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MEMORANDUM

Date: December 14, 2018

To: Surfrider Foundation

From: David Revell, PhD

Subject: Huntington Beach Desalination Review of Sea Level Rise Hazards

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Executive Summary

This technical memorandum evaluates the potential impacts of coastal hazards and sea level rise on Poseidon Water's proposed City of Huntington Beach Seawater Desalination Facility (proposed facility), and to evaluate the need for future coastal armoring using the best available science and the most recent publicly available project description documents. The scope of work for this review included:

1) Acquiring and reviewing relevant background materials, and evaluating fluvial, coastal, and tsunami hazard models for a range of sea level rise scenarios that are plausible for the time horizons of: existing conditions, 2050, 2070, and 2100.
2) Project groundwater and barrier beach flood potential at the proposed site location and evaluate the likelihood of the project to require coastal armoring in the future.

Please note that all elevations in this review are based on the North American Vertical Datum of 1988 (NAVD).

Sea Level Rise

The sea level rise scenarios evaluated in this review include: RCP 2.6 (low emissions), RCP 8.5 (high emissions), and the H++ (worst case) scenario, which is recommended in the Ocean Protection Council Sea Level Rise Guidance (2018) for the evaluation of critical facilities such as the proposed facility (**Bold**). Probabilities of these sea level rise scenarios occurring by 2050, 2070, 2100 are shown in Table 1. The H++ scenario does not have any associated probabilities.

Table 1. Projected Sea Level Rise for Los Angeles

From OPC 2018 Guidance data	Projected Sea Level (in feet)				
Year	RCP 2.6 elevation (50% Probability)	RCP 2.6 elevation (0.5% Probability)	RCP 8.5 elevation (50% Probability)	RCP 8.5 elevation (0.5% Probability)	**H++[1]**
2050	-	-	0.7	1.8	**2.6**
2070	0.9	2.9	1.2	3.3	**5.0**
2100	1.3	5.4	2.2	6.7	**9.9**

Source: OPC Guidance, 2018

[1] High-end sea level rise considers rapid Antarctic ice sheet mass loss and the uncertainty projections are not determined

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It should also be noted that the sea level rise projections for the nearby Newport Bay entrance are 0.1 to 0.2 feet higher than the farther away Los Angeles projections (Kopp et al, 2014)[2]; however, since not all the required time horizons are included in the Newport Bay projections, this analysis reports the Los Angeles results, however the actual sea level rise at the proposed site, may be slightly higher than reported.

Key Findings

- Existing hazards to Poseidon Water's proposed City of Huntington Beach Seawater Desalination Facility (proposed facility) include Federal Emergency Management Agency (FEMA) 500-year fluvial flooding, tsunami hazards, and flooding resulting from a closed barrier beach.
- The proposed facility includes a product storage water tank that will be designated as a critical water supply facility for the community. Damage to this critical facility creates the potential for a loss of water supply to dependent areas and contamination of water and the water delivery system. From recent Ocean Protection Council (OPC) guidance, any critical community facility with a potential lifespan beyond 2050 should evaluate the hazards posed by the high-end H++ sea level rise scenario (5 feet by 2070, 9.9 feet by 2100)[3].
- According to USGS CoSMoS modeling that relied on existing site elevations and no additional grading, access to the site may be severely restricted from a 100-year coastal storm wave event with ~5 feet of sea level rise, which could be reached as early as 2070 under the H++ scenario. The entire existing site under current topography was modeled to be exposed with 6.5 feet of sea level rise and a 100-year storm wave event. (USGS, 2017).
- At current topography, coastal confluence hazards (fluvial flooding exacerbated by sea level rise) was modeled to overtop the Huntington Beach Channel wall and potentially impact the site with ~5 ft of sea level rise and a 100-year river flow event which could occur as early as 2070 (M&N, 2017).
- At current topography, closed beach barrier flooding, caused by natural closing of the ocean outlet on the flood control channel, could increase from an elevation of ~12-15 feet NAVD under existing conditions to ~17-20 feet NAVD by 2070 under the H++ scenario[4] and flood the proposed facility. All of these flood elevations would affect the proposed facility.
- Assuming the proposed road regrading and most of the proposed facility's finished floor elevations will be elevated to 14 feet NAVD[5], the risk of onsite coastal hazards until the year 2070 would be relatively low. However, episodic events such as a tsunami, a large river flood event, or closed barrier beach flooding could still pose a risk to the proposed site and structures, and this risk will be exacerbated as sea level rise accelerates throughout the century.
- The surrounding areas lie at much lower elevations than the proposed facility's site and the adjacent AES HB Generating Station. These critical facilities will eventually become an area of high-ground surrounded by areas that are increasingly impacted by a variety of coastal hazards. This isolation becomes routine during extreme high tide events (5.3' MHHW tide) with as little as one foot of sea level rise (potentially as early as 2030). In

[2] Refer to Kopp et al's Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. Data can be found in Supporting Information files at: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014EF000239.
[3] Refer to the State of California Sea-Level Rise Guidance, 2018 Update. Pages 24-25.
[4] Beach berm elevations were derived from the USGS National Elevation Dataset (NED). Dataset is available through OC Public Works at: http://www.ocpublicworks.com/survey/products/geospatial_data_download
[5] Based on the most recently available correspondence between M&N, Manatt Phelps and Philips, and the Coastal Commission. Refer to page 2 of Manatt Phelps and Philips.

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these conditions, the NOAA Coastal Resilience Statewide Inundation Layer projects complete flooding of both the Huntington Beach Wetlands and the Mobile Home Park to the west. Additional and future developments at this location may incentivize the broader community to remain in the same location, thus limiting future adaptation options, which can be considered a maladaptive long-term approach, potentially leading to future emergencies.

- With the site located behind Pacific Coast Highway 1 (PCH) and the generating station (AES HB) which are likely to be armored by other entities, it is unlikely that additional coastal armoring will be required to protect the proposed facility; however, there is likely to be future needs to elevate the Huntington Beach Channel flood wall to adapt to increased coastal confluence flood risks. The continued management to maintain an open flood control channel outlet across Huntington State Beach will be required to avoid barrier beach flooding.

Table 2. Hazards with the H++ Scenario

Potential Hazards	**All Elevations in Feet**			
	H++			
Years	**Existing**	**2050**	**2070**	**2100**
Base Level of Rise (Mean Sea Level)	***0.0***	***2.6***	***5.0***	***9.9***
King Tide (+7.0 NAVD)	***7.0***	***9.6***	***12.0***	***16.9***
Coastal Erosion				
Coastal Wave Flooding				
Groundwater Daylighting	***5.3***	***7.9***	***10.3***	***14.3***
Fluvial Flooding 500-yr				
Coastal Confluence Flooding 100-yr #1	***9.6***	***11.2***	***12.2***	***15.1***
Coastal Confluence Flooding 100-yr #2	***9.5***	***11.7***	***13.6***	***16.7***
Barrier Beach Flooding	***13.0***	***15.6***	***18.0***	***22.9***
Tsunami	***13.6***	***16.2***	***19.6***	***23.5***

Key
Green: No documented increase in risk of specific hazard impacts at the site.
Yellow: Site access likely to be affected.
Orange: Partial flooding of low-lying areas of the site.
Red: Flooding of highest proposed site grade, causing most proposed structures to be flooded.
Dark Red: Flooding of all proposed structures on site.
Numbers: Where available report the flood elevations for each hazard type, not all hazards have an elevation available

Note: See notes section on page 23 of this review for detailed description of the data and datasets used for this table.

I. Introduction and Methodology

This technical memorandum evaluates the potential impacts of the Poseidon Water's proposed City of Huntington Beach Seawater Desalination Facility (proposed facility) from coastal hazards and sea level rise and evaluates the need for future coastal armoring using the best available science and the most recent publicly available project descriptions. This

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review utilizes other modeling and work from a variety of sources to evaluate the range of coastal hazards for a variety of sea level rise scenarios. Readers are referred to the source references identified by each hazard to provide more detailed and technical information on modeling and data sources. Original analysis on barrier beach flooding and groundwater daylighting conducted in this report relied on a digital elevation model provided by the Orange County Public Works.

Hazards Considered:

- **Coastal Wave Flooding:** Flooding caused by wave run-up and overtopping from a 1% annual chance storm (also referred to as a 100-year coastal storm wave event) (Source: USGS CoSMoS 3.0).
- **Coastal Erosion:** Accelerated coastal erosion caused by sea level rise and a 1% annual chance storm (Source: USGS CoSMoS 3.0, and Huntington Beach General Plan).
- **King High Tide Inundation:** Inundation based on a predicted "King" high tide of 7 feet NAVD (Source: NOAA Sea Level Rise Viewer. King tide extent also modeled by USGS CoSMoS 3.0).
- **Fluvial Flooding:** Creek flood hazards associated with a 1% and a 0.2% annual creek flood event (aka 100-year or 500-year flood) (Source: M&N and Magnolia Tank Farm 2018 analysis by Everest International, FEMA).
- **Tsunami Hazards:** Flooding caused by the velocity and wave run up associated with a series of tsunami waves (Source: Hazard extent provided by Cal OES, California Geological Survey, and USC, and wave runup elevation at site provided by the CCC).
- **Coastal Confluence:** Expanded creek flooding caused by increased tailwater elevations from sea level rise or extreme high tides during a 1% annual creek flood event (Source: M&N and Magnolia Tank Farm 2018 analysis by Everest International).
- **Groundwater Daylighting:** Ponded flooding caused by the daylighting of groundwater on the surface as a result elevated seawater-freshwater interface as sea levels rise (Source: Elevations determined using a digital elevation model provided by the Orange County Public Works).
- **Closed Barrier Beach Flooding:** Ponded flooding created when a barrier beach closes and the water fills like a bathtub to the barrier beach berm crest (i.e. similar to a bar-built estuary) (Source: Elevations determined using a digital elevation model provided by the Orange County Public Works).

This review also relies on a range of publicly accessible data sources to determine relevant site elevations.

Data Sources Considered:

- **Existing Site Topography**: OC Public Works LiDAR data. Sourced from the USGS NED Program (2011-2012).
- **Beach Berm Crest Elevations:** OC Public Works LiDAR data, which indicate a ~13 ft average beach berm crest with variability between 12-15 ft between Brookhurst St and Beach Blvd.

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- **Proposed Site Topography, Building Locations, and Floor Elevations**[6]: The document titled: "Updated Sea Level Rise inundation and Tsunami Flood Hazards Technical Memorandum" from Tetra Tech to Poseidon Water (2016). Docket number 12-AFC-02C in the Huntington Beach Energy Project Compliance CEC documents.
- **Hydraulic Connectivity**: OC Public Works LiDAR data.
- **Flood Control Channel Wall Elevations**: FEMA Effective and Preliminary FIRM Maps and the Orange County Flood Control District.
- **Tidal Elevations**: NOAA's Los Angeles and Newport Bay Tide Gauge Stations.

