service. It is estimated, though a final design would depend upon final marina slip count, that such a pump out station would require at least a 1,500 gallon holding tank.

5.2.g. Boat Ramp

The existing boat ramp although it is in fair condition can be improved upon. It is recommended that the boat ramp be widened such that two boats have the ability to launch or haul a boat at once. Currently the boat ramp is approximately 2-ft deep during periods of low water. It is recommended that this be modified to a deeper depth during periods of low water to allow boaters to haul and launch during all tide cycles.

In addition to widening the ramp, another row of floating docks should be installed on the southern edge of the ramp to allow for temporary berthing. This would aid boaters during the launching and hauling procedure. While this boat launch can support the launching of vessels larger than 30’ in length, this is not an ideal boat ramp or location to haul or launch such vessels. If patrons were to launch or haul a vessel larger than 30’, it would need to occur around times of high water. In addition, sailboats of this length would require a hydraulic lift in addition to a crane to step or unstep the mast for transportation across the roadway.

With the above mentioned improvements, the existing boat launch parking lot should also be improved. The lot layout should create an easy environment for boaters to maneuver their trailers. In addition, there should be parking spaces that accommodate trucks and trailers. As recommended by the Planning and Design Guidelines for Small Craft Harbors parking spaces for a car trailer combination should be approximately 35 to 40 feet in length. The final design of the facility should take into consideration the number of boats that have launched in the past and the potential increase in usage based on the improvements.

5.3. MARINA LAYOUTS

Based on discussions with the City of Stamford and public feedback from public meetings one, two, and three, marina layout alternatives have been created taking into account comments from all parties. It was noted, based on the wait list, that the new marina should accommodate vessels between 20 and 32 feet in length. Based on the public comment it was noted that the City should have a designated transient dock with easy access to the Cummings Park amenities.

In addition to public comments, the marina layouts were based on the recommendations of the Planning and Design Guidelines for Small Craft Harbors (SCH). Slip widths, fairway widths, finger docks size, and main docks are all associated with the proposed boat size. Following is a table based on the SCH for slip design.

Table 9: Typical Schedule for Boat Slips

Slip Length (ft)	Double Slip Clear Width (ft)	Min. Dock Width (ft)	Min. Main Dock Width (ft)
25	26	3	8
30	29	3	
35	32	3	
40	35	4	
45	39	4	

Main docks provide boaters access to and from there finger dock were their boat is berthed. Main dock width can vary depending upon the configuration of the marinas finger docks, obstructions on the walking surface and member foot traffic. A minimum recommended width for mains is 6-ft with 7-ft and 8-ft widths being even more stable. As for the finger docks the minimum recommended width is 3-ft and varies depending upon the length of the finger as noted in Table 9. Another common guideline is the finger width is 10% of the finger length.

In addition to the slip layout the fairway widths need to be considered for boats accessing and egressing the marina. Per SCH the recommended fairway width is between 1.5 to 1.75 times the longest slip within a berthing aisle. For preliminary layouts it is typical to use 2 time the longest slip length.

Based on the aforementioned comments from the public, recommendations from the City, and abiding by the guidelines set forth in the SCH, the following Marina Layouts were created. These layouts have been provided in Appendix E, Figures 12, 13, and 14.

5.3.a. Marina Layout #1

Layout 1 is configured for a boat launch ramp, boat launch floating docks, and three individual floating dock systems each with access from a timber pier and an aluminum gangway. This layout is anticipated to berth approximately (16) 18-ft vessels, (56) 24-ft vessels, and (13) 30-ft vessels for a total of 85 slips. There is approximately 16,530 square feet of floating dock, 163 float anchor piles, and 46 power pedestals associated with this layout.

5.3.b. Marina Layout #2

Layout 2 has a similar configuration as Marina Layout #1 except without the boat ramp and boat ramp floating dock. This layout is anticipated to berth approximately (18) 18-ft vessels, (66) 24-ft vessels, and (13) 30-ft vessels for a total of 97 slips. This layout has approximately 16,480 square feet of floating dock, 170 float anchor piles, and 53 power pedestals associated with it.

