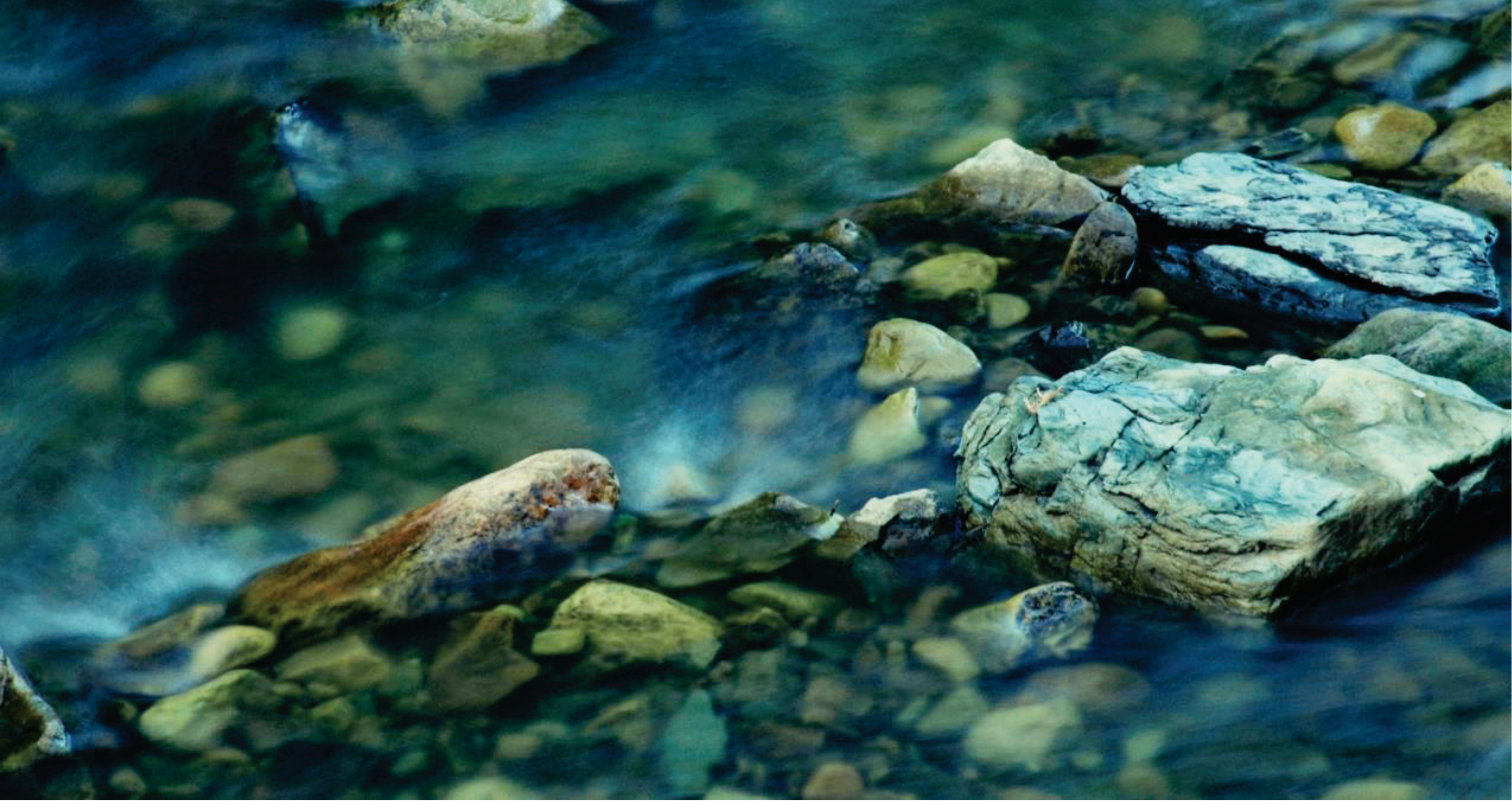


November 2018
Magnolia Tank Farm Redevelopment Project

Sea Level Rise Vulnerability Assessment and Adaptation Plan

Prepared for SLF-HB Magnolia, LLC

November 2018
Magnolia Tank Farm Redevelopment Project

Sea Level Rise Vulnerability Assessment and Adaptation Plan

Prepared for
SLF-HB Magnolia, LLC
2 Park Plaza, Suite 700
Irvine, California 92614

Prepared by
Anchor QEA, LLC
9700 Research Drive
Irvine, California 92618

TABLE OF CONTENTS

TABLES

FIGURES

ABBREVIATIONS

BFE	base flood elevation
CCC	California Coastal Commission
CEQA	California Environmental Quality Act
cfs	cubic feet per second
City	City of Huntington Beach
cm	centimeter/centimeters
CoSMoS	Coastal Storm Modeling System
CNRA	California Natural Resources Agency
EIR	Environmental Impact Report
ESHA	environmentally sensitive habitat area
FEI	Fuscoe Engineering, Inc.
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
HB	Huntington Beach
HB Channel	Huntington Beach Channel
HBW	Huntington Beach Wetlands
HEC-RAS	Hydrologic Engineering Center-River Analysis System
HSB	Huntington State Beach
LCP	Local Coastal Program
LiDAR	Light Detection and Ranging
MTF	Magnolia Tank Farm
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
OPC	California Ocean Protection Council
PCH	Pacific Coast Highway
SLF-HB	SLF-HB Magnolia, LLC
SLR	sea level rise
TDS	total dissolved solids
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
VAAP	vulnerability assessment and adaptation plan

1 Introduction

1.1 Background

The City of Huntington Beach (City) occupies approximately 27.3 square miles of land area and is surrounded by the cities of Westminster to the north, Seal Beach to the northwest, Fountain Valley to the east, and Costa Mesa to the southeast. The Pacific Ocean borders the City to the southwest. Regional access to the City is provided by Interstate-405 to the north; Pacific Coast Highway (PCH) to the southwest; and State Route 39, which bisects the City running north to south.

The City is preparing a programmatic Environmental Impact Report (EIR) for California Environmental Quality Act (CEQA) compliance for a proposed development project to be located at 21845 Magnolia Street in Huntington Beach. The proposed project (Project), known as the Magnolia Tank Farm (MTF), includes new development across an area of 29 acres. The project site previously contained three oil storage tanks used to provide fuel to the adjacent power station. The property currently serves as a staging area for the construction of a new power plant on the same site as the existing power plant. The location of the proposed project is shown in Figure 1. A close-up view of the project site and associated infrastructure (e.g., roads, flood control channels, wetlands, beach, and housing) near the project site are shown in Figure 2. Pursuant to the CEQA public scoping meeting, coastal hazards associated with sea level rise (SLR) was identified as an analysis that would need to be included in the EIR. SLF-HB Magnolia, LLC, retained Everest International Consultants, Inc. (Everest) to prepare an SLR vulnerability assessment and adaptation plan (VAAP). In November 2018, Everest ceased operations and Everest staff joined Anchor QEA, LLC.

1.2 Purpose

The purpose of the SLR VAAP is to determine the potential for coastal hazards to impact proposed project components at the time of project completion and in the future as sea level rises. Knowing the level and extent of potential coastal hazard impacts that the proposed project might be exposed to in the future will help inform the environmental impact analysis. In addition, this information was used to develop SLR adaptation measures that were incorporated into the project design as well as identify adaptation measures that could be implemented in the future, when and if needed.

Figure 1
Project Location Map

Map Source: Google Earth Pro

Figure 2
Project Site Vicinity Map

Map Source: Google Earth Pro

1.3 Existing Conditions

The existing project site is bounded on the north by the ASCON landfill, west-southwest by the Huntington Beach Channel (HB Channel), and on the east-southeast by Magnolia Street. The site is relatively flat and generally slopes from northwest to the southeast. There is a small road access road network within the site that varies in elevation from +10.0 to +12.0 feet, relative to the North American Vertical Datum of 1988 (NAVD88). The ground elevation of the ASCON site located adjacent to the project site to the north varies in elevation from +10.0 to +16.0 feet NAVD88. The HB

Channel runs along the entire west-southwest boundary of the site contained by a vertical sheetpile floodwall ranging in elevation from +13.0 to +13.3 feet NAVD88. The HB Channel runs downstream to the east-southeast where it joins the Talbert Channel before emptying into the Pacific Ocean just upcoast (north-northwest) from the Santa Ana River mouth. The HB Channel and associated floodwall are operated and maintained by the Orange County Flood Control District. On the eastern portion of the project site adjacent to Magnolia Street, there is a grassy berm that averages +17.0 feet NAVD88. The Huntington Beach Wetlands (HBW) are located to the west-southwest of the HB Channel, and PCH is located to the west-southwest of the HBW. Finally, there is a wide, sandy beach (Huntington State Beach) located to the west-southwest of PCH. The major features of the project site under existing conditions are shown in Figure 2.