A. Proposed Facility Setting

The proposed facility is located in the City of Huntington Beach, Orange County, California, in the middle of the historic Huntington Beach Wetlands (Figure 1). The site is located inland of the PCH on a parcel adjacent to and owned by AES Huntington Beach (AES HB) and is bordered by the Huntington Beach Channel to the north and east, AES HB to the south, and the AES HB switchyard to the west. Across the PCH is Huntington State Beach. The Huntington Beach Channel is hydraulically connected to the Huntington Beach wetlands and the Santa Ana River to the east, and meets the Pacific Ocean 1.4 miles to the southeast. Substantial existing residential land uses, including the recently approved redevelopment of the Magnolia Tank Farm across the channel, surround the site (Figure 2).

[6] Details of the existing distribution network or any necessary changes were not considered in this analysis.

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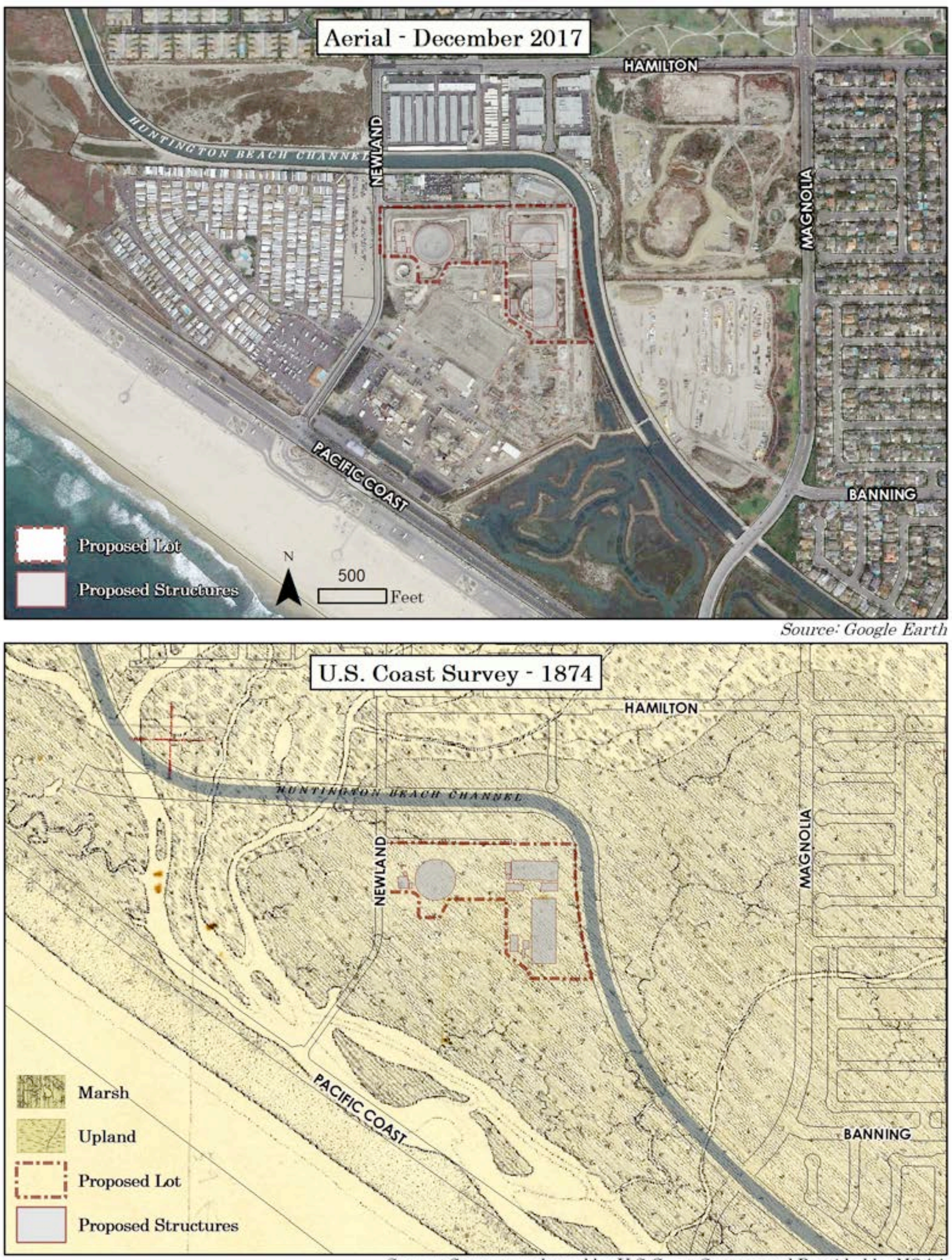

Source: Google Earth

Source: Survey conducted by U.S Coast Survey, and Provided by NOAA

Figure 1. Proposed Facility Site Location in Developed Wetlands. Top: Current location of the proposed site (red dotted line) and structures (semi-transparent). Bottom: Historic Huntington Beach Wetlands (1874 U.S. Coast Survey T-Sheet Below), undeveloped marsh habitat (darker hatching) and upland habitat (lighter spotted hatching), with proposed site (red dotted line), current curb line (thin black line), and flood channel (semi-transparent blue) overlaid.

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i. Applicable Coastal Processes

Littoral Cell. The proposed site, located in the Huntington Beach Littoral Cell, which extends approximately 16 miles from the east jetty of Anaheim Bay to the west jetty of Newport Bay. Sand movement is driven by waves and tides, predominantly from North to South but with seasonal reversals in the summer when southerly waves drive sand transport to the north.

Tides and Water Levels. The two closest National Oceanic and Atmospheric Administration (NOAA) tide gauge stations are the Los Angeles Harbor Station, which is located approximately 17 miles away, and the Newport Bay Station, which is located approximately 6 miles away. Tides in the area are a mixed semi-diurnal type, meaning there are two high and two low tides of unequal elevation each day. A king tide is an extreme high tide that occurs a few times a year in the winter, with tide elevations reaching up to 7.0 feet NAVD. Tidal datums and elevations considered in this study are shown in Table 3.

Table 3. Tidal Datums (Station 9410660 and Station 9410580, Epoch: 1983-2001). Tidal heights in feet (ft) from average lowest daily tide, referred to as mean lower low water level (MLLW), and from a surface of zero elevation, referred to as North American Vertical Datum of 1988 (NAVD88).

Los Angeles, CA Tidal Datums (ft – MLLW)	Ft MLLW	Ft NAVD88
Mean Higher-High Water (MHHW)	5.49	5.29
Mean High Water (MHW)	4.75	4.55
Mean Sea Level (MSL)	2.82	2.62
Mean Low Water (MLW)	0.94	0.74
North American Vertical Datum of 1988 (NAVD88)	0.20	0.00
Mean Lower-Low Water (MLLW)	0.00	-0.20

Newport Bay, CA Tidal Datums (ft – MLLW)	Ft MLLW	Ft NAVD88
Mean Higher-High Water (MHHW)	5.41	5.23
Mean High Water (MHW)	4.68	4.5
Mean Sea Level (MSL)	2.78	2.6
Mean Low Water (MLW)	0.92	0.74
North American Vertical Datum of 1988 (NAVD88)	0.18	0.00
Mean Lower-Low Water (MLLW)	0.00	-0.18

Note: Throughout this review, a conversion factor of 2.6 feet has been applied to elevations in other documents to convert from MSL to NAVD based on NOAA documentation from the nearest Newport Bay Station (#9410580).

Waves. Waves vary seasonally with higher waves from the west in the winter and long periods of smaller southerly waves in the summer. The largest historic storm waves reached 33.5 feet on March 1, 1983 (USACE, 2002). The nearby Wave Information Study location (WIS 83101) from the USACE calculated the 100-year wave event at 18.2 feet.

Tsunamis. Huntington Beach's exposure to tsunamis is similar to the ports of Long Beach and Los Angeles, where a tsunami study modeled seven potential tsunami sources to determine a potential worst-case scenario. Results indicate a submarine landslide near Palos Verdes would cause the worst-case tsunami for the region but has a relatively low probability of occurrence with return intervals on the order of 1 in 10,000 years (M&N, 2007). Analysis of historical tsunami events indicates the region has experienced wave heights on the order of 2 to 3 feet from the magnitude 9.5 earthquake in Chile in 1960 and the magnitude 9.2 earthquake in Alaska in 1964 (Michael Baker International, 2014)[7]. Tsunami inundation maps were developed by the California Emergency Management Agency (Cal EMA) now called the Office of Emergency Services (Cal OES) and by M&N for the Ports of Long Beach and Los Angeles. These studies were reviewed to assess the site's tsunami vulnerability. The California Coastal Commission, in consultation with Cal EMA and California Geological Society, requested that the extreme worst case tsunami run-up elevation be 11 feet above MSL (13.6 NAVD) (CCC W19a & 20A, 2013).

Prado Dam Failure. The site is also within the Prado Dam Failure Inundation Zone, a zone that recognizes the potential failure of this earthen-fill dam. This dam is the principal flood control structure for the Santa Ana River, and if failure were to occur, flooding could inundate over 100,000 acres with maximum water levels at the proposed facility estimated to have flood elevations between 10 and 15 feet (CCC W19a & 20A, 2013)[8].

ii. Flood Control

The Orange County Flood Control District (OCFCD) manages and maintains (along with the City of Huntington Beach and the US Army Corps of Engineers) the vertical steel sheet pile lined Huntington Beach Flood Control Channel to provide regional flood protection. This 80-foot wide channel is bounded on each side by interconnected sheet piles that have a crest elevation of approximately 13 feet NAVD. The channel runs approximately 3.8 miles from Adams Ave to its outlet at the Pacific Ocean, with 860 feet of the channel wall running alongside the eastern portion of the proposed site. Along this course on the eastern boundary of the site, the sheet piles terminate and transitions into riprap (Michael Baker International, 2014)[9].

II. Background Review

The first task was to evaluate the background information for the proposed facility and other relevant projects. A wide variety of reports, model results, planning documents, and agency comment letters were reviewed and are listed in the References section at the end of this report.

Sources of spatially explicit coastal hazard data include the NOAA Sea Level Rise Viewer, USGS CoSMoS 3.0, the City of Huntington Beach General Plan Update (Michael Baker International, 2014), the Preliminary and Existing FEMA Flood Insurance Rate Maps, and the California Geological Survey Tsunami maps. The sources for each hazard type were identified in Section I. In addition, technical studies related to the development of the new AES Huntington Beach

[7] See Section 4.5.
[8] See page 79.
[9] See Table 30.

Generating Station, the nearby Magnolia Tank Farm Specific Plan, and the Draft Desalination Project Sea Level Rise Hazard Analysis were also examined for their relative applicability.

A. Adjacent Projects

Five other adjacent projects have been proposed and or recently permitted for construction. As required by the California Coastal Commission, these adjacent projects have all had to conduct a sea level rise vulnerability assessment specific to their own project sites. The associated sea level rise vulnerability assessments for the following projects were reviewed for consistency and information relative to the proposed project. These include:

- ***Magnolia Tank Farm*** – Occupies approximately 29 acres 150 feet to the southeast of the site and is the location of three former oil storage tanks. Demolition of the three tanks was completed in July 2017 and is currently used as a staging area for the construction of the AES HB Generating Station (Magnolia Tank Farm, 2018).