5.3.c. Marina Layout #3

Layout 3 relocates the marina onto the eastern shoreline of the Cummings Marina Basin. This layout is anticipated to berth approximately (11) 18-ft vessels, (74) 24-ft vessels, and (16) 30-ft vessels for a total of 101 slips. This marina layout includes a new boat house, a security fence along the shoreline, 16,420 square feet of floating dock, 160 timber float anchor piles, 56 power pedestals, and raising the existing seawall.

Note, all marina options include, power pedestals for each double slip, water supply at each slip, a pump-out station, three timber piers, three aluminum gangways, utilities, security gates and a transient dock. All marina pricing also includes replacing the existing boat ramp at West Beach and adding another floating dock system to allow for two vehicles to launch and haul boats. The opinion of probable costs (OPC) are also based on the assumption that the existing electrical service at the site can provide the power required for the proposed layouts.

5.4. OPINION OF PROBABLE COST

Per the layouts discussed in Section 5.3 of this report, the following are opinions of probable costs (OPC) to perform each improvement. These OPC's are based upon comparable projects performed in the general geographic region in the past several years as well as RS Means. These costs are intended to provide a basis for decision and not for the development of project budgets. Note that the provided pricing is based on visual observations. No destructive testing, soil sampling or design has been performed and therefore the prices can vary significantly upon final design drawings. Please find following an estimate to complete the marina improvements for the selected layout.

Table 10: Opinion of Probable Costs for Marina Layouts:

	Marina Layout #1	Marina Layout #2	Marina Layout #3
Total	$4,603,400	$4,045,500	$4,584,800
Total Number of Slips	85	97	101

5.5. DREDGING

In accordance with the Connecticut Department of Environmental Protection (CT-DEP), Cummings Marina was last permitted to be dredged in 2001 under the Certificate of Permission (COP) COP-2001-042-KC. The COP provided the City of Stamford with authorization to dredge the Cummings Marina basin to -4-ft Mean Low Water (MLW) with a 1-ft over dredge allowance.

RACE performed a hydrographic survey of the Cummings Marina basin in June of 2003 following its dredging activities. In 2013, the City of Stamford, elected to have another hydrographic survey of Cumming Marina performed. The hydrographic survey was performed by Hydro Data, Inc. in March of 2013. The drawing titled “Hydrographic Survey Cummings Park Marina Basin” was provided to RACE by the City and used by RACE to determine the accretion rate of the basin.

In order to determine the accretion rate the two drawings had to be overlaid. A computer modeling program “Land Desktop” was utilized to create the surfaces of the two surveys and calculate the differences between them. Prior to modeling both surveys, the vertical datum had to be matched. Therefore, RACE’s drawing was updated from MLW to the NAVD 88 vertical datum. Once the drawings were in the same datum, the surfaces were created. They were then subtracted from one another to determine the amount of accretion that has occurred over the past ten years. Based on the provided data. Approximately 625 cubic yard of material have accreted in the basin.

Cummings Marin dredge template is approximately 119,800 square feet in area. Therefore, the marina basin accreted approximately 0.14-ft throughout the entire basin. Over a ten year period it was determined that there is minimal sedimentation occurring in the Cummings Marina Basin.

5.6. INSURANCE ELIGIBILITY

The Cummings Marina in regards to the in water structures, floating docks, piers, float anchor piles, etc. are currently not insured by the City of Stamford’s property insurance. Based on communications with the City if Stamford’s Risk Manager, Ann Marie Mones, they have been unable to secure property insurance on the marina itself due to its condition. The only item that is insured is the boat house.

It was also noted during our correspondences, that items within the marina needed replacement or updating in order to be insured. The items were never addressed and therefore the marina was never insured. Pending the proposed improvements of the marina, it is recommended that the City seek to insure the proposed upgrades upon completion of the project.

