4 SEAWALL CONDITION ASSESSMENT

4.1 Overview

This chapter provides a summary of existing seawall conditions and assessment of the useable life of the seawall based on site observations and review of available documents, reports and drawings. Detail of the assessment is provided in Appendix C. The review of older drawings and reports provide the historical background, as well as types and modifications of the seawalls on Balboa and Little Balboa Islands. Site observation included visual observations of the conditions of the current seawalls, and cataloguing of obstructions, modifications, utility lines, storm drains, and gangways and platforms as they relate to the seawalls. In addition to assessing the conditions of the seawall, special attention was given to the Balboa Island Ferry Boat Landing and its surroundings and the three bridges on the islands. If an extension or reconstruction of the existing seawalls are to be performed, these four locations would need to be modified to prevent them from acting as openings in an otherwise solid seawall protection around the islands.

4.2 Document Review

4.2.1 Record Drawings

Design drawings from 1929 and 1935 were reviewed. Drawings show that in 1929 over 60% of the walls along the Grand Canal, as well as the returns along the north beach of Balboa Island and the south beaches of both Balboa and Little Balboa Island, were replaced. These walls used a concrete soldier pile and concrete panel design in which soldier piles were driven to a depth of approximately -3.0 feet MLLW[4] along the length of the Grand Canal and to approximately -8.0 feet MLLW[5] at the corners as measured in 1929 and in accordance with City Drawing No. STD-115-L. The concrete wall panels span between the soldier piles. This particular wall relies on tie-backs comprised of 1-inch-diameter steel tie-rods attached to 9-foot-long by 10-inch-diameter timber pile deadmen (approximately 8.0 to 8.5 feet back from the face of the outside seawall) and a structural cap to counteract the overturning moment. The tie-rods are shown to be placed at every other soldier pile at 22 feet on-center.

---

[4] MLLW is used in the Drawing No. STD-115-L but there is no information on the referenced tidal epoch. For the rest of the report, MLLW is referenced to NTDE 1983-2001.

[5] See footnote No. 4

Although the design drawings for the remaining and majority of the seawalls around Balboa Island were dated 1935, construction was not performed until 1938 as part of the National Recovery Act. These seawalls replaced older substandard walls and tied into the existing seawalls along the Grand Canal and along a 500-foot-long section on the western tip of Balboa Island. The new seawalls, as designed and constructed, used a concrete soldier pile and concrete panel design similar to the seawalls built along the Grand Canal in 1929. Soldier piles were driven to a depth of approximately -5.0 feet MLLW[6] as measured in 1938 and in accordance with City Drawing No. STD-115-L. However, the new design placed a tie-back at each soldier pile at 11.67 feet on-center, and according to the design, these tie-backs provide all the resistance to counteract overturning. These tie-backs are comprised of 1¼-inch-diameter steel tie-rods attached to 10-foot-long by 12-inch-diameter timber pile deadmen (approximately 8.0 to 8.5 feet back from the face of the outside seawall). The cap does not have a structural connection to the solider piles or to the concrete panels and relates to an architectural finish to the seawall structure. Since extending the cap is one of the major considerations to be assessed to mitigate flooding, the fact that there is either no, or a substandard connection, between the cap and the wall below for the majority of the Balboa seawall is considered significant.

It is assumed that the aforementioned 500-foot-long section at the western end of Balboa Island predates the 1935 seawall design drawings since the cap of this 500-foot-long seawall was slated to be replaced in said drawings. The 500-foot-long section of wall on the west end of Balboa Island is a sheet pile design similar to the wall surrounding Collins Island and is believed to have been constructed in the late 1920's or early 1930's. This design consists of interconnecting vertical concrete sheet piles and a structural concrete cap with tie-backs extending some distance behind the seawall. This section of seawall was upgraded with a rock revetment as a result of the findings in a 1985 report discussed later in this section.

Both sets of drawings show "square" symbols next to the rebar dimensions indicating that the rebar used was of the square, dimpled type, as opposed to deformed round bars currently used in modern construction. The distance between rebar and the outside face of concrete as shown on the drawings is small compared to a modern standard of 3.0 inches for construction in the marine environment. Furthermore, neither drawing construction notes nor specifications were available identifying concrete and/or rebar material type and strength. Based on common practice of design and construction in the late 1920's and 1930's, it is assumed that the existing seawall concrete is of lower strength compared to modern concrete mix designs.

---

[6] See footnote No. 4

4.2.2 Reports and Studies

Cash & Associates (now part of URS) provided condition survey reports for the Balboa seawall to the City in 1985 and 2005. The 1985 report included a description of the unearthing of tie-rods at the west end of Balboa Island and at various locations around Little Balboa and discussion of opinions regarding seawall stability. Work performed for the 2005 report consisted of a visual inspection of the wall for signs of obvious distress as well as suggested repairs.

In all cases where tie-rods were uncovered, the rods did not have a corrosion protection system (coatings or wrappings) and all rods showed evidence of at least 50% loss of cross-sectional area, with several rods completely severed. Preliminary calculations noted that the walls around Balboa Island would be stable without tie-rods for gravity loads, if the exposed height of support (i.e., the difference in elevation between top of boardwalk and top of mudline) was no greater than 5 feet.

The 1985 Report prompted the City to stabilize the toe of the seawall at four critical locations around the Island by constructing rock revetments as shown in Figure 4.1. Observations also noted a separate seawall stabilization project performed along the seawall east of the Balboa Island Ferry Boat Landing. Earth anchors were installed, as shown in Figure 4.2, and a submerged concrete block revetment was placed at the toe of the seawall.

Figure 4.1 Rock Revetment Stabilization at Western End of Balboa Island

Figure 4.2 Earth Anchors and Concrete Block Revetment (Submerged) at Balboa Island Ferry Boat Landing

The City also responded by pursuing a repair and maintenance program. Most of the noted distresses in the seawall cap and soldier piles were repaired. An example of a typical repair is shown in Figure 4.3.

Figure 4.3 Use of Elastomeric Filler to Seal Cracks to Prevent Seawater Intrusion

4.3 Site Observation

In addition to the seawall and boardwalk elevation surveys described in Chapter 2, a visual survey of Balboa Island was conducted on May 25, and June 6, 2010 to assess the condition of the seawall and to examine Balboa Island Ferry Boat Landing and three bridges of concern. The findings are presented in the following section.

4.3.1 Seawall Cap Visual Survey

During the visual survey of the seawall, seawall cap extensions were observed in the Little Balboa Island. The extension raises the top of wall elevation by between 6 and 12 inches depending on location around Little Balboa. An example of this cap extension is shown in Figure 4.4. Although this extension provides a defense against high water events, the limited remaining useful life and the existing condition of the underlying seawall make further extensions questionable.

Figure 4.4 Little Balboa Seawall Cap Extension

The visual survey also found universal distresses in the cap, specifically multiple cracks, coinciding with the locations of the soldier piles. The development of these cracks at the specific locations of the soldier piles is likely due to a reduced structural cross-section and a concentration of load ultimately relating to concrete stress. Despite a concentration of cracks at the soldier piles, cracking also can be found at many locations along the concrete cap including the structural cap along the Grand Canal. Coupled with similar cracks found on the exposed portions of the soldier piles and panels, the evidence portends to universal distress throughout the seawall. The shot-creted piles and panels along the Grand Canal walls (see Figure 4.5) are of particular concern because the condition of the original concrete is hidden by the shot-crete repairs. Despite repairs to cracks over the years, cracks are still prevalent in the seawall cap (see Figures 4.6 and 4.7).