- ***ASCON Landfill Site*** – Occupies approximately 38 acres 150 feet to the northeast of the site. The landfill operated from 1938 to 1984 and received liquid and semi-liquid oil drilling wastes which were deposited into open lagoons and pits. From 1971 to 1984, these lagoons and pits were filled and covered with construction debris, and environmental remediation of the site is ongoing. The site was rezoned for residential in 1992 but there are no development plans at this time (DTSC, 2018)[10].

- ***Marsh Restorations*** – Occupies approximately 180 acres of salt marsh, seasonal ponds, and dune habitat directly adjacent to the site. The Huntington Beach Wetlands are in various stages of restoration in an area that had formally been drained and hydraulically altered for agricultural and development purposes. Restoration of this land started in 2004 and has been ongoing, with the Talbert, Brookhurst, and Magnolia Marsh restorations completed between 2009 and 2010, and plans are currently underway to restore the nearby Newland Marsh, adjacent to Beach Blvd (Huntington Beach Wetlands Conservancy, 2018)[11].

- ***AES Huntington Beach*** – Occupies approximately 32 acres directly adjacent to the south of the site. The current AES HB Generating Station is being replaced by a new facility to better comply with South Coast Air Quality Management District and CEC regulations as well a State Advisory Committee's regulations requiring the shutdown of existing once through ocean cooled powerplants by 2020 (AES, 2018). The midpoint of the new generating station has a bridge over the Huntington Beach Channel that is currently being used by construction crews for the construction of the new facility. Poseidon Water would lease the former tank farm and proposed site from AES (Dudek, 2010).

- ***Flood Control Channel Improvemen****t* – This project was part of the larger Talbert Valley Flood Control Improvement Program which was initiated to provide 100-year channel conveyance for the regional flood control channels. The Huntington Beach Channel was originally designed to convey storm water form a 10-year storm event and was replaced by a series of interconnected steel sheet piles with a consistent crest elevation of

[10] Refer to: https://www.envirostor.dtsc.ca.gov/public/profile_report.asp?global_id=30490018
[11] More information can be found in the Hydrologic and Hydraulic Baseline Report prepared for the Huntington Beach Wetlands Conservancy by Moffatt & Nichol, 2014.

13 feet (OC Works, 2018)[12]. Seawater is conveyed to Adams Avenue (at the top of the channel) during higher high tides and to within 2,000 feet south of Atlanta St during lower tides (M&N, 2004).

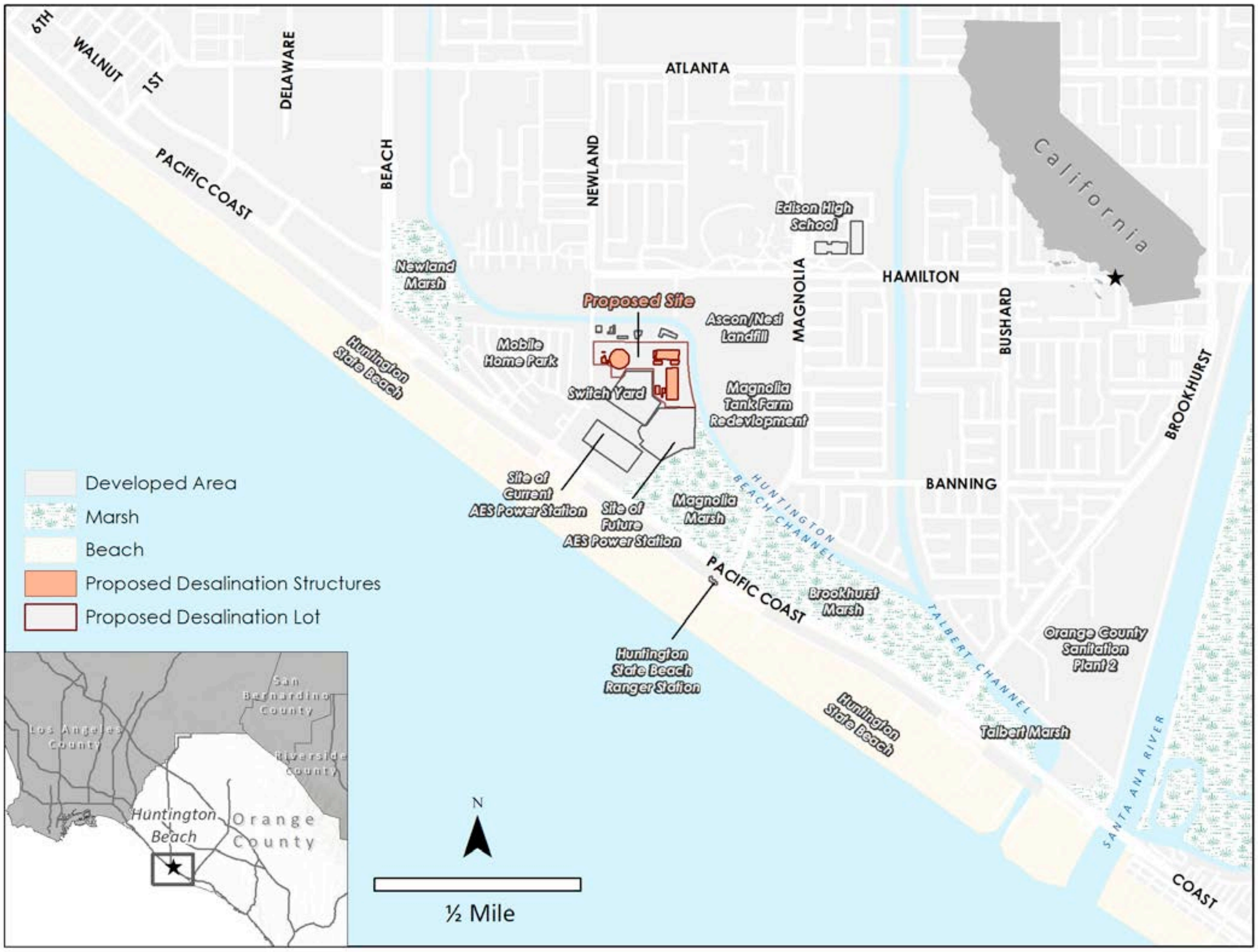

Figure 2. Regional Setting. Proposed site (red) and structures (orange) directly adjacent to the Huntington Beach Channel (light blue), future AES Power Station, Switch Yard, current AES Power Station and mobile home park.

III. Proposed Desalination Facility Description

The pending Coastal Development Permit (CDP) Application No. 9-15-1731 proposes construction of a seawater desalination facility on a 12-acre parcel at 21730 Newland Street in the City of Huntington Beach. The site is adjacent to the AES HB (currently operating and with a replacement plant in construction), which has a generating capacity of 880 MW, and provides 450 MW of electricity (AES, 2018) – enough to power 400,000 homes and businesses. The proposed desal facility's electricity demand will require 7.7% of the AES HB Generating Station's energy production (Dudek, 2010)[13]. A new generating station is currently being constructed to comply with the State's regulation to upgrade all the

[12] Refer to: http://www.ocflood.com/nfc/projects_a/complete/hbchannel/huntington2
[13] See Sections: 3-50 and 3-67.

once through cooling power plants by 2020, to utilize closed-cycle wet cooling. To note, this regulation was established in an effort to protect the marine environment from the harmful impacts of open ocean intakes used for once through cooling plants. Instead of retiring the ocean intake pipe as intended, the proposed desalination project has applied to repurpose the existing once through cooling outfall and intake infrastructure from the generating station to source ocean water and to produce potable water using reverse osmosis technologies. The desalination facility would intake approximately 100 million gallons a day (MGD) to produce 50 MGD (56,000 acre feet/year) of potable water. The remaining 50 MGD of higher concentration saline waters would re-enter the outfall system and be discharged to the Pacific Ocean (Dudek, 2010). Increases in effluent brine concentrations and temperature on nearshore ecosystems is beyond the scope of this study.

The proposed 12-acre site is situated inland of the AES HB parcel on an unused fuel oil tank storage area. The project proposes to recondition the site by removing three legacy oil tanks and related existing interior containment berms, as well as a regrading of the site and access road to prepare for construction of the proposed facility. The proposed facility consists of seven main buildings and their associated secondary buildings, five above ground storage tanks for product water and chemicals, an influent pump station, and an electrical substation[14].

A. Existing Site Elevations

Currently, the general characteristic of the ground level for the site below the raised fuel tanks and above the low-lying drainage areas ranges from 7 to 10 feet NAVD, with the ground plane sloping gradually toward the southwest (Dudek, 2010). Vast stretches of low-lying marshland at approximately 2 feet NAVD border the site to the south east. The site has two potential access points, the main gate for the AES HB Generating Station on Newland Street, which is identified as the main access point (Dudek, 2010)[15], and a gate at the north of the site on Edison Blvd. No data related to the distribution network, depths underground, or alignments were considered in this analysis and may pose additional hazards to the surrounding community in the future.

The 2010 EIR Project Description document describes landscaping and street improvement along Edison Drive but no changes to grade (Dudek, 2010)[16]. Drawing from the 2011 LiDAR USGS NED elevations, the intersection of Edison Drive and Newland St is at approximately 4.6 ft NAVD. Newland Street heading north towards the Huntington Beach Channel Bridge varies in elevation from 6.5 feet to 9 feet NAVD. The elevation at the lot frontage access points from the Edison Drive gate is 7 feet NAVD, and from the Newland St gate at approximately 8 feet NAVD.

The Final Subsequent Environmental Impact Report of 2010 (Dudek, 2010) assessed the potential impacts of sea level rise. These documents were found to be obsolete as construction for the AES HB and Magnolia Tank Farm Projects have already begun and altered the topography of surrounding areas. To specifically assess the proposed site’s exposure to sea level rise and coastal hazards, we relied on the general proposed site grading elevation of 14 feet NAVD used throughout the Huntington Beach Desal Draft Sea Level Rise Hazard Analysis and related correspondence with the CCC (M&N, 2017). Grading changes are not uncommon for projects in development, especially with other industrial redevelopments in close proximity; however, changes in the proposed grading may change the specific findings of this study. The proposed grading to 14 feet is at bare minimum to protect the facility from most hazards and sea level rise.

[14] The most recently available building descriptions are available in the document: “Updated Sea Level Rise inundation and Tsunami Flood Hazards Technical Memorandum”.
[15] See section 3-76
[16] See sections 3-41

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B. Proposed Site Elevations

The proposed site currently has several rings of oil spill containment berms. As part of the project, the internal and south-facing containment berms would be demolished and the exterior berms on the north side of the site would remain. The outer berms have an average crest elevation of 24.8 feet NAVD (Tetra Teach, 2016) (Figure 3). The project description mentions all internal roads within the site will be raised to an elevation of 14 feet NAVD (M&N, 2017), and ground floor elevations for proposed structures would range from 10.6 to 16.6 feet (Tetra Tech, 2016). Outside of the project site, the road elevations on Edison Drive and Newland Street would likely remain the same. Additionally, the top of the Huntington Beach Channel Wall is about 13.1 – 13.3 feet for the stretch adjacent to the project site. Across the PCH, beach berms for Huntington Beach vary between 12 and 15 feet, with 13 ft being typical. It is unclear if there are any proposed changes in the distribution network which will likely be more exposed in the future.