6.0 BEACH MASTER PLAN

As discussed in Section 4.3, it is recommended that the City of Stamford pursue the following for each beach.

6.1. Cummings Beach:

The resiliency of the beach to specific storm events was analyzed and it was determined to be stable during a typical 1 year storm event, but was susceptible to moderate erosion during a 10-yr event, and severe erosion during a 50-yr and 100-yr event. Based on the results, a number of beach improvement schemes were reviewed. After reviewing each of these schemes and the cost implications, it is recommended that a beach nourishment program be implemented. This would involve designing a beach grading template, i.e. specific optimum grades and slope, which the beach would be nourished too in order to minimize erosion. Periodic surveys would need to be performed in order to provide an estimate for the amount of nourishment necessary to maintain the beach. This alternative would allow the City to seek federal funding for future repairs and re-nourishment should the beach be damaged in a storm event. Figure 2 – Cummings Beach Existing Condition & Beach Maintenance Options depicts the proposed improvement plan.

6.2. West Beach:

The resiliency of West Beach was similar to Cummings in regards to erosion. It is recommended that this beach also have a beach nourishment plan implemented. As part of the nourishment plan it is recommended that "back passing" be performed. This procedure would relocate the accreting sand from the eastern side of the beach back to the west side of the beach. Similar to Cumming Beach, this would involve designing a beach grading template, i.e. specific optimum grades and slope, which the beach would be nourished too in order to minimize erosion. This operation will also aid in the minimizing of sediment transportation into the adjacent navigation channel. Figure 10 – Beach Back Passing Option depicts the proposed beach improvement plan.

7.0 MARINA MASTER PLAN

Three marina options were presented at public meeting 2 as well as public meeting 3 for public comment. Following public meeting 2, the marina layout options were posted to an online survey for public feedback. Based on the survey and public comment it was determined that Layout Option #3 found under Appendix E Figure 14 would be the most adequate option for both park patrons and marina members. Therefore, the Marina Master Plan has incorporated relocating the marina to the eastern shoreline of the Cummings Marina Basin. Based on public comment, relocating the marina would create additional open space where the marina once resided, minimizes traffic through the beach area, consolidates parking, and aids in minimizing late night activities in the beach parking lot.

The selected Master Plan includes approximately 16,420 square feet of new floating docks and associated float anchor piles. The floating dock system accommodates approximately 101 vessels ranging in size up to approximately 30-ft. In addition, the marina includes utilities, timber piers, aluminum gangways, a pump-out station, security fence, security gates, and improved shoreline stabilization structures.

8.0 MARINA BUDGET

The City of Stamford's Marina Budget includes all three marinas, Cummings, Czescik, and Cove. As discussed with the City of Stamford's Office of Operations, the marina budget is typically divided equally between all three marinas. Jo-Ann Mori, the Executive Secretary of the City of Stamford, provided the yearly marina budgets for the past ten years. The budget has been included with this report under Appendix F.

8.1. OPERATIONS COSTS

Based on the provided information over the past ten years on average the annual operations cost for the marinas has been $386,072. This includes salaries, overtime, medical insurance, life insurance, social security, telephone, postage, electricity, water, office supplies, etc. Per the City, the operations costs for each marina can be estimated at 1/3 of the total budget or $128,691 per marina annually.

8.2. MAINTENANCE COSTS

Based on the yearly marina budgets, the average maintenance costs which include building, ground, and tool replacement has been $34,722. Again breaking this down into the individual marinas this is $11,574 per marina annually.

Summing the operations and maintenance costs, the annual cost to operate and maintain a City of Stamford marina based on the historic budgets is approximately $140,265.