Figure 4.5 Shot-crete on Grand Canal Seawall

Figure 4.6 Typical Crack and Spall Repairs

Figure 4.7 Crack Repairs with Corroding Rebar

Another common and continuous distress point along the seawall is parallel to and approximately 2 to 4 inches above the boardwalk. As part of the drainage mitigation project performed in the 1980's, the boardwalk was lowered several inches from its original design elevation in order to facilitate drainage away from private properties. This placed the boardwalk below the bottom of the existing cap and it is assumed a patch was done to fill the gap between the boardwalk and the cap. Therefore, the continuous crack appears to be non-structural and related to the patchwork as shown in Figure 4.8. This assumption should be confirmed as part of a subsequent study.

Figure 4.8 Sidewalk Separation from Seawall

In addition to visual observations, we utilized what is known as a “chain-drag” test by impacting the concrete with a heavy metal object to detect holidays (voids caused by concrete chemical reactions or rebar corrosion) and de-laminations in the structure. A hollow sound, typically associated with de-laminations and holidays was heard throughout the cap on both islands, but were particularly evident along the portion of the Grand Canal seawall constructed in 1929. Weathering, settling, and seismic events coupled with porous concrete elements have allowed seawater to seep into the seawall and corrode the rebar within. As the rebar corrodes, the rust expands putting pressure on the concrete from within causing voids and separation, or de-lamination of the concrete from the rebar, thus weakening the structure. These actions lead to cracks and breaking off of chunks of concrete, known as spalling.

Although many major cracks and spalls have been repaired over the past several years by the City, the “chain-drag” test found additional locations needing repair. The results were noted in the field survey, and should be confirmed as part of a subsequent investigation through the use of more invasive testing procedures.

Storm drain outlets that drain through the seawall and into the Bay (see Figure 4.9) have existed for decades at the street ends of Balboa Island, based on the 1935 record drawings and the recent visual survey. In the 1980's as part of the boardwalk reconstruction, a storm water drainage system with 4- to 6-inch diameter drains was constructed landward of and parallel to the seawall. These drains connect to the City's storm drain system outlets at the street ends and were designed to keep water from ponding along the seawall and from spilling onto private property.

This drainage system would not have functioned without the installation of gate valves at all storm water outlets on Balboa Island, as shown in Figures 4.10 and 4.11. These valves are closed during high water events to prevent seawater from flooding low lying spots on the Island. Prior to the valve installation, the storm drain outlets were a major source of flooding during high water events.

Figure 4.9 Storm Drain Outlet Through Seawall

Figure 4.10 Hand-Operated Gate Valve in Storm Drain Manhole

Figure 4.11 Actuated Gate Valve in Storm Drain Vault

4.3.2 Bridges and Ferry Boat Landing

In addition to the visual survey and measurements of the Balboa Island seawall, special attention was given to the Balboa Island Ferry Boat Landing and its surroundings and the three bridges on the Island - the Marine Avenue Bridge, the Park Avenue Bridge, and the Collins Island Bridge. If an extension or reconstruction of the existing seawall is to be performed, these four areas need to be modified to prevent them from acting as openings in an otherwise solid seawall fortification around the Island. Any openings in the bridges that would allow seawater to seep onto the roadway should be sealed, and waterproofing should be performed on surfaces exposed to rising sea level. Any reconstruction or modification of the existing bridges should include modifications to ensure a waterproof structure. The goal is to allow water to escape but not to enter the fortified Island.

<u>Bridges</u>

The Marine and Park Avenue bridges have solid concrete parapet (side) walls that tie into the existing seawall (see Figure 4.12) and have peak roadway elevations about the current Base Flood Elevation of 9.0 feet NAVD88 (9.18 feet MLLW). The Collins Island Bridge cuts through the seawall, has an open metal rail wall (see Figure 4.13) and a peak roadway elevation of approximately 7.3 feet NAVD88 (7.5 feet MLLW), which is below BFE. This bridge will require thorough waterproofing as well as solid concrete parapet (side) walls sealed to the seawall to prevent it from becoming a source of flooding. The seawalls on

Collins Island will need to be retrofitted or replaced in concert with Balboa Island, to prevent flooding of that island and to prevent seawater from flanking the Balboa Island barriers.

Figure 4.12 Park Avenue Bridge Interface at Big Balboa Seawall

Figure 4.13 Collins Island Bridge Interface at Seawall Abutment

Balboa Island Ferry Boat Landing

The approach to the Balboa Island Ferry Boat Landing also breaches the seawall, as shown in Figure 4.14, allowing a path for water to enter the Island. In addition, the Ferry Boat Launch Ramp is particularly low in its current configuration as shown in Figure 4.15. The approach elevation is 6.6 feet NAVD88 (6.8 feet MLLW) at the seawall opening and 7.0 feet NAVD88 (7.2 feet MLLW) at the ramp leading to the ferry boat dock. During high water events, the launch ramp must be shut-down until water recedes.

Figure 4.14 Balboa Island Ferry Boat Landing Approach

Figure 4.15 Balboa Island Ferry Boat Landing as Viewed from Side

If the dock and launch ramp are left in their basic current location, a major effort would be required to raise the launch ramp and the approach street, Agate Avenue. This would impact adjacent buildings and the intersecting boardwalk. Two options of raising the launch ramps are provided in Chapter 5.

4.4 Predicted Lifespan and Remaining Useful Life of Existing Seawalls

The lifespan of structural concrete depends on many factors including the design, construction, quality control and environmental conditions of the structure. Based on a review of the construction documents and an understanding of design and construction practices in the 1920's and 1930's, the lifespan of a reinforced concrete structure would be judged by today's standards, to have a realistic lifespan of between 75 to 100 years.

The condition of the Balboa seawall is somewhat better than the condition of the Little Balboa seawall. Little Balboa, which is aligned with the main channel and harbor entrance, is particularly susceptible to ocean swells. The long fetch also allows for larger wind waves to impact Little Balboa seawalls during storm events. Balboa is somewhat more sheltered and has a shorter fetch, except for its exposed western tip.

The sections of seawall supporting greater gravity loads due to erosion and dredging (i.e., greater exposed seawall height) and exposed to greater wave and swell activity are expected to have a lifespan closer to the lower end of the range, or between 75 and 90 years. Those sections of the seawall protected by beaches and fronting calmer waters are expected to have a lifespan closer to the upper end of the range, or between 85 and 100 years. Since the seawalls are in a corrosive marine environment, none are expected to have a lifespan exceeding much more than 100 years.

In summary, since most of the seawalls on Balboa and Little Balboa Islands were constructed in the 1920s and 1930s, it is estimated that the remaining useful life of the seawalls is between 10 and 25 years, depending on location. The seawalls with estimated shorter remaining useful life span are those constructed in the 1920s, including 60% of the walls along the Grand Canal, as well as the returns along the north beach of Balboa Island and the south beaches of both Balboa and Little Balboa Island.