Past coastal hazard models are all based on elevation data from 2009-2011. At these times, all surrounding containment berms were in place. Current site plans indicate that there will be an opening in the berms from Edison Drive on the north, and from the entire south ocean-facing side. This, in addition to the changes in grading, make interpretation and use of previous coastal hazard models difficult.

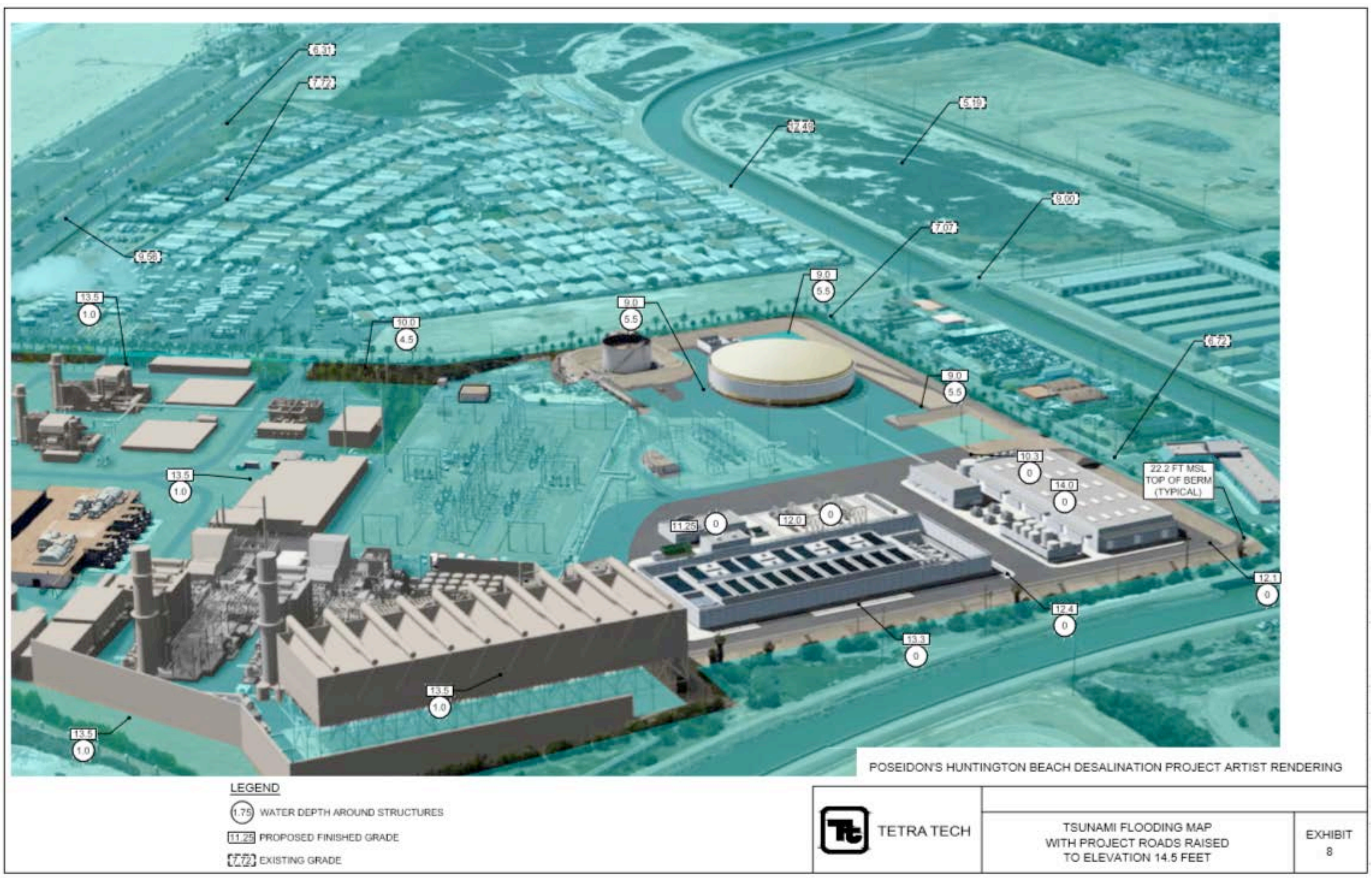

Figure 3. Artistic Rendering of Site Plan with Proposed Regrading and a Tsunami Flood Model Inundation Layer. Tsunami runup elevations were modeled at 11' MSL or 13.6' NAVD88. Inundated areas are shown in blue, with water elevations reaching 5.5' around product water storage tank and structures and up to 12.9' over low-lying neighboring parcels.

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IV. Coastal and Fluvial Flood Risk Analysis

The pending CDP reflects a California Coastal Commission (CCC) request that Poseidon consider at least a 50-year operating life (2020-2070). However, given the potential extension of the project life, possibly by a public agency (such as the City of Huntington Beach), the uncertainty associated with the timing of sea level rise impacts, and the expected designation of this site as a "critical facility" based on new Ocean Protection Council guidance (2018), this report considers a range of sea level rise elevations and timeframes, focusing on the H++ (worst case) scenario of 5.0 feet by 2070 and 9.9 feet of sea level rise by 2100. The report relied upon available model results for each hazard as identified in Section I.

A. Existing Conditions

Review of available hazards show the proposed site is exposed to existing FEMA 500-year flow event fluvial hazards along the Huntington Beach Flood Control Channel (Figure 4) and the potential for tsunami inundation (Figure 3 & Figure 5). Assumptions for the tsunami analysis included no change in existing site elevations. Other existing hazards were also examined, including a FEMA 100-year flow event, a 100-year coastal wave event, coastal erosion, king tides, barrier beach flooding~~,~~ and groundwater daylighting, and found not to inundate the site under current conditions. However, the barrier beach flooding and existing coastal confluence modeling could potentially affect access to the site under existing conditions.

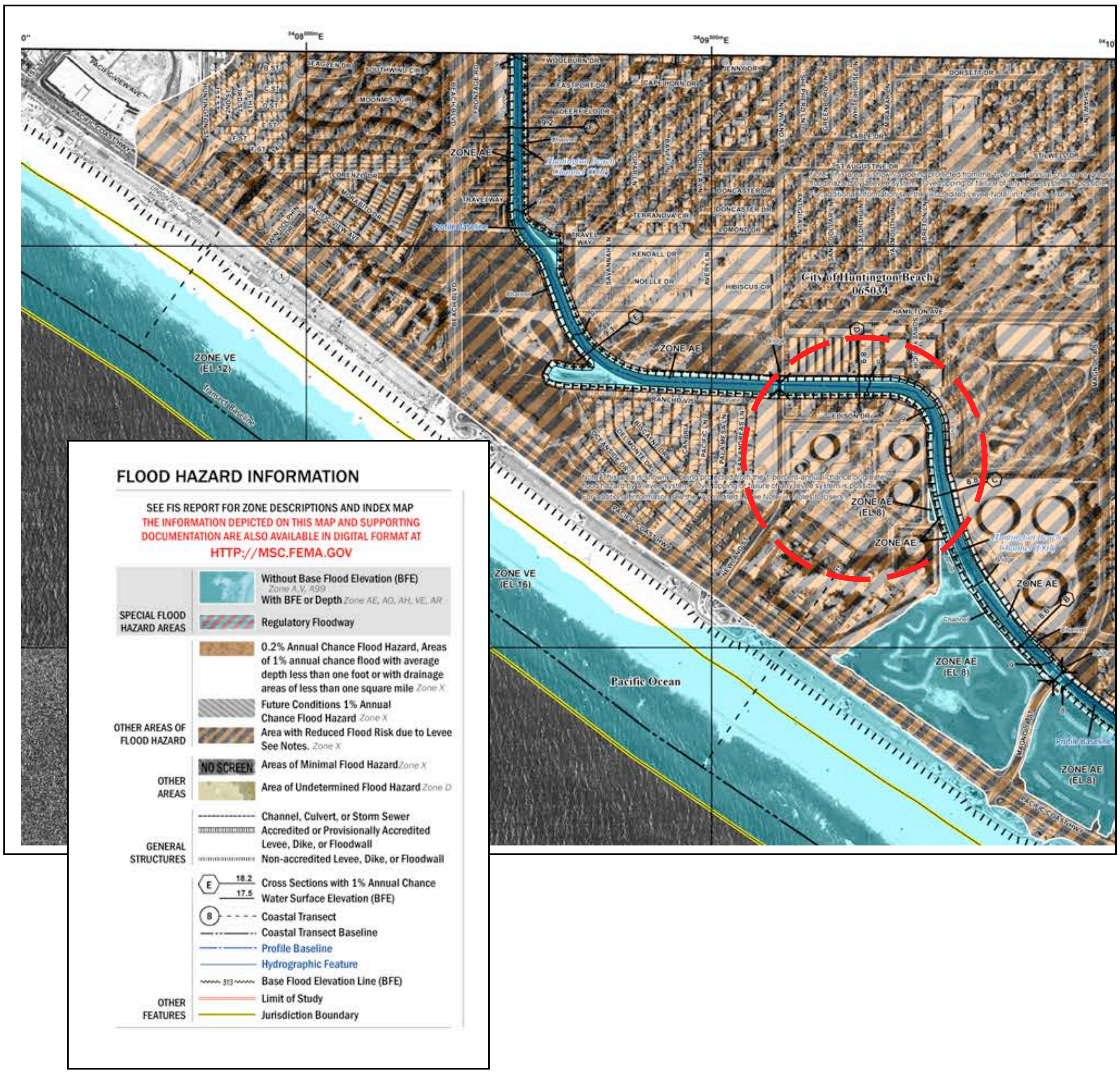
i. FEMA Flooding

FEMA maps delineate existing coastal and creek (fluvial) flood hazards as part of the National Flood Insurance Program (NFIP). This program requires very specific technical analysis of watershed characteristics, topography, channel morphology, hydrology, and hydraulic modeling to map the extent of existing watershed-related, and wave run-up-related flood hazards. These maps, representing the existing 100-year and 500-year FEMA flood events (1% and 0.2% annual chance of flooding), are known as the FEMA Flood Insurance Rate Maps (FIRMs), and determine the flood extents and flood elevations across the landscape. FEMA is currently in the process of updating all coastal floodplain maps in California, and the Preliminary coastal maps are currently under review. It is important to note that these regulatory flood maps do not include evaluation of coastal erosion or sea level rise.