1.4 Project Description

The following two alternatives for the redevelopment of the MTF site will be evaluated in the EIR: Alternative 1 (Mixed-Use) would consist of a 211,000-square-foot lodge that includes 175 guest rooms and guesthouse-style, budget-oriented, family/group overnight accommodations with 40 beds and ancillary resident and visitor-serving retail and dining; up to 250 for sale, residential units (at 15 dwelling units/acre); 2.8 acres of open space to provide a buffer for the adjacent wetlands; and 2.9 acres of public park. Alternative 2 (Residential) would consist of the redevelopment of the MTF site with up to 250 for sale, residential units, parks, and open space only. This alternative would not include the lodge, visitor-serving, and resident-serving uses. All other Project components, including the number of residential units, parks, and open space associated with Alternative 1 would remain the same. In addition, both project alternatives would include the infrastructure (roads, utilities, and storm drain system) necessary to support the facilities described above. The conceptual project site plans are shown in Figure 3 (Alternative 1) and Figure 4 (Alternative 2).

Figure 3
Conceptual Site Plan – Alternative 1

Legend

- Specific Plan Area
- PA 1 - Coastal Conservation (CC)
- PA 2 - Open Space - Parks and Recreation (OS-PR)
- PA 3 - For-Sale Residential (RES)
- PA 4 - Commercial Visitor (CV)

Source: WHA Inc.

Figure 4
Conceptual Site Plan – Alternative 2

Source: WHA Inc.

Under both alternatives, the project would feature a 70-foot wide setback containing an open space buffer along the west-southwest boundary adjacent to the HB Channel. A fringing open space/park area would be included along the east-southeast side of the project site adjacent to Magnolia Street. Under Alternative 1, the northern two-thirds of the project site would contain residential housing while the southern one-third would include a lodge and visitor-serving commercial uses. An additional open space/park area would be provided adjacent to the open space buffer at about the midpoint along the HB Channel. Under Alternative 2, the entire project site would contain residential housing.

The open space buffer would vary in elevation from +10.0 to +16.0 feet NAVD88. The residential areas would feature building pads ranging in elevation from +11.3 to +12.5 feet with streets ranging in elevation from +9.0 to +17.0 feet NAVD88. The lodge and visitor-serving commercial area associated with Alternative 1 would feature a building pad with a ground elevation of +4.0 feet with a finished floor elevation of +17.0 feet NAVD88. The major features of the project site under proposed conditions are shown in Figure 3.

Under both alternatives, rainfall would be collected in an on-site storm runoff drainage system. The drainage would be directed to discharge into the HB Channel through one or two new connections. The number and location of these new connections would be identified as part of final engineering design.

1.5 Relevant Sea Level Rise Policy Guidance

The City completed an SLR vulnerability assessment in 2014, but no local, project-specific SLR policy has been developed yet. Consequently, at this time, State policy guidance from the California Coastal Commission (CCC) is the most relevant information, and that guidance is contained in the August 12, 2015 document, *California Coastal Commission Sea Level Rise Policy Guidance, Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits* (CCC 2015). The SLR projections presented in that document are summarized in Table 1 with the original source (NRC 2012).

Table 1
SLR Projections for California

Time Period*	North of Cape Mendocino (cm)	South of Cape Mendocino (cm)
By 2030	-4 to +23	+4 to +30
By 2050	-3 to +48	+12 to +61
By 2100	+10 to +143	+42 to +167

Note:
*Baseline is Year 2000.
cm: centimeter
Source: NRC 2012

In April 2017, the State released a report, *Rising Seas in California: An Update on Sea-Level Rise Science,* prepared by the California Ocean Science Trust and California Ocean Protection Council (OPC), that represents the "best available science" relative to SLR for the State (Griggs et al. 2017). Since May 2017, the California Natural Resources Agency (CNRA) and OPC have been working to update the State's SLR policy based on this best available science update. On March 14, 2018, the State released the *State of California Sea-Level Rise Guidance: 2018 Update*, prepared by the CNRA and OPC (CNRA and OPC 2018). That document presents State SLR policy and provides recommended guidance to achieve that policy. An overview of the recommended policy guidance is summarized as follows:

1. Identify the nearest tide gauge station.
2. Evaluate project lifespan.
3. For the nearest tide gauge and project lifespan, identify range of SLR projections.
4. Evaluate potential impacts and adaptive capacity across a range of SLR projections and emissions scenarios.
5. Select SLR projections based on risk tolerance and, if necessary, develop adaptation pathways that increase resiliency to SLR and include contingency plans if projections are exceeded.

A hybrid approach was developed for this project-level SLR VAAP to address the policy guidance recommended in the 2015 CCC SLR Policy Guidance and 2018 State SLR Guidance Update. The SLR vulnerability assessment is based primarily on guidance recommendations provided in the 2018 State SLR Guidance Update, while the SLR adaptation plan is based primarily on recommendations in the 2015 CCC SLR Policy Guidance.

1.6 Nearest Tide Gauge Station

The project site is located in Huntington Beach, Orange County, California, which is located between Los Angeles and San Diego counties. The closest National Oceanic and Atmospheric Administration (NOAA) tide gauge station is the Los Angeles Harbor Station (NOAA Station 9410660), which is approximately 17 miles from the project site. This tide gauge station was used for this SLR VAAP. The low risk aversion, medium-high risk aversion, and extreme risk aversion SLR projections for this location from Year 2030 to Year 2100 (i.e., Project Lifespan) are presented in Table 2.

Table 2
SLR Projections for Los Angeles

Time Period[a]	Low Risk Aversion (feet)	Medium-High Risk Aversion (feet)	Extreme Risk Aversion (feet)
By 2030	0.5	**0.7**	1.0
By 2040	0.7	**1.2**	1.7
By 2050	1.0	**1.8**	2.6
By 2060	1.1/1.3[b]	**2.2/2.5**[b]	3.7
By 2070	1.3/1.7 [b]	**2.9/3.3**[b]	5.0
By 2080	1.6/2.2[b]	**3.6/4.3**[b]	6.4
By 2090	1.8/2.7[b]	**4.5/5.3**[b]	8.0
By 2100	2.1/3.2[b]	**5.4/6.7**[b]	9.9

Notes:
a. Baseline is Year 2000.
b. Low-emissions scenario/high-emissions scenario
Source: CNRA and OPC 2018

There would be low to medium consequences to the project site and surrounding area if SLR were underestimated. Flood damages to the residential and commercial properties would be limited to the project site, and economic impacts would be confined to the project site as well. The project would be moderately adaptive to SLR in the future with both protection and accommodation adaptation measures available for implementation as part of initial project construction as well as part of future projects (e.g., floodwall elevation increase) and/or operational solutions (e.g., deployment of measures in advance of storms). Consequently, the medium-high risk aversion SLR projections were selected to assess the vulnerability of the proposed project to future SLR. In addition, in the March 15, 2018 State of California SLR guidance (CNRA and OPC 2018), it is recommended that the medium-high risk aversion scenario be used for residential development projects. These values are shown in **bold** in Table 2.

1.7 Project Lifespan

It is currently anticipated that the project would be constructed in Year 2026, so that year was selected as the year of project completion. Based on guidance provided in the 2018 State SLR Policy Update for residential development, a project life of 75 years was selected for use in conducting this SLR VAAP. This extends the project lifespan to Year 2101, which was rounded to Year 2100 for simplicity.

2 Sea Level Rise Vulnerability Assessment

2.1 CoSMoS

The U.S. Geological Survey (USGS) has developed a numerical modeling system capable of simulating various coastal hazards under existing mean sea level and future mean sea level conditions (i.e., with SLR projections). This modeling system, known as the Coastal Storm Modeling System (CoSMoS) (Erikson et al. 2017), has been updated several times to better simulate the complex processes that affect the accuracy of the results. Results from the most recent version of CoSMoS (Version 3.0, Phase 2) were accessed from the "Our Coast, Our Future" website (http://data.pointblue.org/apps/ocof/cms/) in the form of flood hazard area maps. The maps were downloaded and used to analyze coastal erosion, tidal flooding, and coastal wave storm flooding under the various SLR projection timeframes identified in Table 2. CoSMoS provides results for various amounts of SLR (0 to 200 centimeters [cm] in 25-cm increments) with no consideration of timeframe. Because the 2018 State SLR Policy Update requires analysis of various SLR projections associated with timeframes, the CoSMoS results closest to the SLR projections associated with the 2018 State SLR Policy Update timeframes were used to conduct the analysis presented herein. For example, as indicated in Table 2, the medium-high SLR projection for Year 2100 is 5.4 feet (165 cm) while the closest two CoSMoS results were for 150 and 175 cm. For this analysis, the CoSMoS results for the SLR projection of 175 cm were used, and the result was assumed to be associated with Year 2100. Year 2017 was selected to represent existing conditions, and it was assumed that there has been no SLR between the Baseline Year (Year 2000) and Year 2017. It was further assumed that the CoSMoS results for the scenarios with no SLR represents this condition.