5 PROPOSED SEAWALL REPAIR AND REPLACEMENT ALTERNATIVES AND INUNDATION SOLUTIONS

5.1 Seawall

Given the existing seawall's condition and remaining useful life and an understanding of construction techniques used in the late 1920's and 1930's, major seawall retrofit does not appear to be a feasible option. Installation of earth anchors and rock revetments may provide an increase in overturning resistance and toe support, respectively. However, for most of the seawalls, the primary concern is degradation of the concrete and rebar within the structure. Therefore, the following sections provide interim short-term alternatives to prevent flooding of Balboa Islands and long-term seawall replacement and extension options.

5.1.1 Cap Replacement/Extension Alternatives

In the interim, prior to full replacement of the Island seawalls, the Balboa Islands seawalls may be extended by an incremental amount of 6 to 8 inches to prevent overtopping from waves during high water levels. Based on the existing seawall age, predicted lifespan, condition, and design, two alternatives were developed for increasing the height of the existing seawall.

Alternative 1: Replace the existing cap with a taller cap that is mechanically attached to the soldier piles and concrete panels using dowels.

Alternative 2: Extend the existing cap to a calculated height that will not undermine the seawall or seawall cap structural integrity. This extension may consist of either:

- Option 1 – Mechanically connecting a reinforced concrete extension to the existing seawall cap using dowels,
- Option 2 – Deploying polypropylene sandbags on the seawall cap and other floodwater entry points (i.e., bridges and ferry boat landing) during high water events, or
- Option 3 – Placing geotextile (Longard) bags or tubes on the seawall cap and other floodwater entry points until the seawalls are replaced.

If a mechanical extension (Alternative 2, Option 1) of the seawall cap is chosen, there is precedent for an extension of up to 8 inches, since the Little Balboa seawall was previously extended by this amount. This extension is referred to as a mechanical extension because it utilizes rebar dowels to mechanically connect the new extension to the existing cap. First, the top surface of the existing cap would be roughened. Then, the existing cap would be drilled at distances and to depths to be determined pending tests of the existing cap and a decision on the final extension height. Rebar dowels would epoxy-set in these holes. A reinforced concrete extension would then be built on top of the existing cap incorporating the rebar dowels. The roughened surface of the existing cap would allow for the new concrete to better bind with the original concrete. Any extension beyond 6 to 8 inches may compromise the structural integrity of the Balboa Island seawall cap. For this reason, any mechanical extension of the already-extended Little Balboa seawall should include demolition of the existing extension and reconstruction of a new extension.

The other two extension alternative options use sandbags to extend the protective height of the seawall. Sandbags are provided as options since the Balboa Island seawalls are nearing the end of the useful life and are recommended for replacement between 10 and 25 years. In addition, sandbags are commonly used to protect against flooding in all kinds of weather and water conditions. Typical sandbags (Alternative 2, Option 2) consist of 2-foot-long polypropylene bags filled with sand and tied at one end. Although these bags may be left in place for extended durations, they are primarily designed to be deployed when needed. Two stacks of sandbags will extend the seawall by about 6 inches, providing adequate flood protection for Balboa Island for the next 10 to 25 years based on the flood modeling results described in Chapter 3.

The other sandbag-type option (Alternative 2, Option 3) consists of geotextile (Longard) bags or tubes. An example of using geotextile bags for flood protection is shown in Figure 5.1. These geotextile bags are made of thicker and stronger material than the traditional polypropylene sandbag (Alternative 2, Option 2). These bags can be left in place until the seawalls are replaced, and given their thickness, only one bag will be needed to meet the required height. Just like any other plastic material, ultraviolet (UV) degradation is a concern. The use of UV inhibitors in the geotextile material or the placement of a protective tarp overtop the geotextile bags may be sufficient to shield the bags from UV light.

Figure 5.1 Geotextile Sandbags Used as a Seawall Along a Beach

5.1.2 New Seawall Options

To increase the seawall height beyond a 6- to 8-inch extension, the seawall will have to be replaced because of structural reasons. Two conceptual options for replacement of the seawall were developed. The two options differ in the seawall design but share a similar implementation plan with the five phases graphically illustrated in Figure 5.2.

Phase 1: Short-term augmentation of the seawall by 6 to 8 inches as discussed in the last section.

Phase 2: Begin replacement of the existing seawalls between 10 to 25 years of baseline year 2010. This initial phase will consist of a seawall constructed to 9.8 feet NAVD88 (10 feet MLLW), which would place the new wall 0.8 foot above the current Base Flood Elevation height of 9.0 feet NAVD88 (9.2 feet MLLW) for Balboa Island.

Phase 3: If necessary, extend the seawalls by an additional several feet up to an elevation of 14.0 feet NAVD88 (14.2 feet MLLW) within 40 to 50 years from baseline year 2010, or as required by rising sea levels.

Phase 4: If necessary, construct a deep well groundwater dewatering system to protect the Island from subsequent high water tables associated with high water levels. If sea levels rise as predicted, then dewatering will be required within 40 to 50 years of baseline year 2010.

Phase 5: Establish appropriate minimum lowest floor elevation in accordance with the federal Base Flood Elevation (BFE). The City must continue to adhere to this requirement since Balboa Island is in a Flood Insurance Rate Map (FIRM) Zone A, which is considered a Special Flood Hazard Area. If sea levels rise as predicted, then the BFE will likely be higher in year 2100 compared to the current BFE of 9.0 feet NAVD88 (9.2 feet MLLW).

The two seawall replacement options are outlined below. Both the seawall replacement and the future cap extension are included in these options.

Replacement Option 1 - "H" Piles with Reinforced Concrete Wall (Lag) Panels

Install steel "H" soldier piles at approximately 10 feet on center. Insert prestressed reinforced concrete wall (lag) panels (similar to the existing wall) in a tongue-and-groove fashion in the space between soldier piles. Cast a reinforced concrete structural cap, designed to be extended in the future if and when required, on top of this assembly. This conceptual option is shown in Figure 5.3. An example of this kind of reinforced concrete wall is shown in Figure 5.4.