According to the Effective FIRM (Panel 06059C0263J effective 12/3/2009, Revised via LOMR for the site 09-09-281P certified 12/15/2009), during a 100-year river flood, the flood water level in the Huntington Beach Channel is estimated to reach +9 feet NAVD (FEMA,2009). This corresponds to data from the adjacent Huntington Beach wetlands that show a 100-year flood elevation of between 9 and 10.2 feet NAVD (M&N, 2014). The existing 500-year flood hazard shows inundation at the site and is identified as being in "Zone X" with flood depths of less than 1 foot. Flood protection at the site is influenced by tides, as flood waters are released more slowly during high tide and flow into the flood control channel and surrounding wetlands. It can be anticipated that flood extents and depths on this tidally influenced channel will rise in elevation with rising sea levels.

FEMA identifies the site as being located in "Zone X", which is a designation for an area that is protected by certified flood control structures from a 100-year storm, but is within the 500-year Flood Zone. The site is also identified as being within the Prado Dam Failure Inundation Zone, a zone established by the City of Huntington Beach (Michael Baker

International, 2017)[17]. Maximum water levels at the site for that scenario are estimated to be between 10 to 15 feet (CCC W19a 20a, 2013)[18].



[17] Refer to page 33.
[18] Refer to page 79.

Figure 4. Preliminary FEMA FIRM maps (Effective Map with Preliminary wave run up elevations for existing conditions). The proposed site (red dashed circle) is located within in the orange and blue diagonally hatched area of the map, designated by FEMA as an "Area with Reduced Flood Risk due to Levee. *Zone "X*". The Huntington Beach Flood Control Channel Wall can be identified as the black and white dotted line and is designated as an "Accredited or Provisionally Accredited Levee, Dike, or Floodwall".

ii. Tsunami

Tsunamis are relatively rare events that can be triggered by several sources. Distant large subduction earthquakes such as the recent 2011 Japanese or 1964 Alaskan subduction earthquakes (aka "far-field" events) or more localized submarine landslides (aka "near-field" events) can generate tsunami waves with potential to impact the proposed site.

The proposed site is situated well within the 2009 California Geological Survey (CGS) Tsunami Hazard Zone (Figure 5) which extends two miles inland from shore, and within the City's designated Tsunami Runup Zone, which extends about one mile inland from the shore. The original interpretation by Geosyntec estimated an expected worst case wave run up elevation of 10 feet MSL (Tetra Tech, 2016). Estimating expected tsunami runup elevations at the site is significantly more difficult than modeling other flooding events, as it relies on many onshore and offshore characteristics, and the severity of tsunamis is heavily influenced by propagation direction and potential current amplification from nearby stream channels. CCC staff, in consultation with staff from CGS and CalEMA, interpreted the tsunami run up elevation with available topography, and identified that the AES HB site had a current projected tsunami wave runup elevation of approximately 11 feet MSL or 13.6 feet NAVD88 (CCC W19a 20a, 2013)[19]. No comprehensive study considering both kinetic energy, wave height currents, return flow scour velocities and their forces on proposed structures and "garden walls" was conducted. But based on the analyses that were conducted, the project site is within the Tsunami Wave Runup Zone and would remain inside the hazard zone regardless of the proposed facility grading plan.

[19] Refer to page 85-86.

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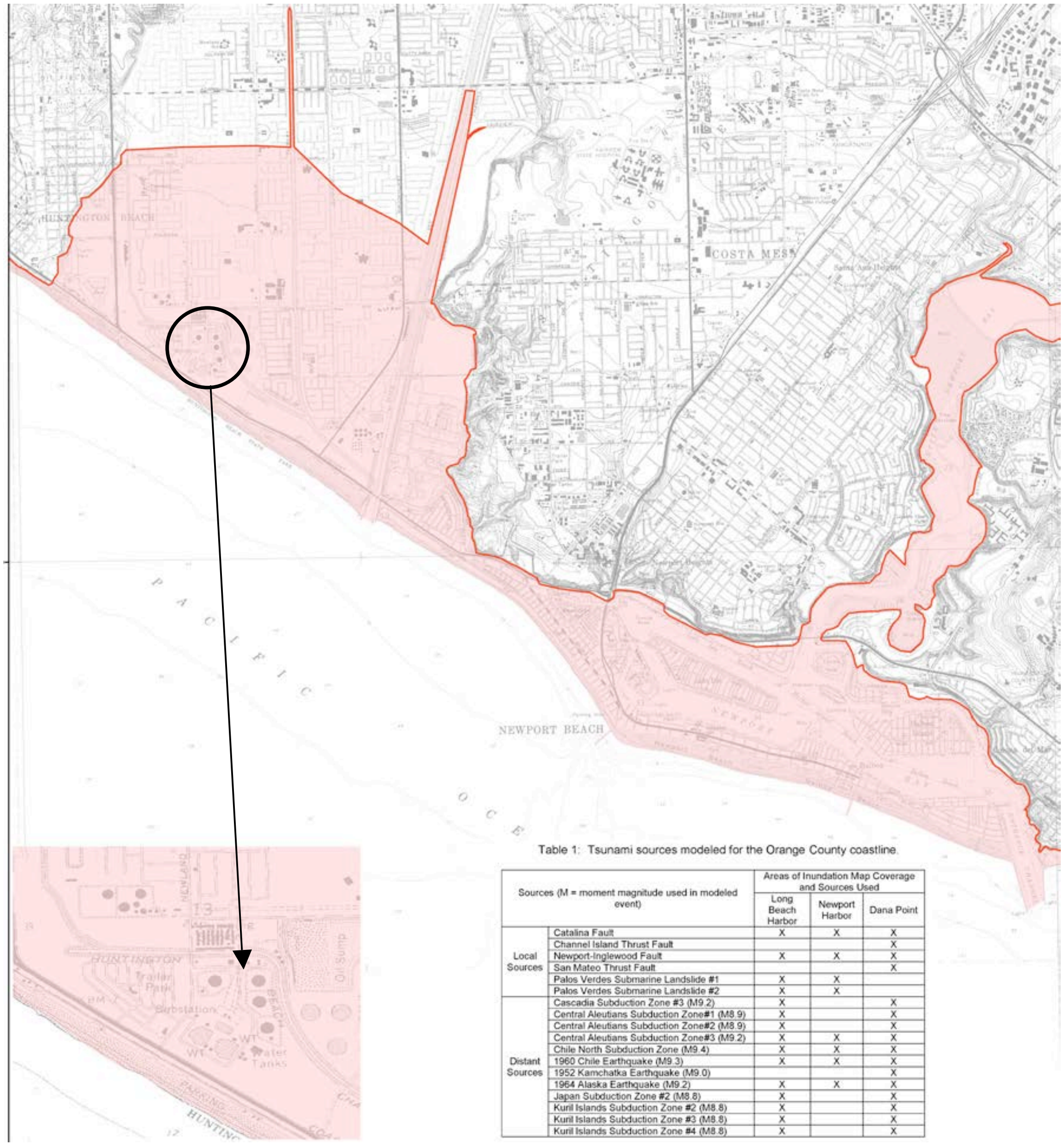

Table 1: Tsunami sources modeled for the Orange County coastline.

Sources (M = moment magnitude used in modeled event)		Areas of Inundation Map Coverage and Sources Used: Long Beach Harbor	Newport Harbor	Dana Point
Local Sources	Catalina Fault	X	X	X
	Channel Island Thrust Fault			X
	Newport-Inglewood Fault	X	X	X
	San Mateo Thrust Fault			X
	Palos Verdes Submarine Landslide #1	X	X	
	Palos Verdes Submarine Landslide #2	X	X	
Distant Sources	Cascadia Subduction Zone #3 (M9.2)	X		X
	Central Aleutians Subduction Zone#1 (M8.9)	X		X
	Central Aleutians Subduction Zone#2 (M8.9)	X		X
	Central Aleutians Subduction Zone#3 (M9.2)	X	X	X
	Chile North Subduction Zone (M9.4)	X	X	X
	1960 Chile Earthquake (M9.3)	X	X	X
	1952 Kamchatka Earthquake (M9.0)			X
	1964 Alaska Earthquake (M9.2)	X	X	X
	Japan Subduction Zone #2 (M8.8)	X		X
	Kuril Islands Subduction Zone #2 (M8.8)	X		X
	Kuril Islands Subduction Zone #3 (M8.8)	X		X
	Kuril Islands Subduction Zone #4 (M8.8)	X		X

Figure 5. Maximum Tsunami Inundation Zone from the California Geological Survey. This map does not represent inundation from a single event, but results from an ensemble of source events with a mapped inland extent of tsunami inundation zone up to 1.8 miles (pink), including the proposed project site.

iii. Barrier Beach Flooding

Existing barrier beach flooding could occur based on beach elevations between 12 and 15' NAVD that could back up watershed flows and fill the channel. This could potentially affect access to the site today without active management by the Flood Control District. Currently, the Flood Control District renews maintenance permits on a 7-year environmental review cycle. The current permit presently does not include consideration or monitoring of sea level rise.

iv. Coastal Confluence

Coastal confluence flooding, or fluvial flooding altered by elevated downcoast (tailwater) water elevations, changes the fluvial flood profile and extents of flooding. The modeling conducted for nearby projects to evaluate this hazard utilized a higher high tide elevation with results indicating that during these events, access to the site could be impacted during the combination of high tide and fluvial flow events. This flood hazard is not currently evaluated in the regulatory FEMA flood maps which ignore sea level rise or in the COSMOS model which doesn't consider the watershed, river channel, or flood control channel.

B. Future Conditions

In addition to the existing coastal hazards of fluvial flooding and tsunami described previously, the most commonly discussed coastal hazards of tidal inundation, erosion, and coastal wave flooding, were evaluated. Additionally, the proposed facility is susceptible to flooding hazards that will be exacerbated by sea level rise, including: coastal confluence flooding, closed barrier beach flooding, and groundwater daylighting. Coastal confluence flooding, or fluvial flooding altered by elevated downcoast (tailwater) water elevations, changes the fluvial flood profile and extents of flooding. Groundwater flooding can occur when groundwater levels daylight (i.e. rise above the ground surface) and cause ponding and flooding even in areas that are behind flood walls. Barrier beach flooding can occur when sand is transported into the river mouth and closes off the connection between the flood control channels and the Pacific Ocean. Once closed, the area landward of the sand bar can fill up like a bath tub to an elevation of the beach berm crest, flooding the surrounding landscape.

i. Sea Level Rise – Tidal Inundation

The NOAA SLR viewer maps a MHHW (5.29' NAVD) flood extent with up to 5' feet of SLR on the existing topography, which could occur as early as 2070 under the H++ scenario (figure 6(B)). The map shows that under existing conditions and 3 feet of SLR, the site is relatively safe from flooding (figure 6(A)). With 5 feet of SLR, the three eastern most oil storage tank sites could be inundated if hydraulically connected, and with 6' of sea level rise, all of the tanks could be flooded. However, a current king tide is nearly 2 feet higher than MHHW, meaning that under existing topography, Figure 6B flooding could occur a few times a year with only 3 feet of sea level rise.