2.2 Coastal Erosion

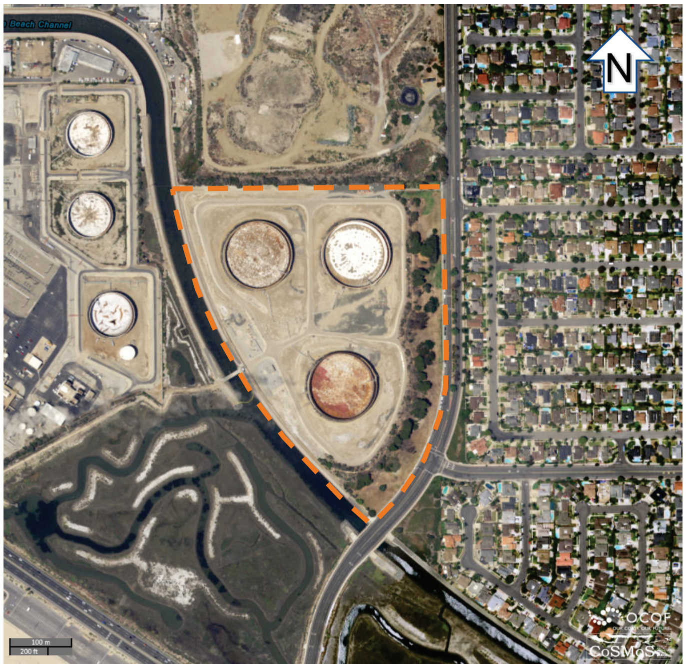
CoSMoS includes the ability to estimate the increased erosion of beaches and erodible bluffs associated with SLR, including direct beach inundation and increased wave erosion due to more frequent and intense wave action. The CoSMoS results for various coastal erosion scenarios (e.g., with and without beach nourishment) were reviewed for existing mean sea level conditions (Year 2017) as well as the three selected SLR projections (25, 75, and 175 cm) and associated timeframes (Years 2030, 2060, and 2100) as part of this SLR VAAP. The results indicated that SLR-induced coastal erosion would not impact the project site now or out to Year 2100 with any of the SLR projections. This is due to several factors. First, the beach is relatively wide (approximately 500 to 600 feet) at this location, which provides a buffer against coastal erosion. Second, the relatively high dune area on either side of PCH, as well as PCH itself, provide a further buffer from coastal erosion. Third, the HBW provide an additional buffer from SLR-induced erosion impacting the project site. In total, these three factors represent a buffer distance of approximately 1,800 to 2,000 feet between the project site and the ocean.

2.3 Tidal Inundation

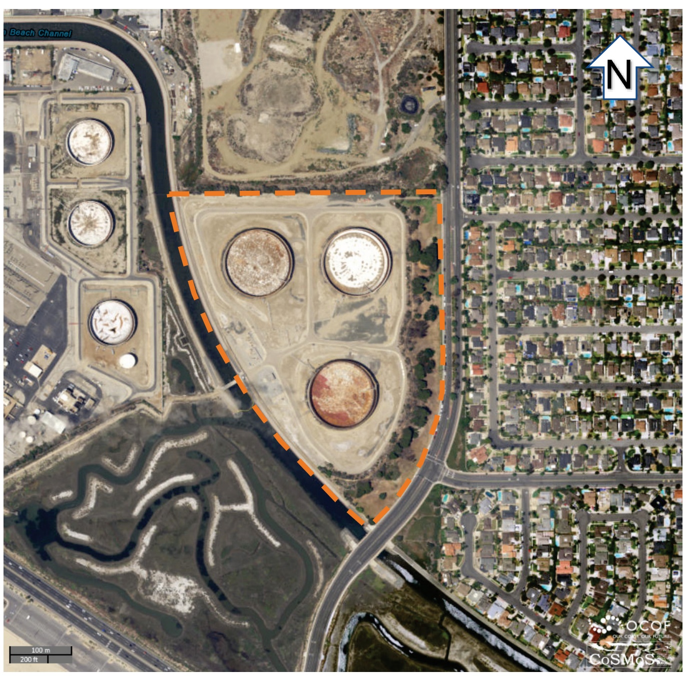
The tidal inundation CoSMoS results (maps) for Years 2017, 2030 (medium-high risk aversion), 2060 (medium-high risk aversion), and 2100 (medium-high risk aversion) are shown in Figures 5a, 6a, 7a, and 8a, respectively. The Year 2017 results represent current (i.e., existing) conditions. The Years 2030 (medium-high risk aversion), 2060 (medium-high risk aversion), and 2100 (medium-high risk aversion) maps depict coastal hazards associated with a SLR of 25, 75, and 175 cm, respectively. The maps were reviewed to assess the vulnerability of the project site to tidal inundation now and in the future with SLR. In general, the results indicated that the project site would not be subject to coastal hazards associated with tidal inundation now or in the future under all SLR projections (25, 75, and 175 cm) and through all timeframes (Years 2017, 2030, 2060, and 2100), although the maps do indicate the potential for some flood prone, low-lying areas under 175 cm of SLR.

Figure 5
CoSMoS Flood Hazard Map: Current Sea Level Scenarios

Legend
Project Site | Flood Hazard Area | Flood-prone Low Lying Areas



a) Without Wave Storm

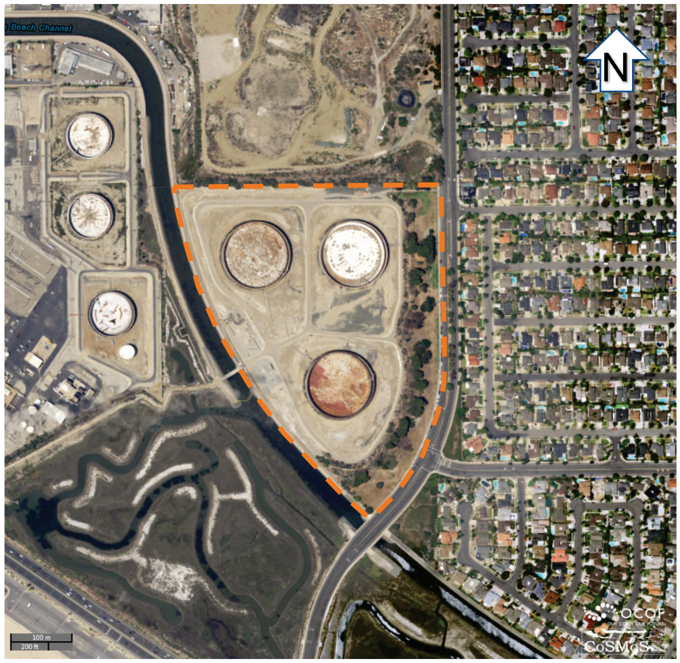


b) With 100-Year Wave Storm

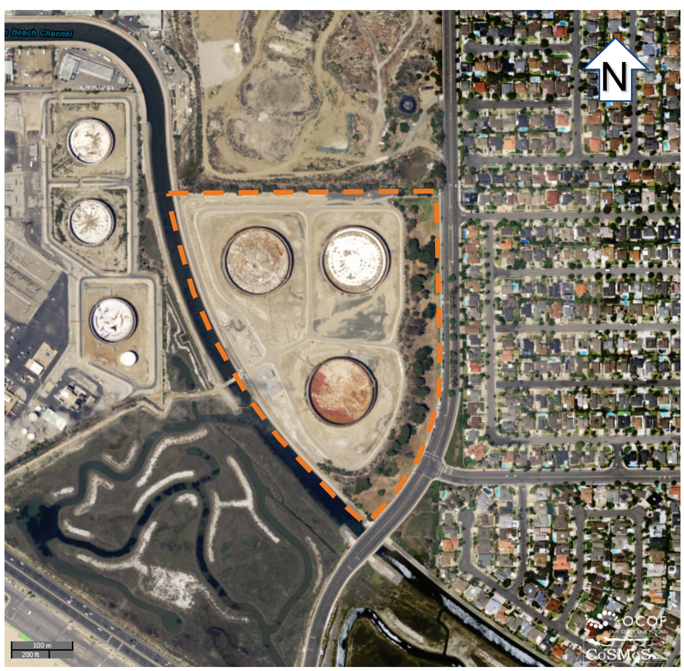
Source: http://data.pointblue.org/apps/ocof/cms/index.php?page=flood-map

Figure 6
CoSMoS Flood Hazard Map: 25-Centimeter SLR Scenarios Selected to Represent Medium-High Risk Aversion SLR Projection for Year 2030