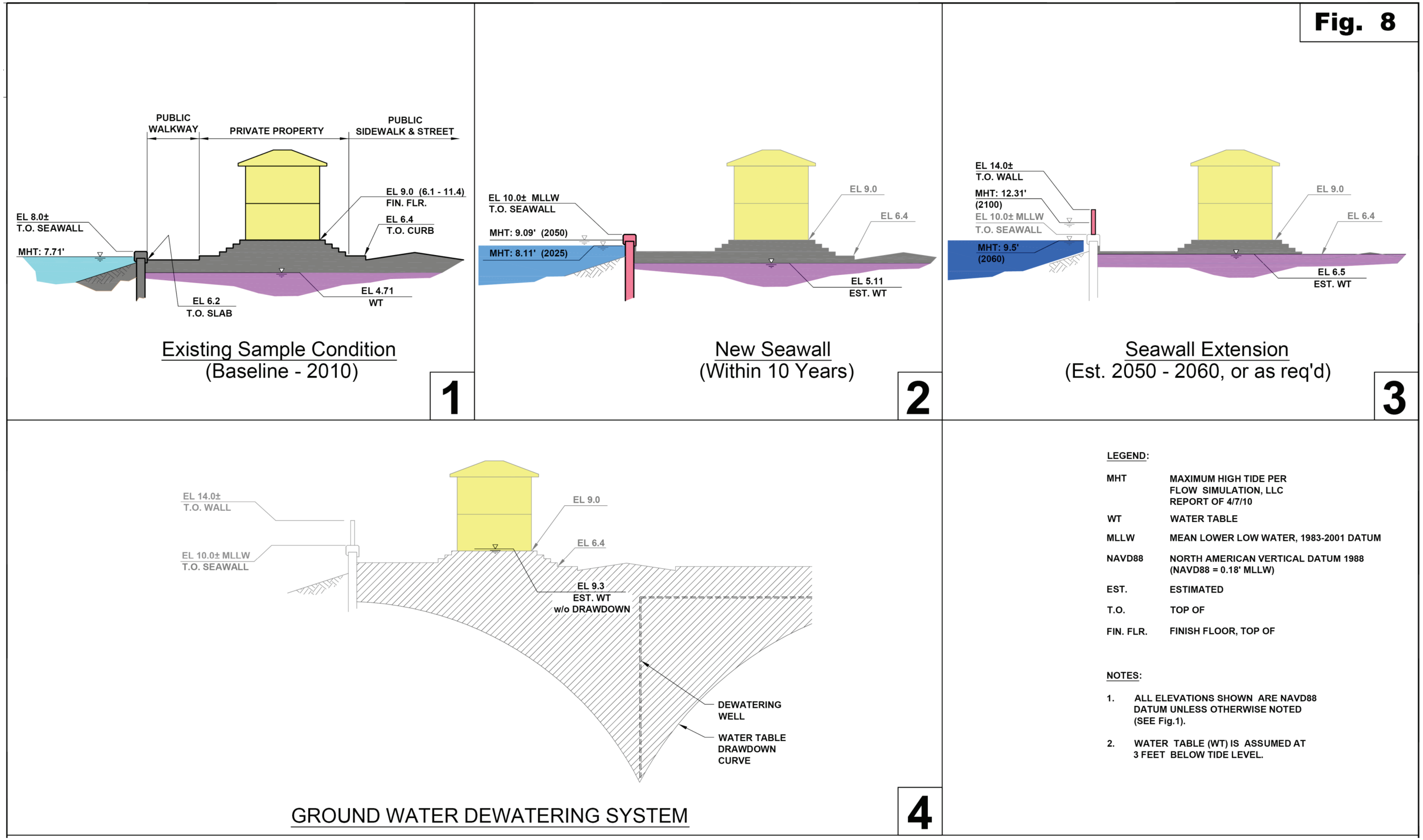

Figure 5.2 Conceptual Seawall Replacement Implementation Plan

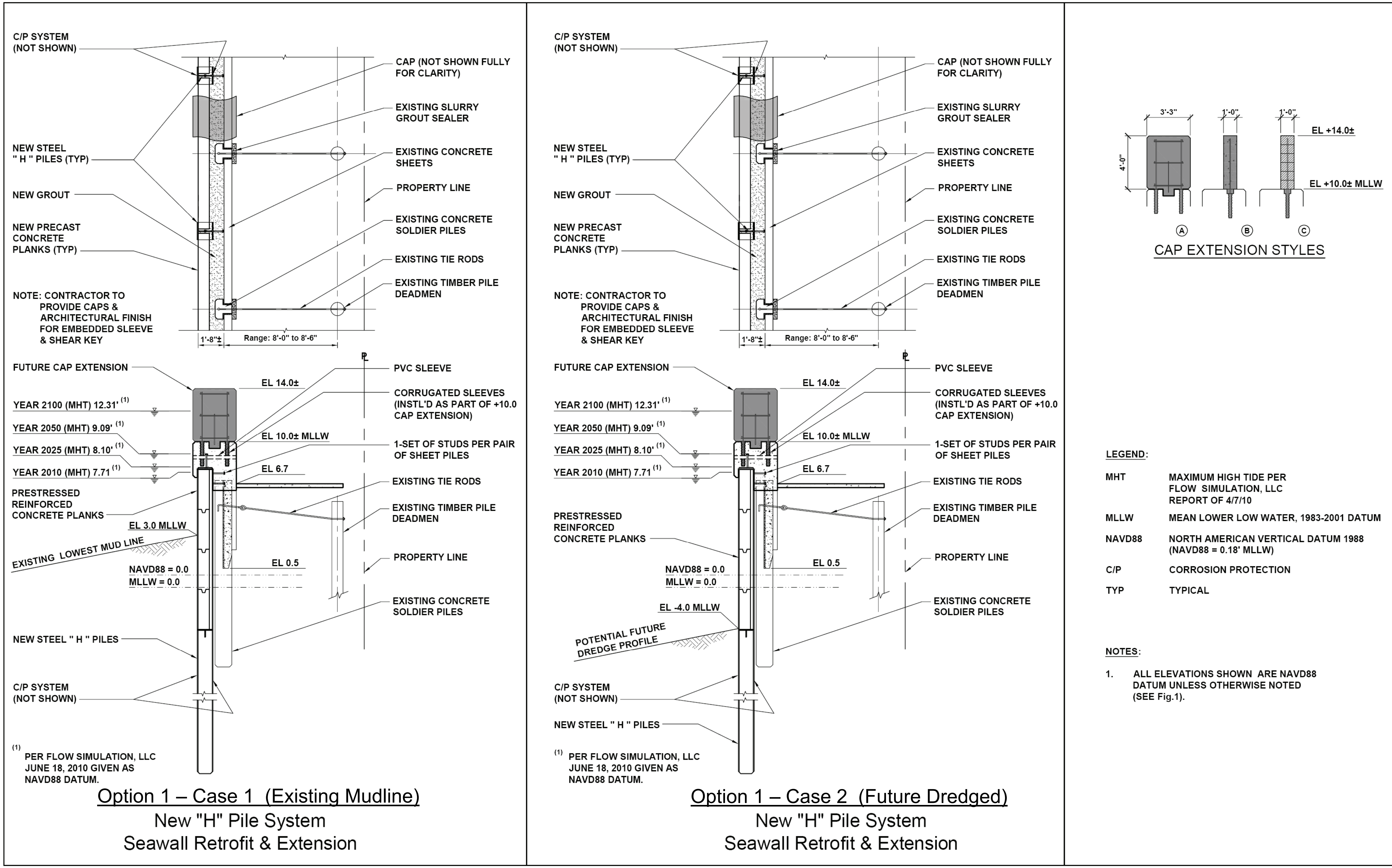

Figure 5.3 New "H" Pile System Seawall Retrofit and Extension

Figure 5.4 Construction of Retaining Wall Using H-piles and Concrete Wall (Lag) Panels

Replacement Option 2 - Continuously-driven Steel Sheet Piles

Install continuous steel sheet piles. Cast a reinforced concrete structural cap, designed to be extended in the future if and when required, on top of this assembly. This conceptual option is shown in Figure 5.5 and a picture for this kind of seawall is shown Figure 5.6.