8.3. SLIP FEES

Slip fees vary depending upon boat length, location, and facility. Following is the average slip fee in 2014 for privately owned marinas in Connecticut:

Table 11: 2014 Privately Owned Marina Slip Fees

Length (ft)	Cost
24	$2,180
26	$2,520
30	$3,330

Following are the 2014 slip fees for the City of Stamford Marina's

Table 12: City of Stamford 2014 Slip Fees

Length (ft)	Cost
Up to 16	$410
17' – 21	$640
22 – 24	$1,130
25 – 27	$1,650
28 – 32	$2,160

Note that the fees have been rounded to the nearest tenth in both tables. Comparing the City's fees to the private facilities there is a significant increase in private to public owned facilities. Based on the proposed upgrades to the facility it is anticipated that the new marina will be operating at 90% capacity annual.

8.4. ADDITIONAL MARINA REVENUE

Revenue is not only created from the slip fees but also amenities included within the marina. Some amenities that could be offered with the new marina facility are as follows:

- Marina Parking Passes
- Wet storage
- Transient Dockage

There are additional amenities such as renting the boat house for events, canoe / kayak storage fees, boat maintenance shop, etc. that would generate revenue but were not included in this marina budget.

8.4.a. Marina Parking Passes

The marina parking pass is estimated at $125 per pass for the season. The elected layout will dictate the number of spaces required for marina parking and the revenue that could be generated from the passes. Per the SCH typically the number of parking spaces adequate for a marina is 75% of the number of slips. The number of parking spaces throughout the park meet or exceed this requirement. Per the proposed plans there will be approximately 30 spaces designated for marina parking only. It is anticipated that these spaces would be separated from the general park parking lots so that boaters can parking within a reasonable distance of their slip.

8.4.b. Wet Storage

The ability to wet store boats allows Cummings marina to continue to generate revenue during the off-season. Based on the anticipated boat sizes berthed within this marina, it is anticipated that only 60% of the slips would be used for wet storage. As recommended in Section 5.2.b a de-icing system should be installed to minimize ice damage to vessels and the marina during the off-season. It was estimated that the winter storage slip fees would be approximately 50% of the seasonal slip cost. This number is a volatile cost since it will be based on the demand for winter storage. Following is Table 13 for the estimated winter storage fees;

Table 13: Winter Storage Fees

Slip Length (ft)	Estimated Slip Fees Based on the Following:	
	City	Private
20	$384.00	$1,050
26	$678.00	$1,305
32	$1,296.00	$1,995

8.4.c. Transient Docks

A transient floating dock system would encourage the park to become not only a destination for locals but also open it up to traveling boaters. The transient dock would allow Cummings Park to become a destination by water. The transient dock as depicted in Appendix D Figures 12. 13, and 14, would provide immediate access to the beach as well as the vendors. Also locating the transient dock along the entrance to the basin allows for easy berthing and launch of a vessel. The 200 linear foot dock is anticipated to be on average 38% occupied during weekends and 8% occupied during weekdays. Based on the occupied day percentages it is estimated that the overnight transient vessels would only be 10% of the day percentages. Following is Table 14 with the annual estimated revenue generated from the transient floating dock;

Table 14: Transient Revenue

	Annual Revenue
Day	$5,285
Night	$1,585
Season Total	$6,870

8.5. MARINA BUDGET SUMMARY

Opinion of Probable Costs have been provided for the three marina layouts as specified under Section 5.4. Following is a Marina Budget Summary which includes the aforementioned items.

Table 15: Marina Budget Summary

	Initial Marina Construction Cost	Estimated Yearly Expenses	Estimated Yearly Revenue	
			City Rates	Private Rates
Marina Layout 1	$4,603,400	$140,265	$142,855	$258,051
Marina Layout 2	$4,045,500	$140,265	$159,831	$290,991
Marina Layout 3	$4,584,800	$140,265	$174,117	$310,423

The expenses as discussed in Sections 8.1 and 8.2, were compared to the potential city revenue fees as well as the private sector fees as discussed in Sections 8.3 and 8.4. Following is a recovery timeframe based on the estimated expenses and revenues. Note that there are additional revenue generating amenities, as noted in Section 8.4, which were not considered in the Marina Budget.