Legend
Project Site Flood Hazard Area Flood-prone Low Lying Areas



a) Without Wave Storm

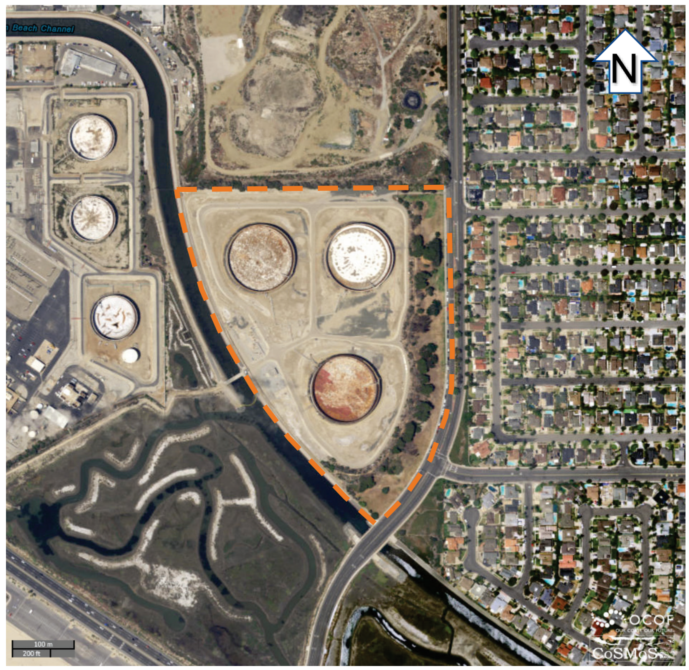


b) With 100-Year Wave Storm

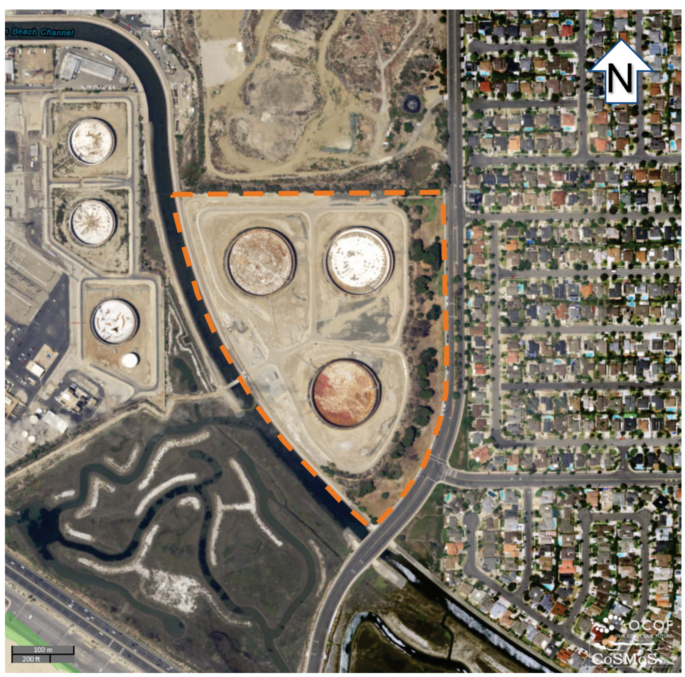
Source: http://data.pointblue.org/apps/ocof/cms/index.php?page=flood-map

Figure 7
CoSMoS Flood Hazard Map: 75-Centimeter SLR Scenarios Selected to Represent Medium-High Risk Aversion SLR Projection for Year 2060

Legend
Project Site | Flood Hazard Area | Flood-prone Low Lying Areas



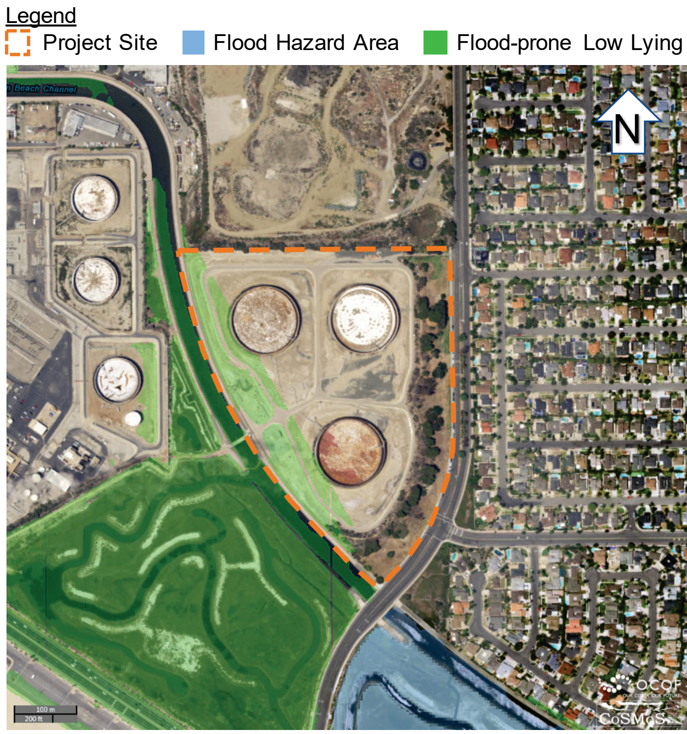
a) Without Wave Storm



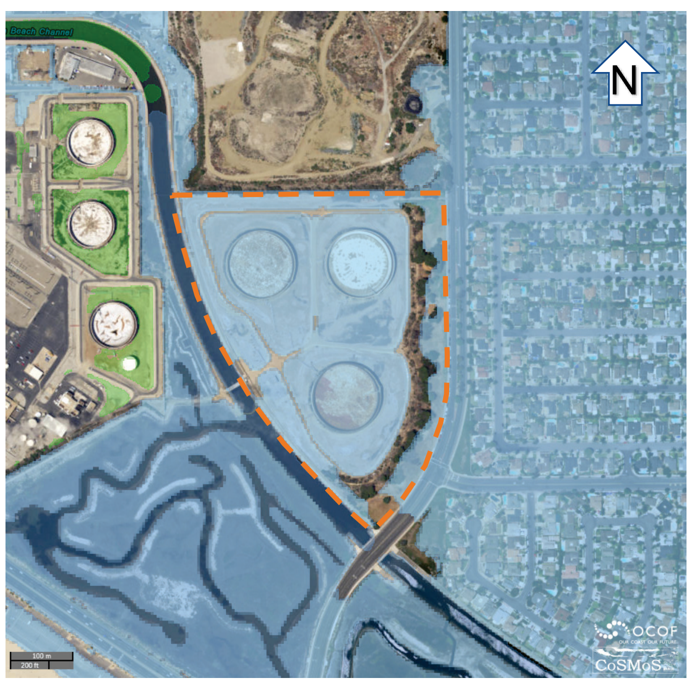
b) With 100-Year Wave Storm

Source: http://data.pointblue.org/apps/ocof/cms/index.php?page=flood-map

Figure 8
CoSMoS Flood Hazard Map: 175-Centimeter SLR Scenarios Selected to Represent Medium-High Risk Aversion SLR Projection for Year 2100



a) Without Wave Storm



b) With 100-Year Wave Storm

Source: http://data.pointblue.org/apps/ocof/cms/index.php?page=flood-map

2.4 Coastal Wave Storm Flooding and Wave Runup

The coastal wave storm CoSMoS maps for Years 2017, 2030 (medium-high risk aversion), 2060 (medium-high risk aversion), and 2100 (medium-high risk aversion) are shown in Figures 5b, 6b, 7b, and 8b, respectively. The Year 2017 results represent current (i.e., existing) conditions. The Years 2030 (medium-high risk aversion), 2060 (medium-high risk aversion), and 2100 (medium-high risk aversion) maps depict flood hazards associated with a 25-, 75-, and 175-cm SLR, respectively. The mapped results were reviewed to assess the vulnerability of the project site to coastal wave storm flooding now and in the future with SLR. In general, the results indicated that the project site would not be subject to coastal hazards associated with coastal storm wave flooding under most SLR projections (25 and 75 cm) and through most timeframes (Years 2017, 2030, and 2060). The results indicate that the project site would be subject to coastal hazards associated with coastal wave storm flooding under the SLR projection of 175 cm (Year 2100).

The results indicating that the project site would be subject to coastal hazards associated with coastal storm wave flooding under the SLR projection of 175 cm (Year 2100) do not appear to be accurate given the known site conditions. The maps (e.g., Figure 7b) show that there is an area of "unflooded" high ground represented by an interior loop road as well as some high ground park/open space on the eastern side. The elevation of the floodwall is equal to or greater than the elevations of these high ground areas, so it is unclear how these areas would not be flooded if the floodwall were overtopped. Based on an August 2017 topographic survey conducted by Fuscoe Engineering, Inc. (FEI), the top of the floodwall is +13.0 feet NAVD88 or higher along the northeastern side of the HB Channel and along the western side of the Talbert Channel near the project site. CoSMoS flood elevation results (in GIS format) downloaded from the USGS website indicate that water elevations associated with coastal wave storm flooding in the project site would range from +10.0 to +10.7 feet for the 175-cm SLR scenario and +12.0 to +12.5 feet NAVD88 for the 200-cm SLR scenario. Existing topographic data indicate that the existing high ground areas (i.e., interior loop road and berm along the eastern edge of the project site) are higher than the CoSMoS flood elevations for the 175-cm SLR scenario.