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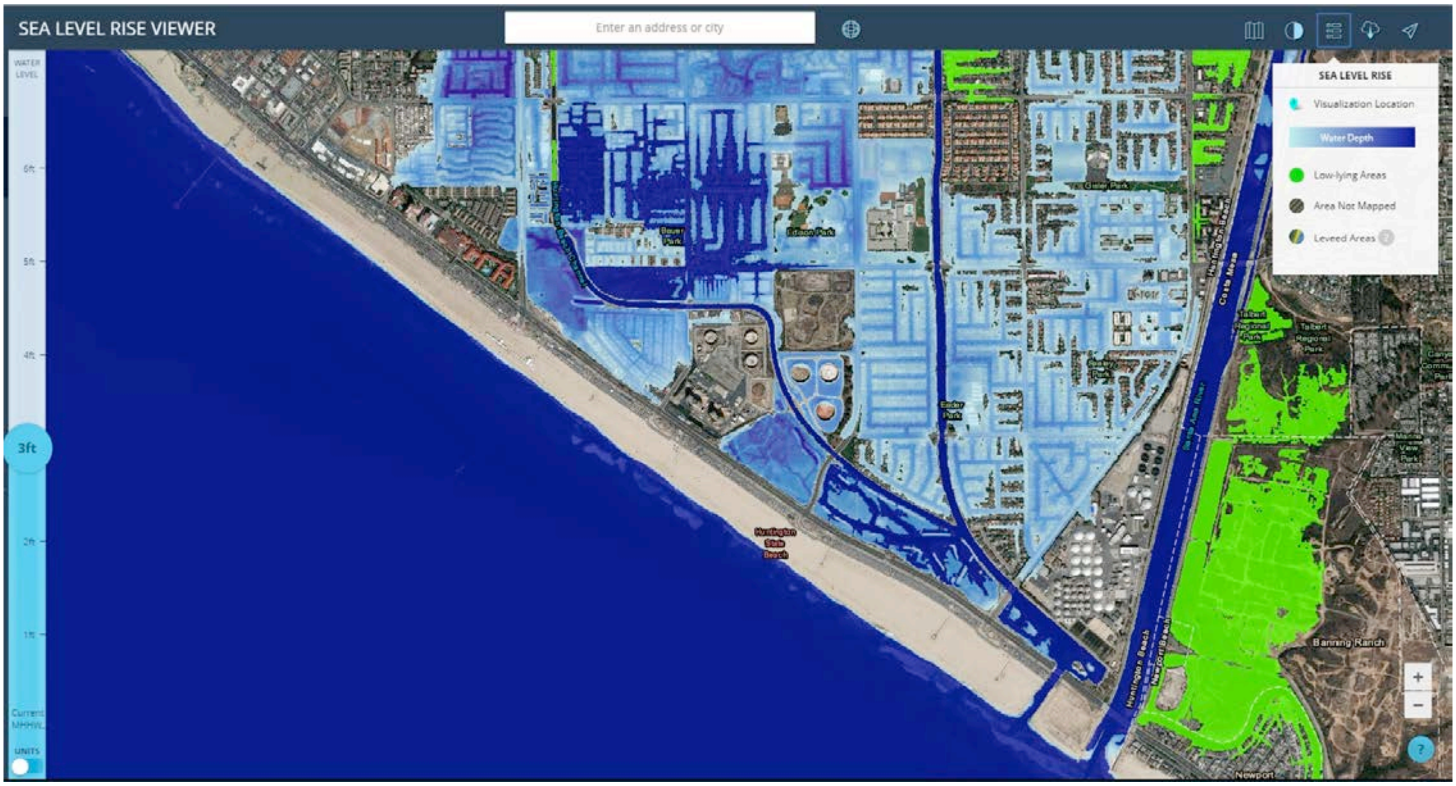

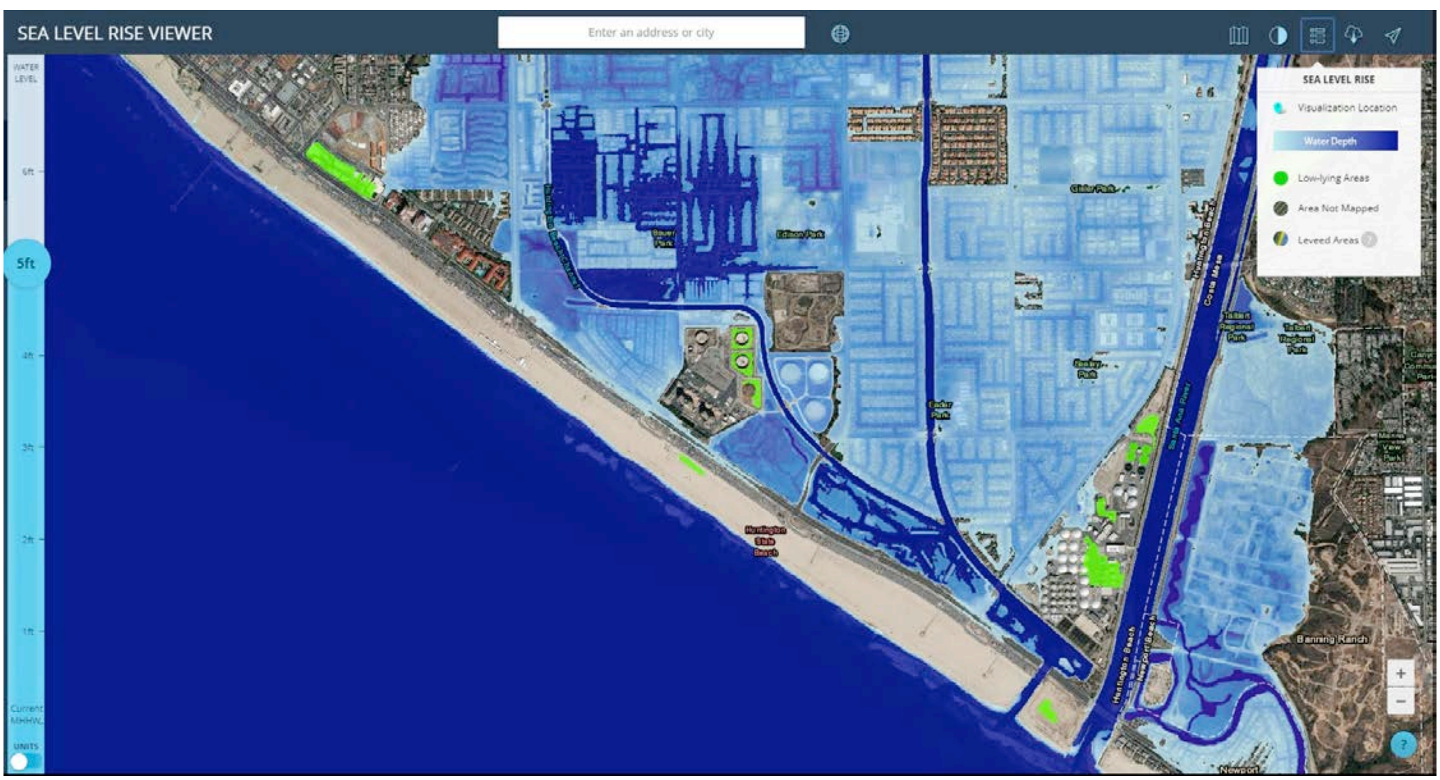

Figure 6. (A) Tidal inundation caused by a 5.3' tide with 3 feet of SLR (B) Tidal inundation caused by a 5.3' MHHW tide with 5 feet of sea level rise. Note that a current king tide is ~7' tide. Darker blues show deeper relative depths and green areas show areas that could flood if there are hydraulic connections (*Source: NOAA Sea Level Rise Viewer)*

Results of the tidal inundation mapping show relative depths in the shades of blue which don't appear to affect the site. Shades of green are low-lying areas where, if hydraulic connections exist (e.g. via a culvert or gap in containment berms) beyond the resolution of the model elevation grid, those areas could also be flooded. This indicates that the existing berms are serving as flood protection under these conditions. The green could also indicate areas that could be flooded through daylighting groundwater if the duration of those tide waters is sufficient. An in-depth analysis on daylighting is provided in a following section.

ii. Sea Level Rise – Coastal Erosion

Coastal erosion was not explicitly calculated or mapped in any of the available documents except for the HB General Plan Sea Level Rise Vulnerability Assessment. The HB Sea level rise study applied an erosion calculation based on a simple Bruun rule landward transgression that relates inland erosion along the measured existing topography solely based on sea level rise. This model projected that with 3 feet of sea level rise, the MSL shoreline could retreat by 72 feet, and with 5.5 feet of sea level rise, the MSL shoreline could erode by 128 feet (Michael Baker International, 2014)[20]. Beach erosion caused by a 100-year storm event was calculated using a more sophisticated storm induced beach response model - XBeach (See USGS CoSMoS documentation in the references). With a calculated maximum wave runup elevation of 17.4 feet with ~3 feet of sea level rise and 19.8 feet with ~5 feet of sea level rise, there is a potential storm erosion distance of 109 feet with ~3 feet of sea level rise, and 542 feet with 5.5 feet of sea level rise (Table 4). Given that the typical beach width in front of the site is greater than 1,000 feet, coastal erosion would not affect the site with 5.5 feet of sea level rise assuming that sediment supply and bypassing activities continue. Due to the inland distance, coastal erosion does not seem to be a vulnerability to the proposed site. While not specifically modeled, it is unlikely that even with the H++ 2100: 9.9 feet at 2100, that coastal erosion would impact the proposed facility.

Table 4. Coastal Erosion from Sea Level Rise and Storm Erosion. (*Source: Huntington Beach General Plan, Volume III, Appendix P: Sea Level Rise Vulnerability Assessment. Michael Baker International, 2014.)*

Sea Level Rise Elevation	Scenario: Year	Wave Run-up Elev. (Feet NAVD)	Sea Level Rise Erosion (Feet)	Storm Erosion (Feet)	Total Erosion (Feet)
3 feet	High: 2070 H++: 2050-2060	17.4	72	109	181
5.5 feet	High: 2080-2090 H++: 2070	19.8	128	542	670

iii. Sea Level Rise – Coastal Wave Flooding

Coastal wave flooding is caused by large waves running up the beach and inland. These waves typically have velocity that can carry debris and cause damages from the wave loads on a structure. The most recent source of available wave

[20] See table 7.

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run up data comes from the USGS Coastal Storm Modeling System (CoSMoS) 3.0, which uses downscaled climate models to project future wave conditions, and then transforms those waves from a Pacific Ocean wide analysis down to nearshore conditions at roughly 300 feet alongshore with cross shore transects. CoSMoS 3.0 flood maps show areas that would be inundated for more than 1-minute during a wave storm event and are mapped on topographic elevation data collected between 2009-2011. More recent changes to the site and proposed grading is not included in these model results. Along each transect, the point of maximum wave run up extent is also shown as a green dot. Results for a ~5 foot and ~6.5 foot sea level rise with a 100-year wave event are shown in Figure 7. The color scheme shown is similar to the NOAA Tidal Inundation Maps (Figure 5), with the blues indicating surface flooding or "over-topping", and greens indicating areas that are low lying and potentially subject to groundwater daylighting.