Table 16: Recovery Timeframe

	City Fees	Private Fees
Marina Layout 1	>50 Years	39 Years
Marina Layout 2	>50 Years	27 Years
Marina Layout 3	>50 Years	27 Years

Reviewing the initial cost of the marina as well as the operation and maintenance costs versus the generated revenue, the above Table 16 specifies the estimated amount of time required to net even. Based on the proposed marina improvements, propose shoreline re-stabilization and expenses for the marina it is recommended that the City revisit the slip fees for their marinas.

9.0 REGULATORY PERMITTING

Regulatory permitting from the State of Connecticut Department of Energy and Environmental Protection (CT-DEEP) and U.S. Army Corps of Engineers New England District (USACE) will be required to perform any and all of the recommended repairs included within this report. CT-DEEP jurisdictional limit is the Coastal Jurisdiction Line which is elevation +5.5-ft (NAVD 88) in Stamford, CT. As for the USACE there jurisdictional limit is the High Tide Line (HTL) which is equivalent to the 1 year frequency tidal flood or EL. +4.6-ft (NAVD 88) for Stamford, CT.

Historical research of past permits for West Beach, Cummings Park and Cummings Marina was performed as part of the marina assessment. The historic permits have been included in Appendix I of this report.

9.1. Beach Permitting

The proposed alternatives discussed in Section 4.2.c Improvement Schemes would require either a General Permit, Certificate of Permission, or an Individual Permit since all proposed work would most likely be taking place below CJL.

Beach grading and nourishment can be performed under a General Permit as long as the work taking place is above MHW. This State permitting process would require the City to fill out a Registration Form and submit the required supplemental information. Once the information has been submitted to the CT-DEEP the Applicant is authorized to proceed with the proposed work. The General Permit would allow the Applicant to perform one beach grading event per calendar year for a three year period. Following the three year period the Applicant would have to apply for another General Permit.

Beach grading and nourishment would be able to be performed to MLW with either a Certificate of Permission (COP) or Individual permit. Depending upon the project, typically if it has been permitted in the past and the Applicant is seeking to maintain or replace the previously authorized activity, the Applicant will be able to apply for a COP.

This process is significantly quicker than an Individual Permit process. Once the information has been provided to the CT-DEEP, they have 90 days to approve or deny the proposed project. Depending upon the project, the COP can be valid for a number of years typically between 3 to 5 years with an option for a 1 year extension. Based on historic permit research it may be possible to perform the recommended repairs to West Beach under a COP since beach nourishing permits have been issues for this site. Prior to starting the application process it is recommended that the Applicant or Applicants representative contact the CT-DEEP.

There has not been any beach nourishment performed at the Cumming Beach based on the collected historic permits. Therefore, to perform the recommended work the City of Stamford would likely have to seek an Individual Permit. Prior to submitting the permit, the Applicant is required to receive Consultation Forms from the following agencies:

- State of Connecticut Department of Agriculture/Bureau of Aquaculture

- City of Stamford Shellfish Commission
- City of Stamford Harbor Management Commission
- United States Army Corps of Engineers

Once the Consultation Forms have been received the Application can proceed with filing the Permit Application. Once submitted to the CT-DEEP the permit can take up to a year or longer to receive approval. Once the Permit has been approved the length of the permit can vary but is typically valid for 5 years with the option for a 1 year extension.

9.2. Marina Permitting

The permitting conditions for the marina would be similar to the permitting condition explained above for the beaches. Pending the selected alternative, the representative for the City of Stamford would need to contact the CT-DEEP and discuss the proposed project.

Based on historic permits, the marina and associated structures have been permitted in the past therefore if the marina is to remain in its current location, the recommended work would likely fall under a COP Application. Once the Application and additional information has been complied and submitted to the CT-DEEP. They would have up to 90 days to either approve or deny the proposed work.

If the marina access was to be relocated to the eastern shoreline, due to existing tidal wetlands, an Individual Permit would likely be required from the CT-DEEP. Again this process would require a number of agencies reviewing the Application, a public notice period, and review from the CT-DEEP which could take over a year.