Both options are based on installing the new seawall waterside of the existing wall, and then grouting the void between the two walls for a seal. Both State and Federal permitting agencies typically do not promote projects that contain impacts to tidal wetlands. Taking into account the entire length of the Balboa Island seawall and the offset between the face of the existing seawalls and the face of the proposed seawall, approximately 0.5 acre of tidelands would be lost. For either of the proposed seawall replacement options, discussions will be necessary with State and Federal permitting agencies to illustrate the impracticality of other alternatives which carry more risks to utility lines and private properties as well as higher construction costs.

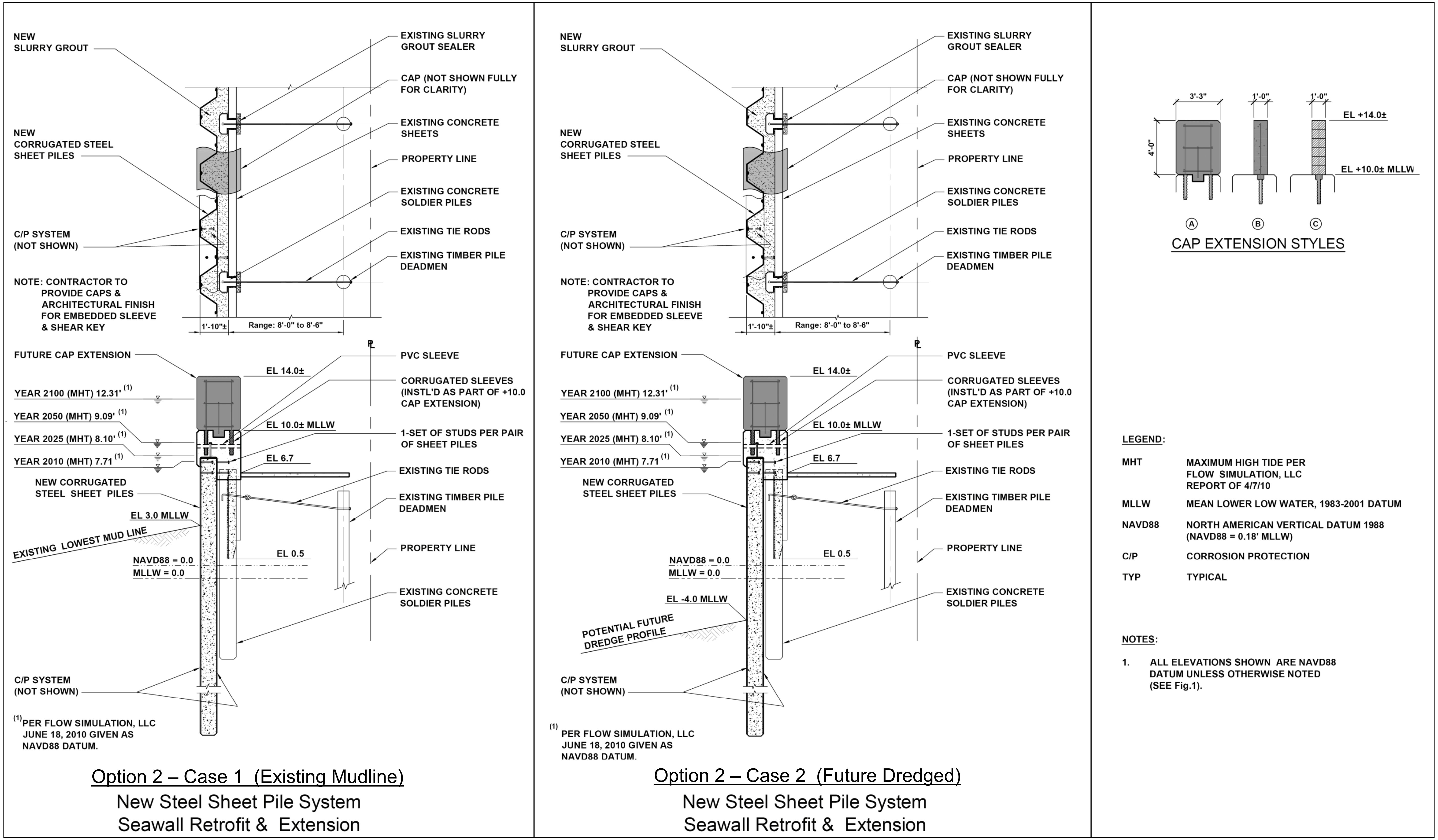

Figure 5.5 New Steel Sheet Pile System Seawall Retrofit and Extension

Figure 5.6 Steel Sheet Pile Bulkhead

Both replacement seawall designs are also cantilevered, meaning they do not require tie-rods, deadmen, or earth anchors to be drilled into the earth behind the wall. The ability to cantilever the seawall is a function of the depth of seawall embedment, of the exposed height of the wall (difference between top of boardwalk on the landside and top of mudline on the waterside), and of the type of structure desired. With cathodic protection and a rigorous maintenance and repair schedule, both replacement options have a lifespan of up to 150 years.

It is assumed that either seawall option selected will be designed to one of two mudline conditions (Case 1 and Case 2 shown in Figures 5.3 and 5.5) depending on the location on the Island and based on anticipated City and community desires. The majority of the rebuilt seawall (approximately 9,200 feet of shoreline) would be designed using a mudline elevation of 3.0 feet NAVD88 (3.2 feet MLLW) allowing continuing use of existing beaches around Balboa Island. The remaining 4,000 feet would have a rebuilt seawall designed with a mudline elevation of approximately 4.0 feet NAVD88 (4.2 feet MLLW) to allow for dredging for boat berthing and navigation.

5.2 Balboa Island Ferry Boat Landing

With the replacement of the seawalls on Balboa Island, the dock and launch ramp at the Balboa Island Ferry Landing would also need to be modified. If the dock and launch ramp are left in their basic current location, a major effort would be required to raise the launch ramp and the approach street, Agate Avenue. Two options for raising the launch ramp were developed; they are shown in Figure 5.7. As shown in the figure, both options would impact adjacent buildings and the intersecting boardwalk.

Option 1 blocks the boardwalk at the intersection with the proposed ferry boat landing approach ramp. Pedestrians have to travel an additional 200 feet around the approach ramp to get from one side of the boardwalk to the other side. This option only allows one-way traffic from the ferry to the intersection of the approach ramp and alleyway. Existing grade-level sidewalk and delivery access are maintained on Agate Avenue.

Option 2 allows continuous boardwalk access by constructing 5% grade ramps on either side of the approach ramp. These ramps are ADA-compliant and do not require handrails. However, the ramps do extend beyond the Agate Avenue right-of-way and impact access to six waterfront properties. The proposed approach ramp and adjacent sidewalks are widened to the full right-of-way width allowing for two-way traffic on Agate but blocking access to two structures on Agate.

It is hard to envision raising the launch ramp without requiring the reconstruction of the two buildings on either side of Agate Avenue adjacent to the launch ramp. Despite the impacts to surrounding properties and pedestrian access, Options 1 and 2 are land-based and only require the ferry launch ramp and float to be raised in concert with the new approach ramp. Additionally, these options do not impact existing navigation in the main channel.