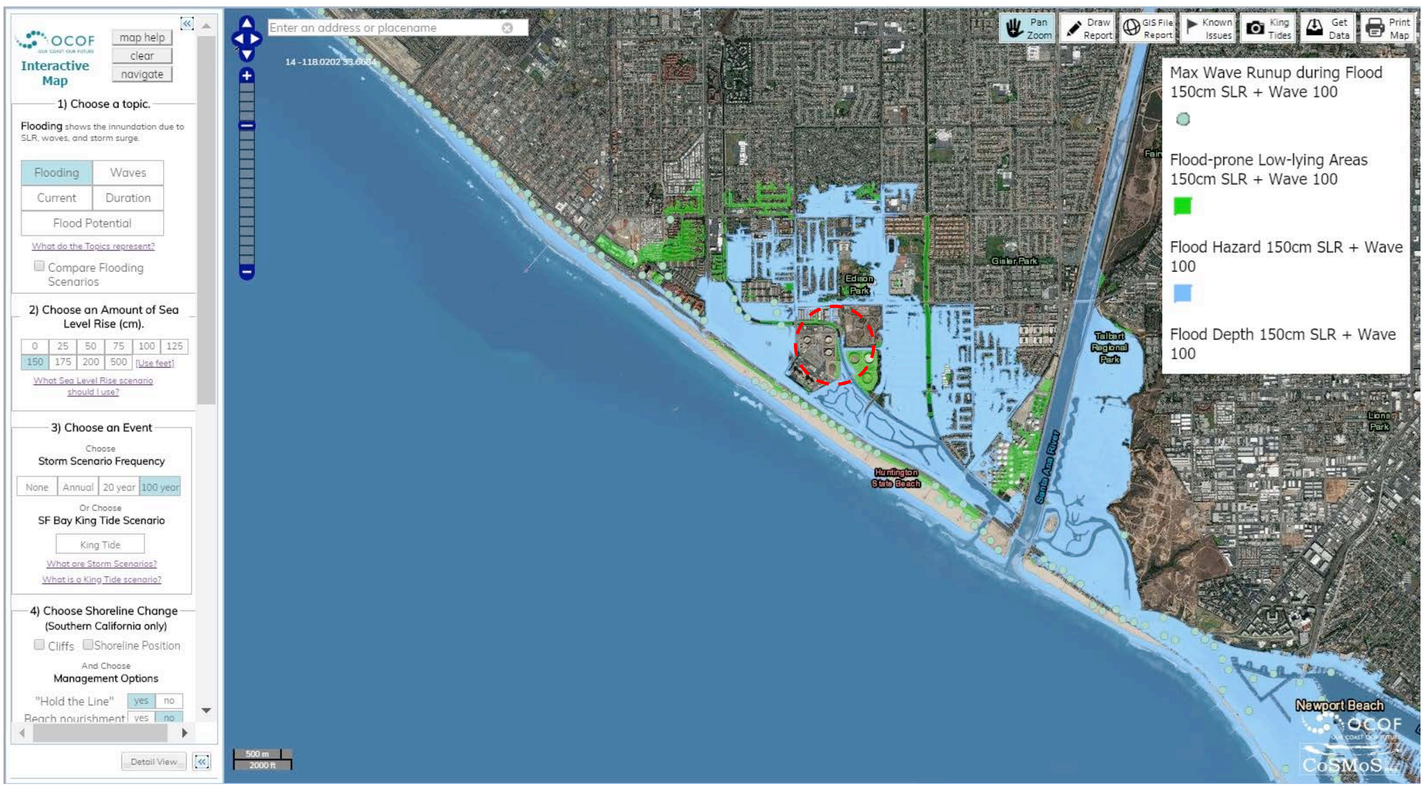

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Figure 7 (A). Wave run up flooding from a 100-year wave event and 5 feet of sea level rise. (B). Wave run up flooding from a 100-year wave event and 6.5 feet of sea level rise. Site identified in red circle.

Results of the CoSMoS 3.0 model do not show much sustained coastal wave flooding to the site with up to ~5 feet of sea level rise, even with current low elevations. However, maximum wave run up does show that waves could run up to inland areas beyond the proposed site, potentially impacting access to the proposed facility (Figure 7A). With 6.5 feet of sea level rise, the site could be expected to be impacted by sustained flooding across most of the site, and maximum wave run up extents could extend over 2 miles inland. Flood depths at the proposed site for existing topography show potential flood depths of 0.8 feet to 3.4 feet with ~5 feet of sea level rise and 1.5 to 4.1 feet with ~6.5 feet of sea level rise. The range in flood depths are based on model uncertainties. Results of the model also show that the existing berms would provide some level of flood protection under this scenario.

There are some apparent issues with the CoSMoS 3.0 results. First, the model does not account for flood control channels on Talbert Channel or Huntington Beach Channel, nor does it account for the existing hydraulic connection across the beach under the bridge on the PCH. It is also not entirely clear why wave run up at one transect would not get the beach wet during a 100-year wave event and 6.5 feet of sea level rise, yet on the adjacent transect wave run up could travel 2 miles inland. The variability in these model results do call into question the vulnerability to wave run up at the actual site.

iv. Sea Level Rise - Coastal Confluence Flooding

As sea levels rise they also affect the depths and extents of creek flooding, by backing up water during high tides. Rising sea levels will increase the downstream controlling water surface elevation in the Huntington Beach channel, resulting in a higher water flood surface profile upstream. The extent of these impacts was evaluated in the City of Huntington

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Beach Sea Level Rise Vulnerability Assessment (M&N, 2014). The existing 100-year flood elevation was modeled at 9.6 feet NAVD without any sea level rise. Results from a hydraulic flood model (RM-2 model) indicate that 1 foot of SLR would increase water surface elevations within the Huntington Beach Channel by about 0.6 foot near Magnolia Street (referred to as Coastal Confluence #2) and 0.4 foot near Adams Avenue (Michael Baker International, 2014)[21]. The reach averaged increase in water surface elevation within the Huntington Beach Channel near Newland Street and the proposed facility is about 0.5 foot.

The results indicate that 2 feet of sea level rise would increase the 100-year water surface elevation at Newland Street (referred to as Coastal Confluence #1) by about 1 foot. The 100-year flood profile remains below the top of channel, with about 2.4 feet of freeboard. A sea level rise of 3 feet would further increase water surface elevations in the channel, reducing the freeboard to less than 2 feet. For the modeled 2100 high sea level rise of 5.5 feet, the 100-year flood profile would increase 3.9 feet exceeding the flood control wall elevation and likely overtop the flood control channel downstream of Newland Street (M&N, 2014).

Small changes in either precipitation and/or run off intensity coupled with sea level rise could dramatically increase the extents and depths of fluvial flooding which has not been suitably modeled at present. While some work has been done[22], it does not consider data on projections of future rainfall intensity and increased development and its corresponding increase in impervious surfaces. It is recommended that the applicant examine this hazard in additional detail to ensure that the facility will not be compromised by this combination of future fluvial and coastal hazards exacerbated by sea level rise.

v. Sea Level Rise - Groundwater Daylighting

The proposed site sits over the Talbert Aquifer in a tidal flats area characterized by poor drainage. This area is underlain by shallow near-surface water with average yearly depths ranging from five to nine feet below ground surface, and the site is subject to tidally influence groundwater levels with the existing monitoring wells at the AES site recording groundwater levels at or above existing grade (Dudek, 2010, CCC W19a 20a, 2013)[23]. The Huntington Beach Wetlands to the southeast of the site can have increased water levels during storm events, and these water levels are highly influenced by groundwater levels (Dudek, 2010).

Rising sea levels could result in a corresponding increase in groundwater levels. It is reasonable to assume that a groundwater elevation of ~MHHW would daylight based on the observed Huntington Beach wetland marsh plain elevations. The existing MHHW elevation is currently 5.3 ft NAVD, and with the H++ scenario, the existing site is anticipated to be flooded by the 2070 time horizon to an elevation of +10.3 ft NAVD. However, if the proposed grading is conducted, then only 6 of the 18 proposed structures would potentially be flooded[24]. Since groundwater levels are expected to increase as sea levels rise, the higher groundwater levels may create additional buoyancy forces on underground structures such as storage tanks or pump stations. The liquefaction potential below proposed structures may also be affected by an increase in groundwater levels over the proposed project's design life. The effect of these forces on the building foundations may be of concern in the future but are beyond the scope of this assessment.

[21] Refer to page 74.
[22] Specifically: Moffatt & Nichol's Hydrologic and Hydraulic Baseline Report for the Huntington Beach Wetlands Conservancy.
[23] Refer to section 4.3-2 of Dudek 2010, and page 78 of CCC W19a 20a, 2013.
[24] Proposed Building Elevations from Tetra Tech Memo, 2016.

vi. Sea Level Rise - Closed Barrier Beach Flooding

The Huntington Beach Channel and the Santa Ana River were all historically bar built estuaries which meant that the sand berm fronting the estuary would open and close seasonally in response to wave energy and river flows. When the beach berm closes, water fills the channel/estuary like a bath tub to the elevation set by the beach berm crest. By evaluating available topographic data for the nearby beach berm crest during late summer/fall conditions, it was determined that the berm crest elevation routinely reaches between 12 and 15 feet NAVD. Assuming a beach berm crest of 13 feet was reached and not artificially breached, then barrier beach flooding today could potentially reach the top of the existing flood control channel. With any amount of sea level rise, this closed barrier beach flooding could overtop the Huntington Beach Channel and potentially inundate the proposed site. Considering proposed regraded site elevations, any amount of sea level rise over 1 foot could inundate the proposed facility site (Figure 8).