Therefore, it is unclear how flood waters would be able to overtop the floodwall and enter the project site as depicted in the CoSMoS maps, so this apparent discrepancy warranted further consideration. One possible explanation is that CoSMoS did not include the floodwall. The floodwall, which is fairly narrow in width, might not have been resolved in the Light Detection and Ranging (LiDAR) survey data used to represent the topography in CoSMoS. USGS was contacted regarding this potential explanation. Dr. Li Erikson (USGS) verified that CoSMoS was based primarily on LiDAR survey data and that the model did not include the floodwall (Erickson 2017). If the floodwall was included in CoSMoS, then the results would not have shown flooding in the project site under the 175-cm SLR scenario.

A wave runup analysis was not conducted as part of this VAAP because the project site is located far enough inland that wave runup would not be expected to reach the site as it would have to overtop the beach at Huntington State Beach (HSB), cross PCH, and flow through the HBW before reaching the site. Moreover, it is anticipated that management efforts would be undertaken in the future to maintain HSB, PCH, and HBW for recreation, transportation, and wildlife, respectively, so wave runup was not analyzed under existing conditions (Year 2017) or through Year 2100 with SLR. In the absence of these anticipated management efforts, the CoSMoS results indicate that wave runup would not be expected to reach the project site through Year 2100 with SLR.

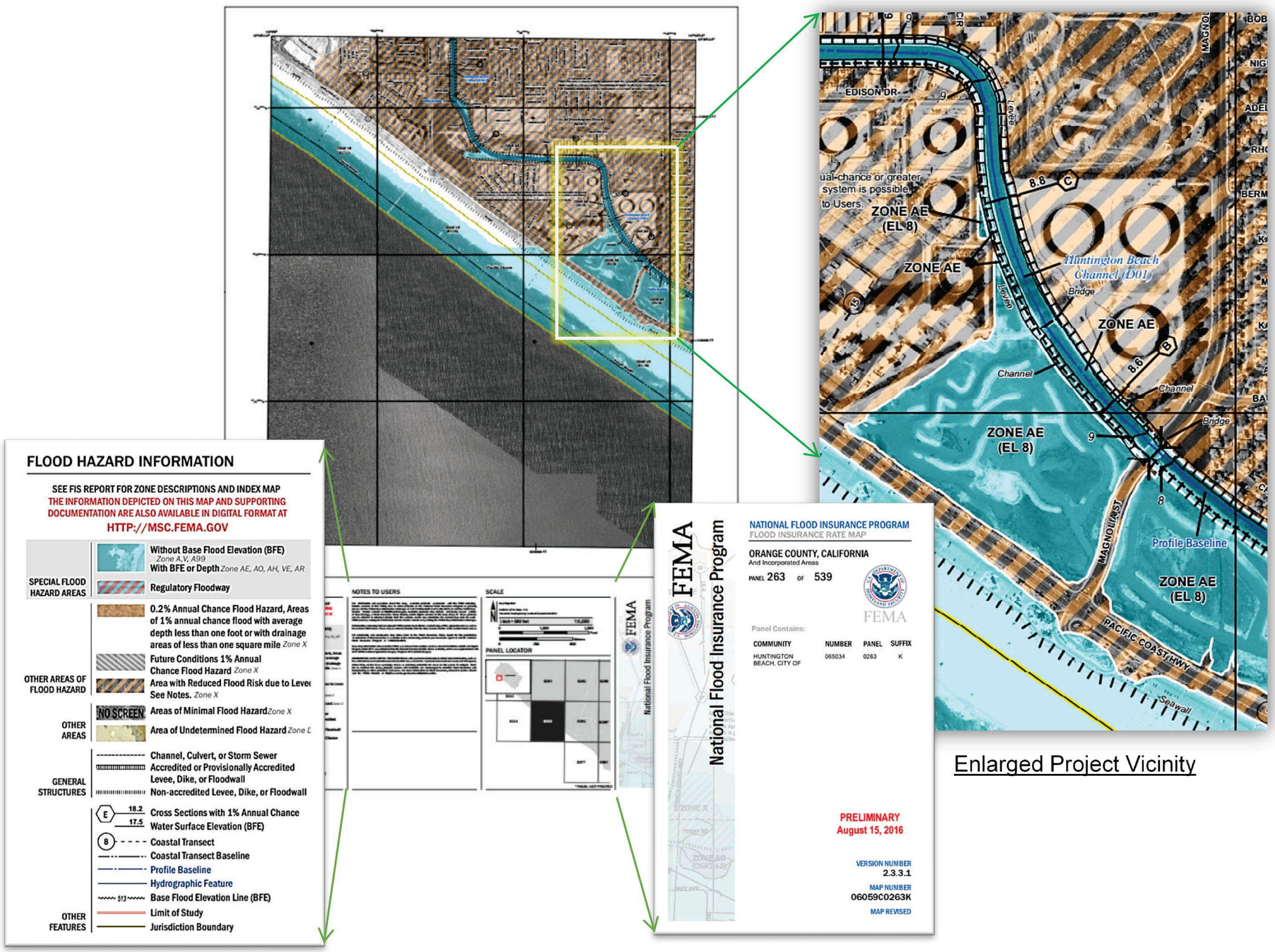
2.5 Fluvial Flooding

2.5.1 Assessment Using Existing Resources

An initial assessment of the potential impact of SLR on coastal hazards associated with fluvial flooding was conducted using existing resources. The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) dated August 15, 2016 (Figure 9), was selected as the most relevant existing resource for this SLR VAAP. The objective of the initial assessment was to identify the potential for fluvial flooding at and near the project site to be impacted by SLR in the future.

The project site is located adjacent to the northeastern side of the HB Channel. The HB Channel and HBW are in areas designated as Zone AE with base flood elevations (BFEs) provided for those areas. The BFE within the HBW is shown as +8.0 feet, while the BFE within the HB Channel is shown varying from +8.8 to +9.0 feet NAVD88 along the project site. The project site is in an area designated as Zone X ("Area with Reduced Flood Risk due to Levee"). The flood levee and associated floodwall provide a level of flood protection that is adequate to keep flood waters from entering the project site under the design storm conditions used in the analysis conducted to prepare the FIRM. Because flood waters would not enter the project site under design storm conditions, no BFEs within the project site are shown on the FIRM. This also means that development within the project site does not currently require a flood elevation certificate nor is there currently a requirement to have the finished floor elevations above the BFEs by some height (e.g., 1 foot).

Figure 9
FEMA Flood Insurance Rate Map (Preliminary August 15, 2016)



The areas outside the HB Channel and HBW are designated as Zone X as indicated by the areas marked with brown and gray stripes to the west, north, and east of the project site. This designation suggests that the levee and associated floodwall provide an adequate level of protection for these areas as long as the floodwall is not breached or overtopped. If the floodwall were to be breached or overtopped, then the lower lying areas (e.g., project site) in Zone X would have a higher flood risk than the higher lying areas (e.g., ASCON site).

The analysis used to prepare the FIRM was based on existing sea level conditions, so the impact of future SLR on fluvial flooding was not evaluated by FEMA. To assess the potential impact of SLR on fluvial flooding in the future, the SLR projections presented in Table 2 were added to the HB Channel BFEs presented in the FIRM. For simplicity, a constant BFE of +9.0 feet NAVD was used for this analysis. The potential BFE results are presented in Table 3 for the SLR projections, risk scenarios, and time periods used in this SLR VAAP. In reality, SLR might impact fluvial flooding at the project site via increases in the backwater effect, which could be analyzed quantitatively through the use of numerical hydrodynamic models. The method used herein was developed to conservatively estimate the impact of SLR on fluvial flooding for the purpose of establishing potential future coastal hazards that could be used during the environmental review process.

Table 3
Potential Base Flood Elevations for a 100-Year Fluvial Flood Occurring in the Future with the Medium-High Risk Aversion SLR Projections

Time Period*	Potential BFE (feet NAVD)
By 2030	+9.7
By 2060	+11.2
By 2100	+14.4

Note:
*Baseline is Year 2000.

The top of the existing floodwall is at a minimum elevation of +13.0 feet NAVD, so no flooding of the project site would be expected to occur by Year 2030 because the projected SLR increase would not be expected to increase flood risk compared to existing conditions. Likewise, no flooding of the project site would be expected to occur by Year 2060. By Year 2100, the projected SLR increase would be expected to increase flood risk substantially compared to existing conditions because the floodwall would be overtopped. The areas outside of the project site to the west, north, and east would likely experience increases in flood risk depending on the ground elevations of those areas, with lower areas experiencing greater flood risk and higher areas experiencing lower flood risk.