An option to shift the launch ramp further into the main channel so that existing properties can remain unchanged was also developed. This proposed option (Option 3) is shown in Figure 5.8. To account for the effect of sea level rise to the Balboa Peninsula and to show the full extent of anticipated channel width reduction, a similar redevelopment of the ferry landing and launch ramp on the Balboa Peninsula side of the channel will be required. After some assessment of navigational clearances, which included incursions on both sides of the channel, the proposal appears feasible, although additional study would be necessary as well as discussions with the U.S. Coast Guard, California Coastal Commission, California Fish & Game, and the U.S. Army Corps of Engineers. Such a shift would likely require a similar extension of the adjacent fuel dock to prevent any reduction to ingress and egress into this facility. These changes would affect the existing pierhead lines.

Any reconstruction of this facility, regardless of the type, will take time. The facility could be inactive for nine months or more during construction of a new approach and launch ramp including installation, testing, and activation of all utility and mechanical systems. Furthermore, if this channel-ward approach were taken, a similar structure should be required on the Balboa Peninsula.

Option 1
Street Approach Ramp with Diverted Walking Path
@ 8% : ELEV. 14.0

Option 2
Street Approach & Boardwalk Ramps
@ 8% : ELEV. 12.5

GRAPHIC SCALE

Datum: NAVD 88

Figure 5.7 Two Options to Raise the Launch Ramp at Balboa Island Ferry Landing

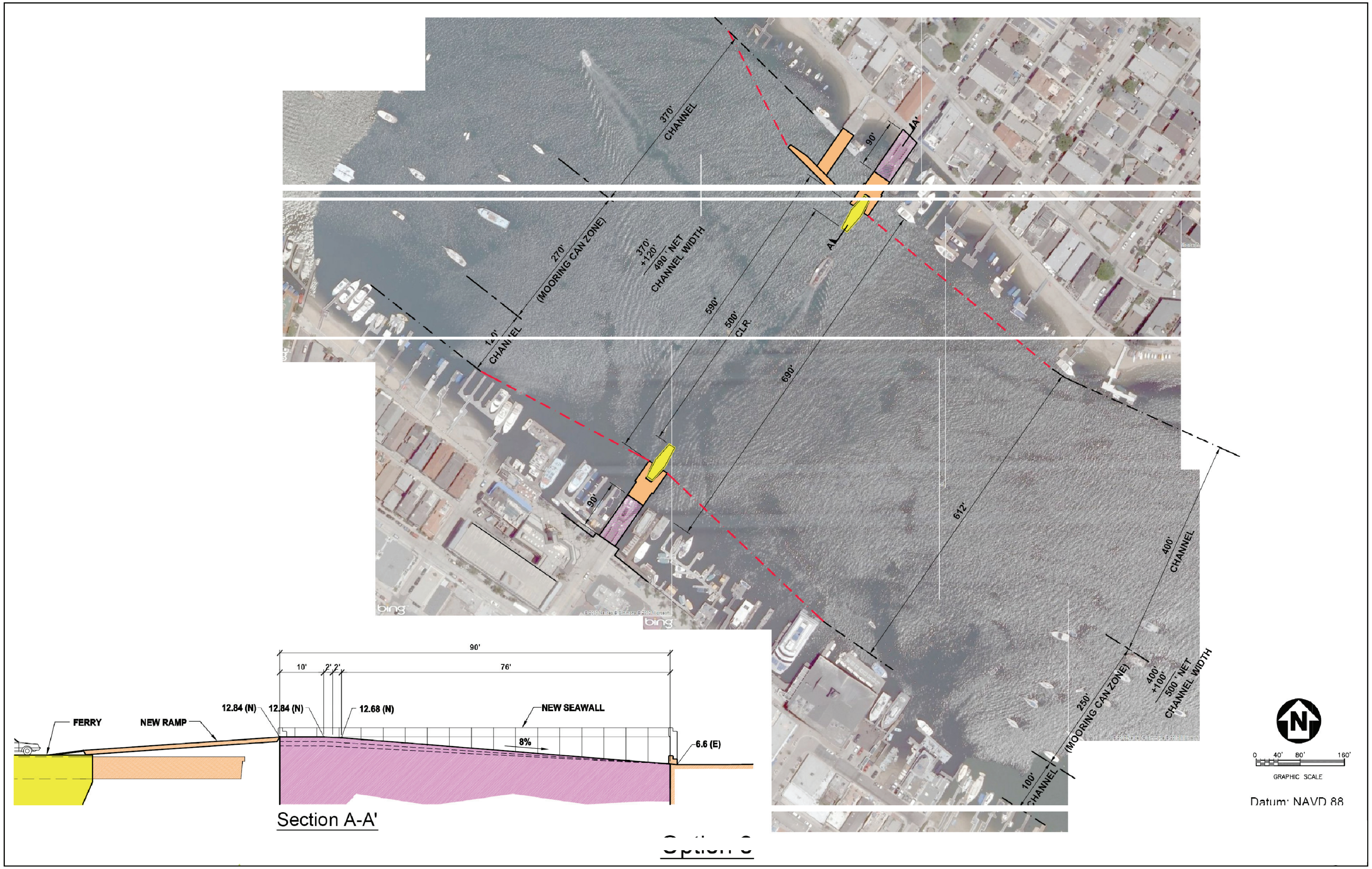

Figure 5.8 Balboa Island Ferry Modification

5.3 Groundwater-Caused Inundation of Balboa Island and Little Balboa Island

Residents of Balboa Island have lived with the risk of floods since it was first constructed. Ever since then, individual residents, the Balboa Island Improvement Association (BIIA), and the City have investigated various solutions to flooding of Balboa Island during high water events. With the potential introduction of groundwater induced flooding, the risks of flooding and associated measures to combat these conditions become more complex.

Based on the sea level rise scenarios discussed in Chapter 3, the mean sea level (MSL) could be as high as 7.3 feet NAVD88 (7.5 feet MLLW) by 2100. This water level is higher than many of the finished floor elevations of buildings in the Balboa Island. Therefore if sea levels rise as modeled, widespread flooding is predicted by 2100 as groundwater percolates through finished surfaces onto Balboa Island streets. Assuming that the water table lags the tide by approximately 3 feet adjacent to the seawall, it can be assumed that flooding may become a common occurrence between the interval Years 2050 and 2100 as the predicted high water level (with one percent probability of occurrence) increases from 9.1 feet to 12.3 feet NAVD88 (9.3 to 12.5 feet MLLW). If the predicted high water level and MSL occur, then a deep well groundwater dewatering system, coupled with seawall reconstruction, most likely would be necessary to prevent widespread flooding with current Island ground elevations.

The risks and benefits associated with a groundwater dewatering system should be assessed in further detail. The primary benefit is that existing infrastructure, except for the seawall (which is proposed to be reconstructed) and piers, may remain in their current state. However, operations of such a system may be high over time and disposal of groundwater may be problematic. Regional Water Quality Control Board does not allow direct discharge into Newport Bay. Additional pump redundancy and power backup will be required to prevent any failure of the system, which would likely result in extensive flooding and damage. Therefore, it is recommended that other long-term solutions be investigated. As part of any chosen solution, the City should continue adopting revisions to the Base Flood Elevation for Balboa Island as determined by FEMA. The Base Flood Elevation is likely to increase in the future to account for sea level rise.