It is noted that once an Individual Permit is issued, any modifications to previously authorized work can typically be granted under a COP application or a General Permit.

10.0 CONCLUSION

RACE was tasked with review the existing beach conditions at Cummings Beach, West Beach and Cummings Marina. In addition, **RACE** was charged with providing beach and waterfront infrastructure recommendations for repairs or maintenance to the beaches and marina. The existing beaches modeled with coastal engineering software applications to develop recommended repairs. Structural engineering software applications as well as reference were utilized to develop the recommended repairs and modifications for the marina facility.
Preliminary beach and marina improvement concepts were presented to the Public to receive comments and questions during a series of public meetings held by Stantec. Based on public feedback preferred alternatives were created. All schemes related to the beaches and the marina have been included as part of this report. **RACE** has developed, based upon public input and comments from the City of Stamford, specific recommendations for each of the following facilities.

<u>Cummings Beach:</u>

The existing conditions of the beach were analyzed and it was noted that during 1-yr storm events minimal erosion occurs. The existing beach condition was then analyzed for significant storm events. Based on our models, significant erosion would occur during the 10, 50, and 100 year storm event.

In order to improve and create a more resilient beach to storm events, a number of beach improvement alternatives were analyzed for this report. Following are the alternative which were reviewed and analyzed;

- Do Nothing
- Beach Nourishment
- Grain Size Modification
- Addition of a Sand Dunes
- Sand Gradation Modification
- Offshore Wave Attenuator

As presented in this report, it is recommended that the City of Stamford implement and permit a beach nourishment program for Cumming Beach. The beach nourishment plan should be based on an annual occurrence. This would aid in procuring federal funding for beach repairs upon sand lost during a significant storm event.

West Beach:

In addition to Cumming Beach, the existing conditions of West beach were also reviewed and modeled. Based on our beach models, significant erosion to the beach would occur during the 10, 50, and 100 year storm events.

In order to improve and create a more resilient beach to storm events, a number of beach improvement alternatives were analyzed for this report. Following are the alternative which were reviewed and analyzed;

- Do Nothing
- Beach Nourishment
- Grain Size Modification
- Addition of a Sand Dunes
- Sand Gradation Modification
- Offshore Wave Attenuator
- Beach backpass

Based on **RACE's** field observations and preliminary analysis, the preferred alternative for West Beach is to implement a backpass plan. As presented in this report, the natural movement of the sand in this area is towards the existing Federal Channel. An existing timber jetty is providing protection to the federal channel by limiting the sand migrating. Once enough accretion against the timber jetty occurs, it will eventually migrate around the waterward terminus of the structure and start to impact the channel.

In order to maintain the beach and minimize sand migration into the channel it is recommended that backpassing be performed. This can be accomplished by removing the sand from the eastern end of the beach and relocating it back to the western end. While alternative would need to be monitored annually, the backpassing procedure would only need to occur periodically. This work would likely be COP eligible since West Beach nourishment activities have been permitted in the past.

<u>Cummings Marina:</u>

RACE completed a visual assessment of the existing structures at Cummings Marina and provided recommendations for repairs or modifications. Following is a list of items observed;

- Timber piers
- Pier utilities
- Aluminum gangways
- Floating docks
- Timber float anchor piles
- Shoreline stabilization structure
- Boat ramp & ramp floats
- Dredge depths
- Marina Budget

Overall Cummings Marina is in poor condition and requires improvements. Based on the observed conditions and provided information from the City of Stamford, **RACE** recommends the following:

- Replace the timber piers
- Upgrade the existing utilities
- Replace the aluminum gangways
- Install a new floating dock system
- Replace the float anchor piles
- Repair existing shoreline stabilization structures
- Replace the existing boat ramp
- Install another floating dock system along the southern edge of the boat ramp
- Perform typical maintenance dredge

RACE reserves the right to amend this report if additional information becomes available.