2.5.2 Fluvial Flood Hydraulics Analysis Using Site-Specific Hydrodynamic Model

2.5.2.1 Purpose and Objectives

Given the potential for vulnerability to increased coastal hazards associated with fluvial flooding in the future due to SLR identified under Section 2.5.1, a more rigorous analysis (fluvial flood hydraulics) was undertaken to further evaluate this potential vulnerability. The purpose of the fluvial flood hydraulics analysis was to determine the potential for the project to increase coastal hazards associated with fluvial flooding now and in the future under various projections of SLR. The following objectives were identified to meet this purpose:

- Select an appropriate fluvial flood numerical model
- Establish the SLR projections for use in the fluvial flood modeling
- Identify the appropriate tidal series and flood hydrographs
- Define the model domain
- Collect topographic and bathymetric data for Existing Condition (Without Project), and proposed finished ground elevations for Proposed Condition (With Project)
- Set up the fluvial flood model
- Conduct fluvial flood modeling for Existing Condition (Without Project) and Proposed Condition (With Project) both now and in the future with projected SLR
- Analyze the fluvial flood modeling results to determine what, if any, impacts the project would have on fluvial flooding now and in the future with SLR

2.5.2.2 Model Selection

The 2D unsteady flow simulation component of the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System software (HEC-RAS) was selected to conduct the fluvial flood modeling. The 2D component of HEC-RAS Version 5.0.5 (HEC-RAS 2D) was selected to analyze the more complicated flow patterns that would likely occur within HBW located along the southwest boundary of the project site along the far side of HB Channel. In addition, the 2D model was selected because it can better simulate flood overtopping of the flood channel wall. Detailed information regarding HEC-RAS 2D can be found in the *HEC-RAS River Analysis System 2D Modeling User's Manual* (USACE 2016).

2.5.2.3 Model Development

Sea Level Rise Projections

The SLR projections for Years 2030, 2050, and 2100 were selected for consideration in the fluvial flood modeling. For Year 2100, the low-emissions scenario was selected for the medium-high risk aversion projections. The rationale for selection of the tide gauge location, project lifespan, emissions scenario, and level of risk aversion was presented previously. The selected SLR projections are presented in Table 2.

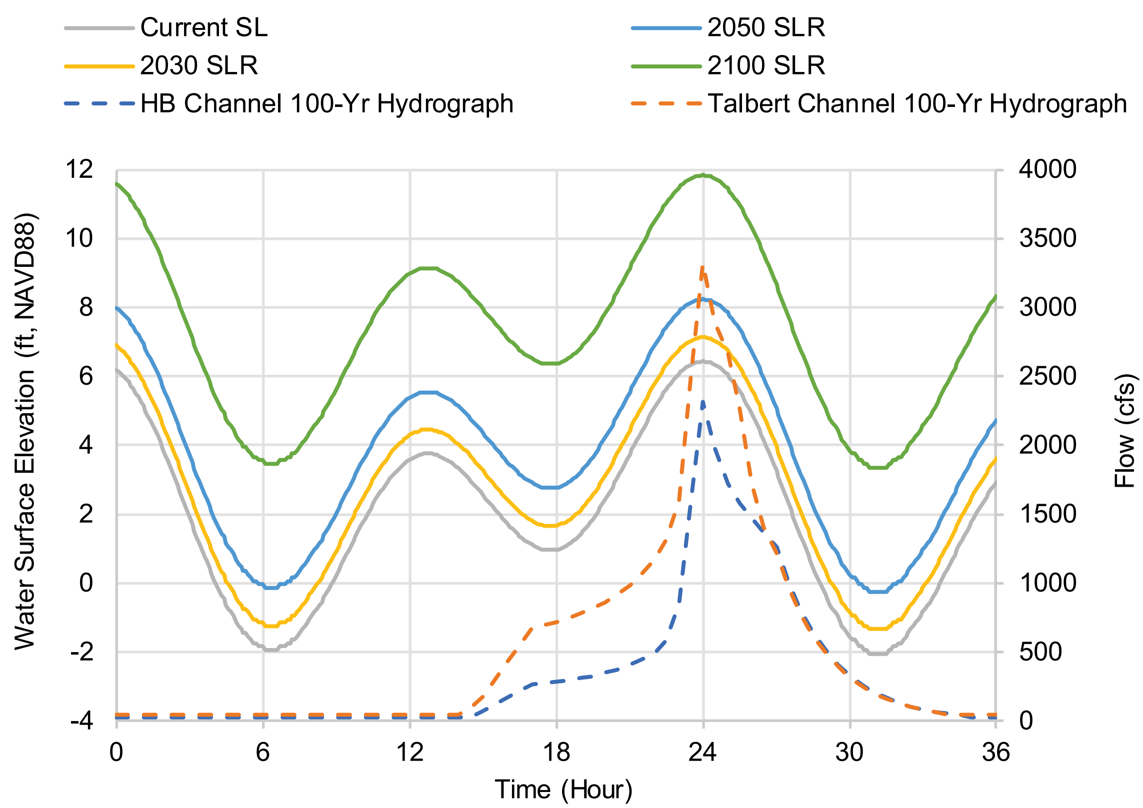
Ocean Water Level and Fluvial Flood Hydrographs

A water level time series was developed to represent the ocean water level variation offshore of the Talbert Channel ocean outlet. In 2014, the City completed an SLR vulnerability assessment that included fluvial flood modeling for the HB Channel and Talbert Channel. That work, which was performed by Moffatt & Nichol (2014), used a maximum ocean water level of +6.44 feet NAVD88. That maximum ocean water level value was selected for this fluvial flood modeling effort to provide consistency with that prior SLR vulnerability assessment work. To capture the time-varying nature of the ocean water level fluctuations, a spring tide ocean water level time series of December 3 to December 4, 2017, was selected from NOAA Los Angeles Station 9410660 (NOAA 2018a), and the peak higher high water was adjusted to match the maximum ocean water level of +6.44 feet NAVD88. Ocean water level time series for these conditions were developed for conditions without substantial SLR, which was taken as Year 2020. To represent the effect of the three SLR projections on ocean water levels in the future, ocean water level time series were also developed for Years 2030, 2050, and 2100 by adding the amount of SLR projected (as presented in Table 2) to occur by that particular year.

The 100-year fluvial flood event was selected to conduct the fluvial flood modeling because it is consistent with the event size used by FEMA in preparing the fluvial flood plain maps (FIRM). In addition, Moffatt & Nichol used the 100-year fluvial flood event in conducting the fluvial flood modeling that supported development of the City's 2014 SLR vulnerability assessment. The 100-year peak flow discharges for the HB Channel and Talbert Channel published in the Moffatt & Nichol study report were used for this fluvial flood modeling. The 100-year peak flow discharges for the HB Channel and Talbert Channel were 2,315 and 3,325 cubic feet per second, respectively. Flood hydrographs were developed for these two peak discharges based on the hydrographs documented in the *Hydrologic and Hydraulic Baseline Report* for the HBW hydrologic and hydraulic conditions study (Moffatt & Nichol 2004).

The ocean water level time series and fluvial flood hydrographs used for the fluvial modeling are shown in Figure 10. In the figure, the left axis provides unit readings for the tide water surface elevation, and the right axis provides flow readings for the hydrographs. The peak fluvial flood discharges were timed to occur when the ocean water level hits the maximum level of +6.44 feet NAVD88. This assumption provides a high fluvial flood water level, at least when compared to an assumption of low tide or slack tide co-occurrence.

Figure 10
100-Year Flood Flow Hydrographs and Spring Tide Water Surface Elevations for Various SLR Scenarios



Model Domain

To properly simulate fluvial flooding, the model domain needs to cover the full area that could be impacted by the project now and in the future with SLR. Although the project site is adjacent to the HB Channel, it is located within the Talbert Channel Watershed, which is drained by both the HB Channel and Talbert Channel. The HB Channel drains the western portion of the watershed while the Talbert Channel drains the larger, eastern portion of the watershed. The HB Channel empties into the Talbert Channel just downstream from the project site where the combined flows of both channels continue to flow out to the ocean through the Talbert Channel ocean outlet just northwest of the Santa Ana River mouth. The domain selected for the fluvial flood model covers the middle and lower reaches of both channels, as well as the nearshore portion of the ocean immediately upcoast and downcoast from Talbert Channel ocean outlet. The model domain boundary is shown in Figure 11, along with major points of interest and the existing topography/bathymetry, which are described in the following subsections.

Project Site Topography

The topographic conditions of the project site were selected to represent both existing and proposed conditions. The Existing Condition was represented by a topographic survey base map prepared by FEI (FEI 2018). The project site topography under Proposed Condition was represented by the proposed Mass Grading Master Plan prepared by FEI (FEI 2018). Relevant to fluvial flooding modeling, the major difference between the Existing Condition (Without Project) and Proposed Condition (With Project) is the addition of approximately 93,000 cubic yards of fill placed within the project site as part of the Proposed Condition.

Model Domain Topography/Bathymetry

As-built drawings containing elevation information of the top and bottom of the channels within the study area for the Talbert Channel and HB Channel were obtained from Orange County Public Works Department and FEI. Project site survey data collected in 2017 by FEI were also used in developing the fluvial flood model (FEI 2017). The survey data indicate that the top of the HB Channel wall that runs along the entire western boundary of the project site ranges in elevation from +13.3 feet at the upstream end to +12.6 feet NAVD88 at the downstream end. As-built topographic/bathymetric data of the HB – Magnolia Marsh was obtained from Moffatt & Nichol in the form of 0.25-foot contour lines in AutoCAD format. Topographic raster data for the rest of the area within the model domain were obtained from the NOAA Data Access Viewer website (NOAA 2018b). Topographic data selected for the fluvial flood model include "NOAA Office for Coastal Management Coastal Inundation Digital Elevation Model: Aggregate Record" and "2014 USACE NCMP Topobathy Lidar DEM: California."