5.4 Conceptual Costs

A conceptual level costs for each of the recommended flood inundation mitigation components are summarized in the following. These costs are based on 1st quarter 2011 construction costs with no escalation. These values should be adjusted for inflation and material and labor cost increases (i.e., contingency) if these values are projected to some future date. Details of the cost estimates can be found in Appendix C.

5.4.1 Short-term Seawall Extension Alternatives

Alternative 1: Cap Replacement

The cost to remove and replace the existing seawall cap is estimated to be between $625 and $725 per lineal foot for a total cost of between $8.25 and $9.57 million. This estimate includes costs of design, permitting, and construction management and inspection.

Alternative 2: Cap Extension

The estimated construction cost to extend the existing seawall cap using a doweled-in concrete extension (Option 1) is between $250 and $300 per linear foot for a total cost of between $3.30 and $3.63 million. This estimate includes costs of design, permitting, and construction management and inspection.

For the use of polypropylene sandbags (Option 2), the estimated cost is between $170 and $190 per linear foot for a total cost of between $2.26 and $2.52 million over twenty years. This estimate includes operation and maintenance costs and assumes the sandbags need to be replaced once every five years.

For the use of geotextile (Longard) bags/tubes (Option 3), the estimated cost is between $130 and $160 per linear foot for a total cost of between $1.72 and $2.11 million over twenty years. This estimate includes projected maintenance items such as repair of damaged bags, replacement of lost or destroyed bags, and upkeep of UV-protection measures.

5.4.2 New Seawall

Seawall Replacement Option 1 consists of steel “H” piles with concrete panels placed between the piles to form a panel wall. The major cost components include demolition of the existing seawall cap, boardwalk, construction of a new boardwalk and drainage system, construction of the seawall and cap to 9.8 feet NAVD88 (10 feet MLLW), and cathodic protection of the steel “H” piles. The seawall, including all piles, panels, the seawall cap, drainage structures and pipes, and all associated costs such as corrosion protection and design, costs between $3,800 and $4,000 per lineal foot. The total construction cost is estimated to be between $50.2 and $52.8 million.

Seawall Replacement Option 2 consists of continuous steel sheet piles with a grout seal pumped between the existing seawall and this new seawall. Installation of the seawall sheet piles and cap, including all associated costs such as corrosion protection and design, is estimated to cost between $4,100 and $4,300 per lineal foot with a total construction cost of between $54.1 and $56.8 million.

Potential Future Cap Extension: Extending the seawall cap several feet up to 14.0 feet NAVD88 (14.2 feet MLLW) if needed as sea level rise in the future as modeled is estimated to cost between $400 to $500 per lineal foot for a total between $5.3 and $6.6 million.

The new seawall including the extended cap (14.0 feet NAVD88, 14.2 feet MLLW) and all associated soft costs is estimated to cost between $55.5 and $59.4 million for Option 1 and between $59.4 and $63.4 million for Option 2.

5.4.3 Balboa Island Ferry Boat Landing

Three options were presented in Section 5.2 to retrofit the Balboa Island Ferry Boat Landing. Options 1 and 2 are similar in that they propose to retrofit the existing Ferry Boat Landing approach structure and construct an approach ramp on Agate Avenue. These two options differ in how pedestrians cross the interface between the Ferry Boat Landing and the boardwalk. However, given the similarities and differing impacts of adjacent structures, the anticipated cost of these two retrofit options is estimated to be between $3.5 and $5.0 million. This includes the cost for retrofitting the existing restroom and mechanical building serving the Ferry Boat.

Option 3 calls for both the Balboa Island Ferry Boat Landing and the fuel dock to be moved further into the Main Channel. In addition, the fixed structures such as the restroom building and approach structure for the ferry boat landing and the tackle and supply shop for the fuel dock will need to be raised. The cost associated with the ferry boat landing is approximately $2.0 and $3.0 million. The cost associated with the fuel dock is approximately between $1.5 and $2.0 million. These costs includes all demolition, new bulkheads as needed, fill behind new bulkheads as needed, reconstruction of approach structures and fixed piers and gangways, and construction of new wharves and buildings as needed. It is assumed that the owners of both facilities will bear the cost of raising existing or driving new guidepiles and providing all new connections for their respective floating docks.

5.4.4 Retrofitting Bridges

The cost to waterproof and retrofit the Island bridges is estimated to be $250,000 to $350,000 per bridge. Although the Collins Island Bridge requires additional work such as construction of solid wall parapets, its cost is similar to the other bridges since it is relatively short. If any bridge is reconstructed in the near future, savings may be found by incorporating the long-term planning measures in the design.

5.4.5 Long-term Solutions

The cost of measures associated with installation of deep groundwater dewatering wells and pump stations cannot be determined at this time since the number of wells and pump stations are dependent on a through geotechnical report and soil permeability testing program. Additionally, the costs associated with meeting revisions to the Base Flood Elevation (BFE) cannot be calculated since the ultimate BFE is unknown as is the integration of associated costs into the typical structure design, permitting, and construction process.

5.4.6 Total Estimated Cost

A summary of the conceptual cost estimates is provided in Table 5.1. Assuming the proposed seawall is eventually extended to a final height of 14.0 feet NAVD88 (14.2 feet MLLW), the total projected cost of the short-term protection measures and long-term Balboa Island seawall replacement and fortification is anticipated to be between $61.5 and $79.0 million.

Table 5.1 Estimated Conceptual Construction Costs

MITIGATION COMPONENT	UNIT PRICE ($/LF) [1]	CONCEPTUAL COST [2]
Interim Seawall Height Extension		
Alt. 1: New Seawall Cap	$625 - $725	$8.25 - $9.57 million
Alt. 2: Existing Seawall Cap Extension		
Option 1: Mechanical Extension	$250 - $300	$3.30 - $3.63 million
Option 2: Polypropylene Sandbags	$170 - $190	$2.26 - $2.52 million
Option 3: Geotextile Bags/Tubes	$130 - $160	$1.72 - $2.12 million
New Seawall		
Option 1: Steel H-Piles w/ Conc. Panels	$3,800 - $4,000	$50.20 - $52.80 million
Option 2: Steel Sheet Piles	$4,100 - $4,300	$54.10 - $56.80 million
Subsequent Seawall Extension: 3 – 4 feet (When/If Required)	$400 - $500	$5.30 - $6.60 million
Ferry Landing and Bridges		
Ferry Boat Landing and Fuel Dock Retrofit (All 3 Options)		$3.50 -$5.00 million
Bridge Retrofit (3 bridges)	$250,000 - $350,000 per bridge	$0.75 - $1.05 million
Total Estimated Program Cost [3]		**$61.47 - $79.02 million**

1 *All prices provided as $ per lineal foot, LF, unless noted otherwise. Range in unit prices includes design, permitting, and construction costs as described in the preceding paragraphs.*

2 *Engineer's Conceptual Cost Estimate is based on 1st quarter 2011 construction costs with no escalation.*

3 *Assumes the proposed seawall is extended to a final height of 14.0 feet NAVD88 (14.18 feet MLLW NTDE 83-01).*

5.5 Funding Mechanisms

Given the scope of the proposed seawall project, the City of Newport Beach is likely to issue bonds to fund the project. The formation of a Special Assessment District likely will be needed to pay off these bonds. Formation of these assessment districts are governed by Propositions 13 and 218. Prior to the formation of an assessment district, Proposition 218, which is now incorporated as Section 4, Article XIII D of the California Constitution, requires a report detailing 1) the total project cost, 2) how the total cost was calculated, 3) the individual project cost to each parcel, 4) the parcels of record within the assessment district, 5) the duration of the assessment, and 6) the reasons for the assessment. In addition, Proposition 13 prevents the calculation of an assessment calculated as a percentage of the property value. In other words, assessment districts must base their fees on either 1) parcel area, 2) relative benefit, or 3) a flat rate.