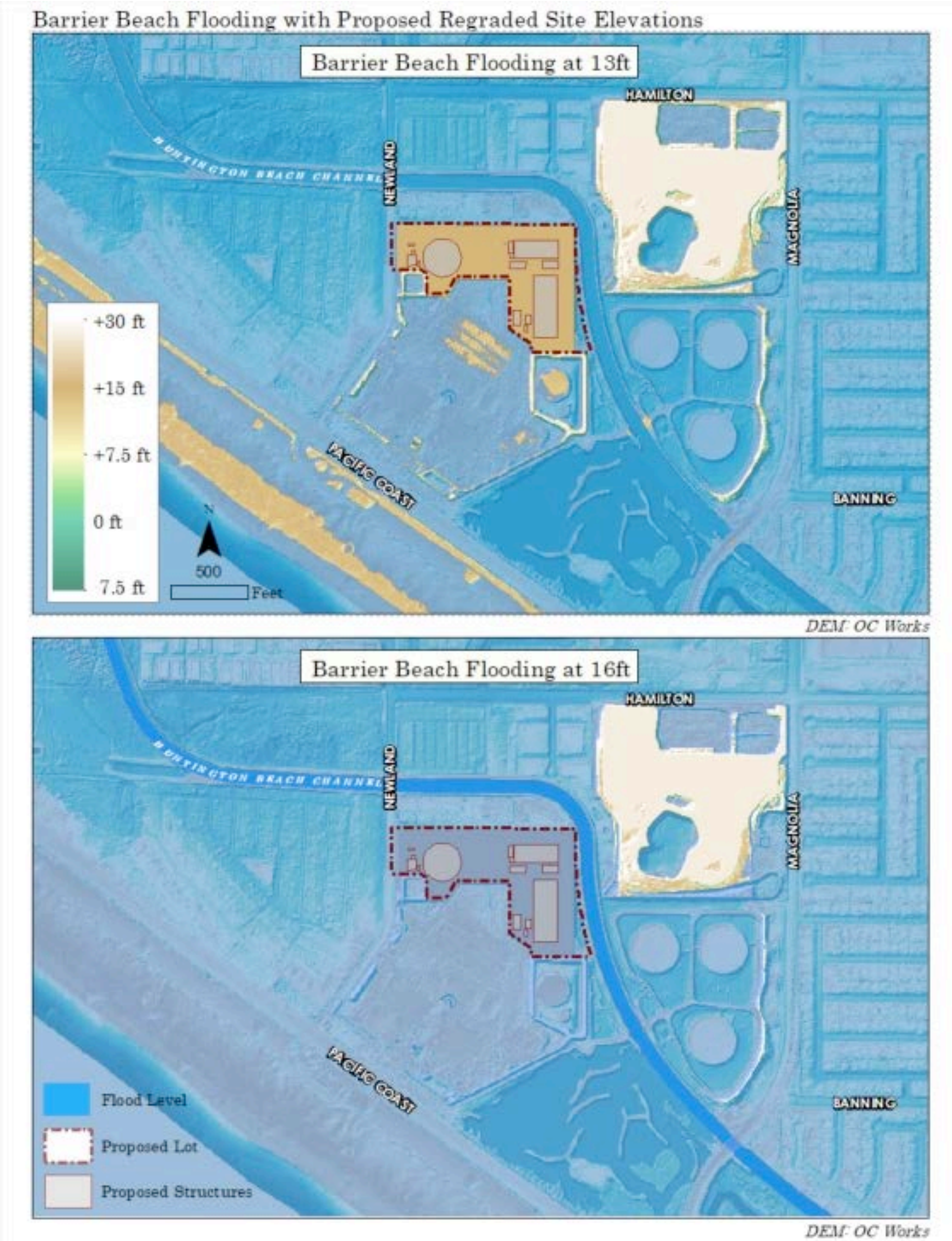

Figure 8. Closed Barrier Beach Flooding Extents with Proposed Grading. (Source: OC Works Digital Elevation Model). The figure at the top indicates a simple bathtub flood model to an elevation of 13' NAVD. At this level, only the highest beach berms, oil containment berms, the landfill site, and the proposed regraded site remain unflooded. The figure at the bottom indicates potential flood levels at 16 ft NAVD, which could occur during a closed barrier beach and 3 feet or less of sea level rise. At this level, the proposed facility regraded site and structures are inundated.

Critical Facility and the "Island Effect"

The Huntington Beach Wetlands (adjacent and south east of the site) and the mobile home park (due west of the site) are very low lying and are presently delineated in "flood-prone low-lying areas" during existing conditions (which includes extreme high tide or any type of coastal storm) by both the NOAA Coastal Resilience model and the USGS CoSMoS model. The severity of flooding in these areas is expected to increase in depth and frequency due to sea level rise in the future, which would make the proposed facility an isolated area of high-ground surrounded by areas increasingly impacted by coastal or fluvial hazards. The City of Huntington Beach is teaming with Poseidon Water to designate the product water storage tank as a reservoir for the City water supply system in case of water supply loss from other sources (CCC W19a & 20A, 2013). The proposed tank would be about 250 feet in diameter and 30 feet high, and hold approximately 10 million gallons of water. It would be located on the former site of the West Fuel Oil Storage Tank near Newland St (CCC W19a & 20A, 2013).

FEMA has established that planning and siting for "critical facilities," including water facilities such as the proposed reservoir, be based on avoiding risks from a 500-year flood event. The facility has a 1 in 16 chance (6.25% annual chance) of experiencing a 500-year event between 2020 and 2050. Risks from flood damage include loss of water supply, contamination of the facility's water and water delivery system, and costs associated with providing measures to protect or remediate the site (CCC W19a 20a, 2013)[25].

The larger concern; however, is that this desalinization facility is a critical water supply and co-located with a critical energy facility. While the proposed site may have relatively low risk to most coastal hazards, the surrounding community is much lower in elevation and is projected to be increasingly impacted to the entire suite of coastal hazards analyzed in this report. Because all surrounding community land uses depend on water and power, access to these critical facilities is crucial. This location incentivizes the broader community to remain in the same location, likely increasing the need for shoreline stabilization and increasing the height of the flood channel walls. The location of these critical facilities may limit future adaptation options beyond the life of these facilities which can be considered a maladaptive approach.

V. Review Stabilization Needs and Flooding impacts

Hard stabilization techniques, or "coastal armoring" such as revetments or seawalls to defend from erosion are unlikely to be needed to protect this site, largely due to its location of being inland of a major transportation corridor (PCH), and other critical infrastructure (AES HB). The site is already dependent on the flood control channel walls to protect from fluvial flood sources, and will continue to require the walls regardless of site regrading. However, the critical nature of this proposed facility and the adjacent power plant incentivizes the community to remain in the same low-lying vulnerable location and thus increases the likelihood that additional increases in the flood control wall elevations will be required in the future. Grading will be required to elevate the proposed facility and reduce the flood exposure risk. Should coastal armoring be needed for the proposed site or the critical infrastructure mentioned above, then there are a host of secondary impacts could occur including the loss of the beach and resulting impacts to beach recreation, sandy beach ecosystems, sales tax and transient occupancy tax revenues, and an additional increase in wave run up and coastal flooding extents.

[25] Refer to pages 26, 79, and 88.

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VI. Conclusion

Under existing topography and hazards, the proposed facility location is subject to tsunamis and a 500-year fluvial flood event. Existing access to the site is may also impacted by coastal confluence and barrier beach flooding today. Sea level rise will increase extents and depths of these hazards. A summary of potential flood exposure by coastal hazard type are shown in Table 5. Barrier beach flooding could occur with only a few inches of sea level rise. Coastal wave flooding may affect the property episodically with 5 feet of sea level rise during a 100-year event. A king tide of 7.0 feet inundation begins to affect access to the site with 1 foot of sea level rise and expose the property to flooding with 3.0 feet of sea level rise which could occur before 2100. Access to the site could be affected by coastal wave flooding with as little as 3.0 feet of sea level rise. With 5.0 feet of sea level rise the proposed facility would be routinely isolated by high tides. No data related to the distribution network (e.g. pump stations, pipe alignments, or depths underground were considered in this analysis. This network may be exposed to additional hazards and vulnerabilities threatening the surrounding community in the future.

The proposed site will be a critical facility to the community of Huntington Beach and deserves consideration of the worst case of sea level rise (H++ scenario). A larger concern; however, is that this proposed facility is a critical water supply and co-located with a critical energy facility. While the proposed site may have relatively low risk to most coastal hazards, the surrounding community is much lower in elevation and is projected to be increasingly impacted to the entire suite of coastal hazards analyzed in this report. Because the surrounding community land uses depend on water and power, access to these critical facilities is crucial. This location incentivizes the broader community to remain in the same location, likely increasing the need for shoreline stabilization and increasing the height of the flood channel walls. The location of these critical facilities may limit future adaptation options beyond the life of these facilities which can be considered a maladaptive approach.

Table 5. Hazards with the RCP 2.6, RCP 8.5, and H++ Scenarios (all elevations in feet NAVD when available)

		RCP 2.6			RCP 8.5			H++		
Years	**Existing**	**2050**	**2070**	**2100**	**2050**	**2070**	**2100**	**2050**	**2070**	**2100**
Base Level of Rise (Mean Sea Level)	0.0	1.3	2.9	5.4	1.8	3.3	6.7	2.6	5.0	9.9
King Tide (+7.0 NAVD)	6.8	8.1	9.7	12.2	8.6	10.1	13.5	9.6	12.0	16.9
Coastal Erosion										
Coastal Wave Flooding										
Groundwater Daylighting	5.3	6.6	8.2	10.4	7.1	8.6	12.0	7.9	10.3	14.3
Fluvial Flooding 500-yr										
Coastal Confluence 100-yr #1	9.6	10.4	11.0	12.6	10.7	11.3	13.5	11.2	12.2	15.1
Coastal Confluence 100-yr #2	9.5	10.6	11.8	13.4	11.0	12.2	14.4	11.7	13.6	16.7
Barrier Beach Flooding	13.0	14.3	15.9	18.4	14.8	16.3	19.7	15.6	18.0	22.9
Tsunami	13.6	14.9	16.5	19.0	15.4	16.9	20.3	16.2	19.6	23.5

Key

Green: No documented increase in risk of specific hazard impacts at the site.
Yellow: Site access likely to be affected.

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Orange: Partial flooding of low-lying areas of the site.
Red: Flooding of highest proposed site grade, causing most proposed structures to be flooded.
Dark Red: Flooding of all proposed structures on site.
Numbers: Where available report the flood elevations for each hazard type, not all hazards have an elevation available

Notes on Table 5:

1) *Base Sea level rise is referenced to NOAA's Los Angeles Tide Gage.*
2) *All RCPs are referenced to a: "0.5% Probability that Sea Level Rise Meets or Exceeds"*
3) *Proposed finished grade elevations are assumed to range between 10-14 feet NAVD[26], with building floor elevations ranging from 10-16.6 ft NAVD, and sensitive site structures such as the RO Process Building and Transformers mitigated to 17.1 ft NAVD[27].*
4) *Coastal erosion is not expected to affect the proposed site during this timeframe.*
5) *Coastal wave flooding elevations are color coded based on data available from the CoSMoS 3.0 100-yr storm scenario model.*
6) *Coastal confluence flooding 500-yr is derived form FEMA FIRM Maps. No elevations have been reported.*
7) *Coastal Confluence #1 is based on M&N analysis from 2014. The elevation location is the Newland St Bridge. Their study used RCP 8.5, NAVD, and a baseline of 2010. A trendline was used to remap the output to the horizon years in this table. RCP 2.6 and H++ scenario output is based on mapping the relative proportions in RCP 8.5 (61/.51/.56).*
8) *Coastal Confluence #2 is based on Everest International Consultants and CNRA & OPC 2017. The elevation location is the Magnolia St Bridge. Baseline is adjusted forward from 2000 to approximately 2020 to better match the M&N baseline. Their study used a Medium-High Risk Aversion. A trend line was used to remap the output to the horizon years in this table. A trendline was used to remap the output to the horizon years in this table. RCP 2.6 and H++ scenario output is based on mapping the relative proportions in RCP 8.5 (.83/.81/.73).*
9) *Barrier beach flooding assumes an existing beach berm height 13 feet NAVD and sea level rise analysis assumed sediment supply was sufficient for beach elevations to rise at the same rate as sea level rise. Height is derived from OC Works LiDAR data, 2011.*
10) *Tsunami height is derived from CCC guidance of 11ft MSL and converted to NAVD.*

[26] See M&N, 2017 Section 1.3 Site Topography
[27] See Tetra Tech, 2016 Table on Page 8

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