Figure 11
HEC-RAS 2D Model Domain and Topography/Bathymetry

2.5.2.4 Results

The 2D unsteady flow component of the HEC-RAS 2D fluvial flood model presented above was used to analyze flooding under existing and proposed conditions both without and with SLR. This was done by running the model for several different scenarios as presented in Table 4. The results (water surface elevations) were then analyzed and compared to determine what, if any, potential impact the project would have on flooding. The results are presented first without SLR and then with SLR.

Table 4
Fluvial Flood Modeling Scenarios

Model Simulation No.	Project Site Condition	Sea Level Condition	Fluvial Flood Event
1	Existing	Existing (No SLR)	100-Year
2	Proposed	Existing (No SLR)	100-Year
3	Existing	Year 2030	100-Year
4	Existing	Year 2050	100-Year
5	Existing	Year 2100	100-Year
6	Proposed	Year 2030	100-Year
7	Proposed	Year 2050	100-Year
8	Proposed	Year 2100	100-Year

Results Under Current Timeframe

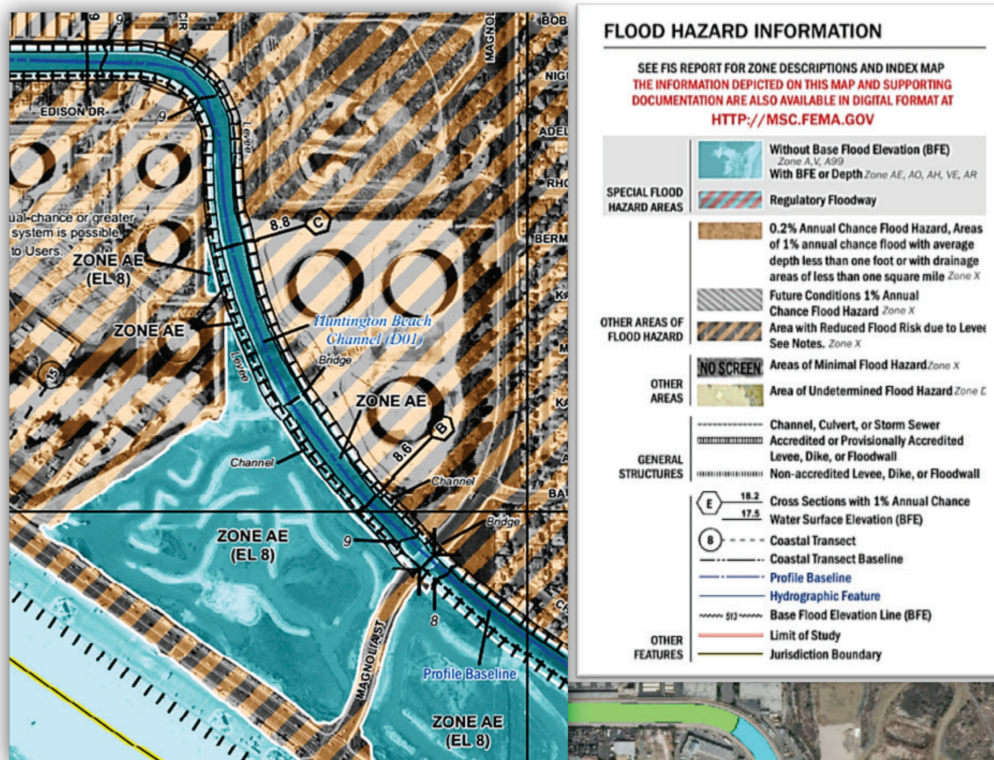
The water surface elevation results for the 100-year flood event occurring under Current Timeframe (Year 2020 without SLR) are presented in Figure 12 for Existing Condition (Without Project). The results indicate that the maximum water surface elevation would reach between +6.0 and +8.0 feet NAVD88 within the Talbert Marsh and Brookhurst Marsh portions of the HBW, which is similar to the maximum water surface elevation in the ocean just offshore from the Talbert Channel ocean outlet. The results indicate that the maximum water surface elevation in the Magnolia Marsh portion of the HBW would reach between +8.0 and +10.0 feet NAVD88, and this range in water surface elevations would extend up the HB Channel for several thousand feet. Just north of where Atlanta Avenue crosses the HB Channel, the results show that the maximum water surface elevations would be above +10.0 feet NAVD88. The results reveal similar patterns moving upstream within the Talbert Channel. The results indicate that no overtopping of either flood control channel would occur throughout the entire model domain during a 100-year flood.

Figure 12
100-Year Flood Maximum Water Surface Elevation Under Current Timeframe for Existing Condition (Without Project)

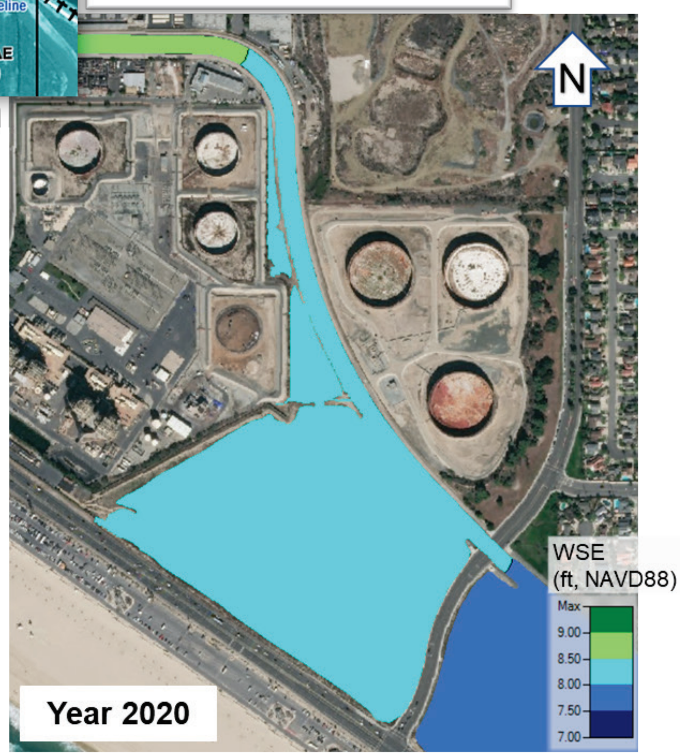
The results under current timeframe (Year 2020) for Existing Condition were compared with the level of flooding shown in the latest FIRM (FEMA 2016). The latest FIRM is shown in the top left panel of Figure 13, while the results under Current Timeframe (Year 2020) for Existing Condition (Without Project) are shown in the bottom right panel of the same figure. The latest FIRM identifies the HB Channel and Magnolia Marsh as Zone AE with maximum water surface elevations of +8.0 feet NAVD88. The fluvial flood model simulated results for the same 100-Year event are similar, ranging from +8.0 feet in the vicinity of the project site to +9.0 feet NAVD88 just upstream of the project site. Consequently, there is good agreement between the model results and the results published in the latest FEMA FIRM.

The water surface elevation results for the 100-year flood event occurring under Current Timeframe (Year 2020 without SLR) are presented in Figure 14 for the Proposed Condition (With Project). The results are almost identical to the Existing Condition results. As with the Existing Condition, the results indicate that no overtopping of either flood control channel would occur throughout the entire model domain during a 100-year flood.

Figure 13
100-Year Flood Water Elevation Comparison Between HEC-RAS Model Result and FEMA FIRM



FEMA Flood Insurance Rate Map (Preliminary, August 2016)



HEC-RAS Model Simulated 100-Year Flood Maximum Water Elevation

Figure 14
100-Year Flood Maximum Water Surface Elevation Under Current Timeframe (Year 2020 Without SLR) for Proposed Condition (With Project)

Results Under Future Timeframes

The water surface elevation results for the 100-year flood event occurring under the Current Timeframe (Year 2020 without SLR) and Future Timeframes (Years 2030, 2050, and 2100 with SLR) are presented in Figure 15 for Existing Condition (Without Project). The results indicate that the maximum water surface elevation within the Magnolia Marsh portion of the HBW would reach between +8.0 and +10.0 feet NAVD88 in Years 2020, 2030, and 2050. The results for Year 2100 indicate that the maximum water surface elevation would reach between +10.0 and +12.0 feet NAVD88 within Magnolia Marsh and the portion of the HB Channel immediately upstream from the project site. The results reveal flooding of low-lying areas outside the HB Channel primarily within the power plant site to the west of the HB Channel and within the residential neighborhood east of Magnolia Street. There would also be some minor flooding of low-lying areas within and along the project site on both the western and northern boundaries. For Existing Condition (Without Project), these results indicate that the project site would have some potential vulnerability to fluvial flooding due to SLR in Year 2100.