There are a few assessment district mechanisms that may apply to the seawall project. These are:

1) Geological Hazard Abatement District
2) Seismic Safety Assessment District
3) Reclamation District
4) Facilities Benefit Assessment District

A Geological Hazard Abatement District and/or a Seismic Safety Assessment District may be formed since the seawalls were not designed to handle seismic loads and rising sea level will erode the land in front of the seawall. Given that Balboa Island is subject to flooding and is below the Base Flood Elevation, formation of a Reclamation District may be another option. Finally, since the seawall is a public facility, a Facilities Benefit Assessment may be used to repay the bonds. These Special Assessment Districts are easier to approve if they are brought to the City as a petition from the residents as this appears to be the least legally challenging avenue.

The City may consider seeking assistance from the U.S. Army Corps of Engineers (USACE) in addressing the flooding problems at Balboa Island. The USACE has five core missions, they are: commercial navigation, flood damage reduction, hurricane and storm damage reduction, ecosystem restoration, and comprehensive watershed planning. This project is most likely to fall under the flood damage reduction and the hurricane and storm damage reduction missions.

Section 103 of the 1962 River and Harbor Act (Hurricane and Storm Reduction Program) authorizes the Corps of Engineers to study, design, and construct small coastal storm damage reduction projects in partnership with non-federal government agencies, such as cities. Hurricane and storm damage reduction projects are not limited to any particular type of improvement. The maximum federal cost for planning, design, and construction of any one project is $5,000,000. Final design and construction costs are 65% Federal and 35% non-federal.

The USACE Floodplain Management Services (FPMS) Program's authority stems from Section 206 of the 1960 Flood Control Act (PL 86-645). Goals of the program include: 1) improving the capabilities to collaboratively deliver and sustain flood damage reduction and flood hazard mitigation services to the nation, and 2) identifying and assessing flood hazards posed by aging flood damage reduction infrastructure. Upon request, program services may be provided to state, regional, and local governments, and other non-federal public agencies without charge.

6 RECOMMENDATIONS

The existing seawalls at Balboa and Little Balboa Islands only have a remaining usable life of between 10 to 25 years. They are showing extensive signs of distress and over the next 25 years, these walls will exhibit advanced deterioration which will be quite costly to repair. Furthermore, they are frequently being overtopped during extreme tide and high wave events. Therefore, instead of continually spending large sums of money for significant repairs for the seawalls with estimated remaining usable life of between 10 to 25 years, we recommend the City to begin implementing a plan to replace the existing seawalls with higher ones, as well as other mitigation solutions to address potential flood inundation of the two islands due to projected future sea level rise. Our recommendations include the following:

1. In anticipation of future rising sea levels, City staff should begin to review potential impacts to the Islands' infrastructure (streets, sidewalks, storm drains, sewer system, water system, street lights, landscaping, gangways and docks) associated with raising seawalls or building pads and plan to make adjustment as opportunities arise. Additionally, staff should review current City codes, standards and policies that could be affected by rising water levels (building and garage elevations, docks, private bulkheads, etc) and propose and process any necessary revisions.

2. Begin replacement of the existing seawall within 10 years from baseline year 2010. This initial stage will consist of a perimeter seawall constructed to 9.8 feet NAVD88 (10 ft MLLW) which would place the new wall 0.8 feet about the current Base Flood Elevation of 9.0 feet NAVD88 (9.18 feet MLLW). In the interim, augment the exiting seawalls by 6 to 8 inches either by adding a cap extension, or by being prepared to deploy sandbags around the Balboa and Little Balboa Islands. A cap extension would be more aesthetically pleasing but would cost more than deploying sandbags.

3. When necessary, extend the seawall by an additional 3 to 4 feet during a timeframe spanning Years 2050 and 2060 (i.e., 40 to 50 years from baseline year 2010).

4. When necessary, consider constructing a deep well groundwater dewatering system or other solutions to protect the islands from subsequent high water tables associated with highest extreme water levels. If sea levels rise as predicted, this would need to be done during a timeframe spanning Years 2050 and 2060 (i.e., 40 to 50 years from baseline Year 2010).

5. Establish appropriate minimum lowest floor elevation in accordance with the federal Base Flood Elevation (BFE). The City of Newport Beach must continue to adhere to this requirement since Balboa Island is in a Flood Insurance Rate Map (FIRM) Zone A, which

is considered a Special Flood Hazard Area. If sea levels rise as predicted, then in the future, the BFE may be higher than the current BFE of 9.0 feet NAVD88 (9.18 feet MLLW).

6. Start planning for reconstruction of the Ferry Boat Landing infrastructure. This study recommends two options for raising the launch ramps and one solution of moving the approach ramp further into the main channel. Any of these options will take time to implement, and the facility could be inactive for nine months or more during construction. The City may want to further investigate other alternatives.

7. The City should develop and implement a community awareness program. Inclusion of Collins Island and its residents in the Balboa Island seawall process is critical to the success of any Balboa Island mitigation measure, since Collins Island needs to raise their seawalls in concert with the Balboa Island program.

8. The City should undertake opportunities to coordinate with other Federal, State and County agencies to draw upon as a large pool of expertise that will be needed to address the complex and unprecedented issues associated with sea level issue. The City may be able to utilize the resources of other agencies which may have been working on addressing regional sea level rise impacts. In addition, the City should start investigating potential funding sources from other agencies that may help the City to develop a regional plan to mitigate sea level rise impacts.

The recommendations on replacement of existing seawalls, interim extension of the seawall cap and the deep well groundwater dewatering system were analyzed based on the current projection of future sea level rise. Recommendations could change when there is better certainty in the projected sea level rise. Hence, we recommend the City periodically revisit mitigation.

7 REFERENCES

U.S. Army Corps of Engineers. 2009. Water Resources Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs.

Veri-Tech, Inc. 2009. Coastal Engineering Design and Analysis System (CEDAS) 4.03. http://www.veritechnic.com/products/cedas/index.php.

Vermeer, M and Rahmstorf, S. 2009. Global Sea Level Linked to Global Temperature. Proceedings of the National Academy of Sciences, 106(51), 21527–21532.