The water surface elevation results for the 100-year flood event occurring under Current Timeframe (Year 2020 without SLR) and Future Timeframes (Years 2030, 2050, and 2100 with SLR) are presented in Figure 16 for the Proposed Condition (With Project). The results indicate that the maximum water surface elevations for the Proposed Condition (With Project) are almost identical to the water surface elevations for the Existing Condition (Without Project). Like with the Existing Condition (Without Project), the results reveal flooding of low-lying areas outside the HB Channel primarily within the power plant site to the west of the HB Channel and within the residential neighborhood east of Magnolia Street. There would also be some minor flooding of low-lying areas within and along the project site on both the western and northern boundaries. These results indicate that for the Proposed Condition (With Project) the project site would have some potential vulnerability to fluvial flooding due to SLR in Year 2100, similar to the results for the Existing Condition (Without Project).

Figure 15
100-Year Flood Maximum Water Surface Elevations Under Current Timeframe (Year 2020 Without SLR) and Future Timeframes (With SLR) for Existing Condition (Without Project)

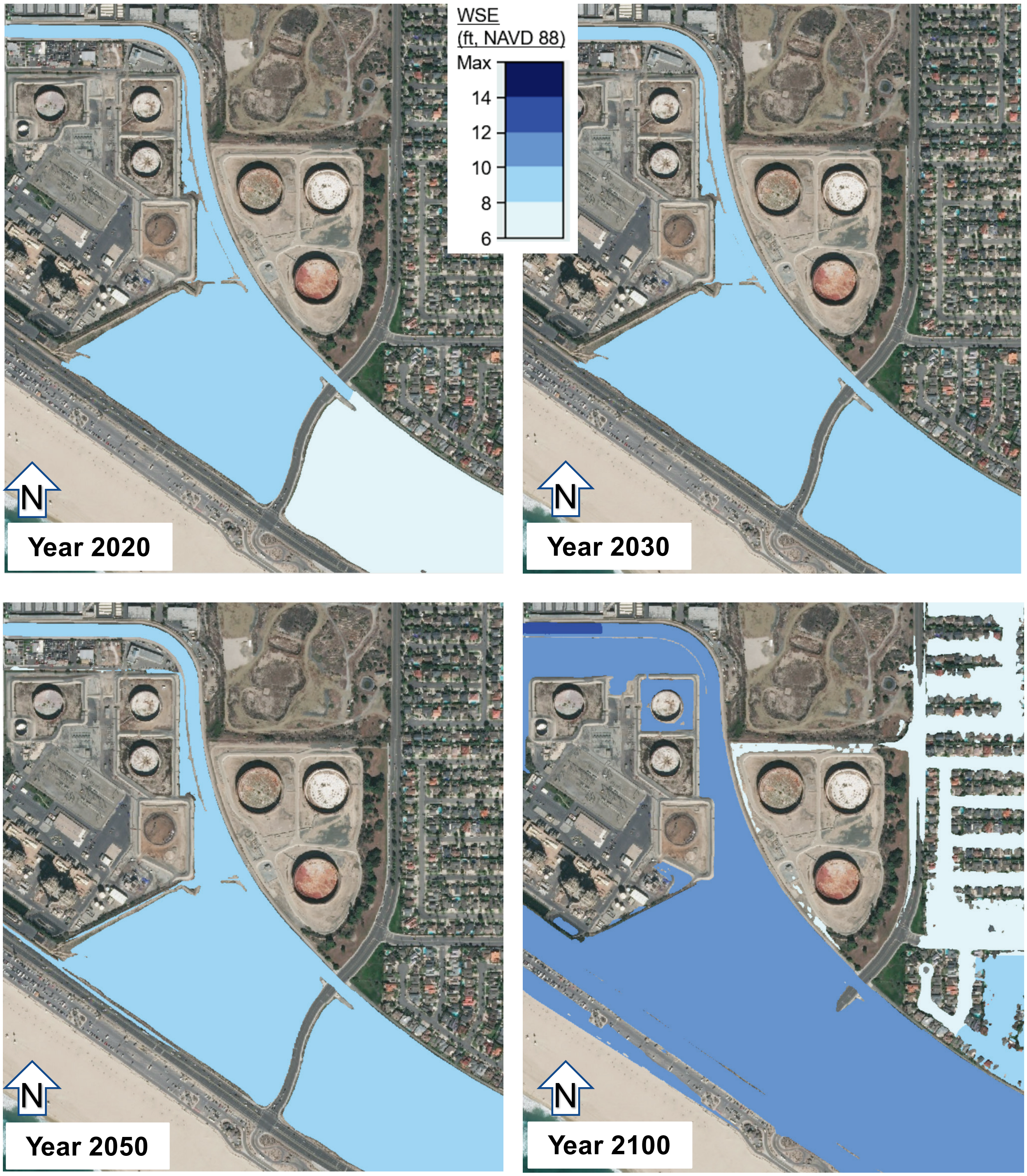
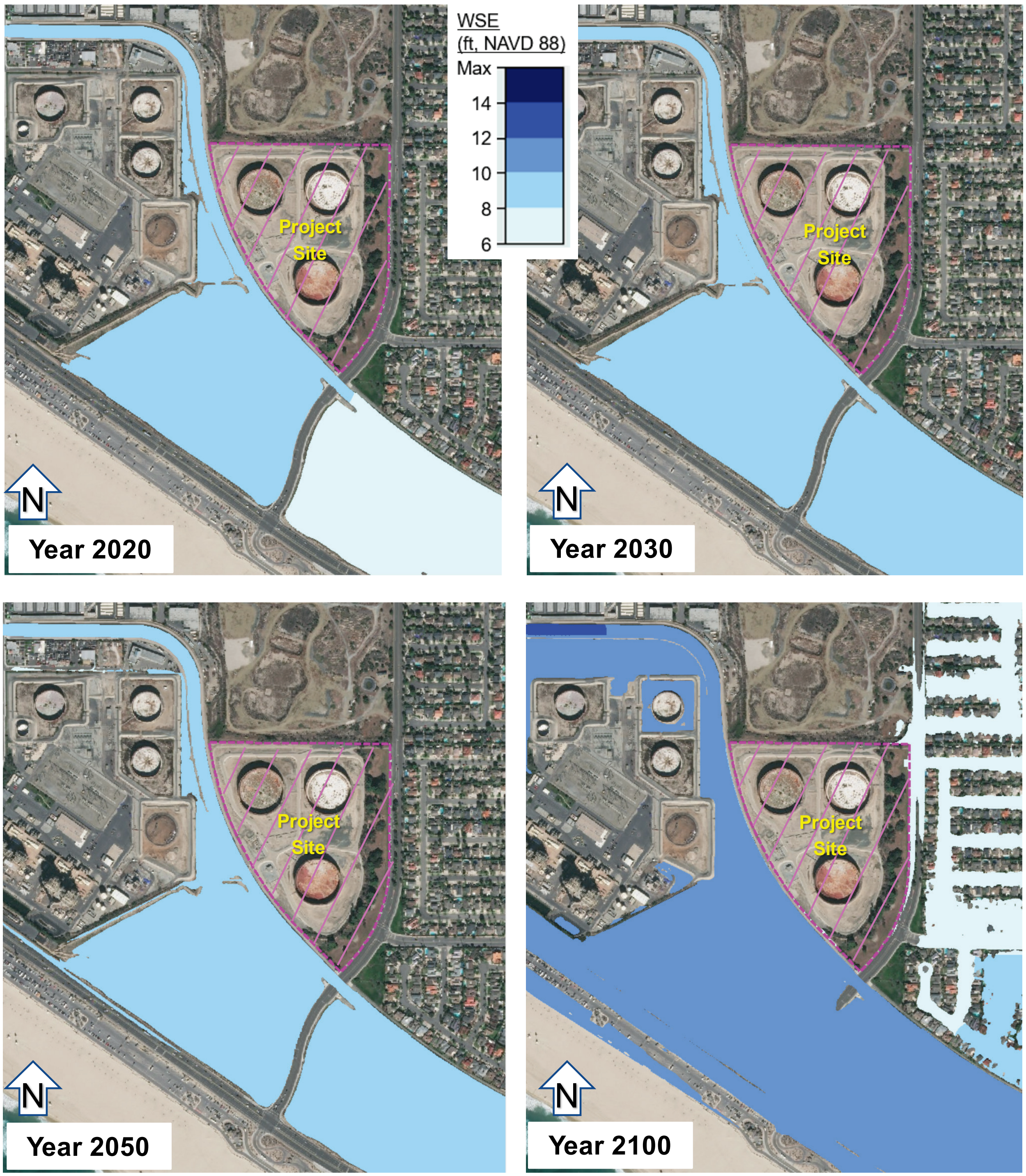


Figure 16

100-Year Flood Maximum Water Surface Elevations Under Current Timeframe (Year 2020 Without SLR) and Future Timeframes (Years 2030, 2050, and 2100 with SLR) for Proposed Condition (With Project)

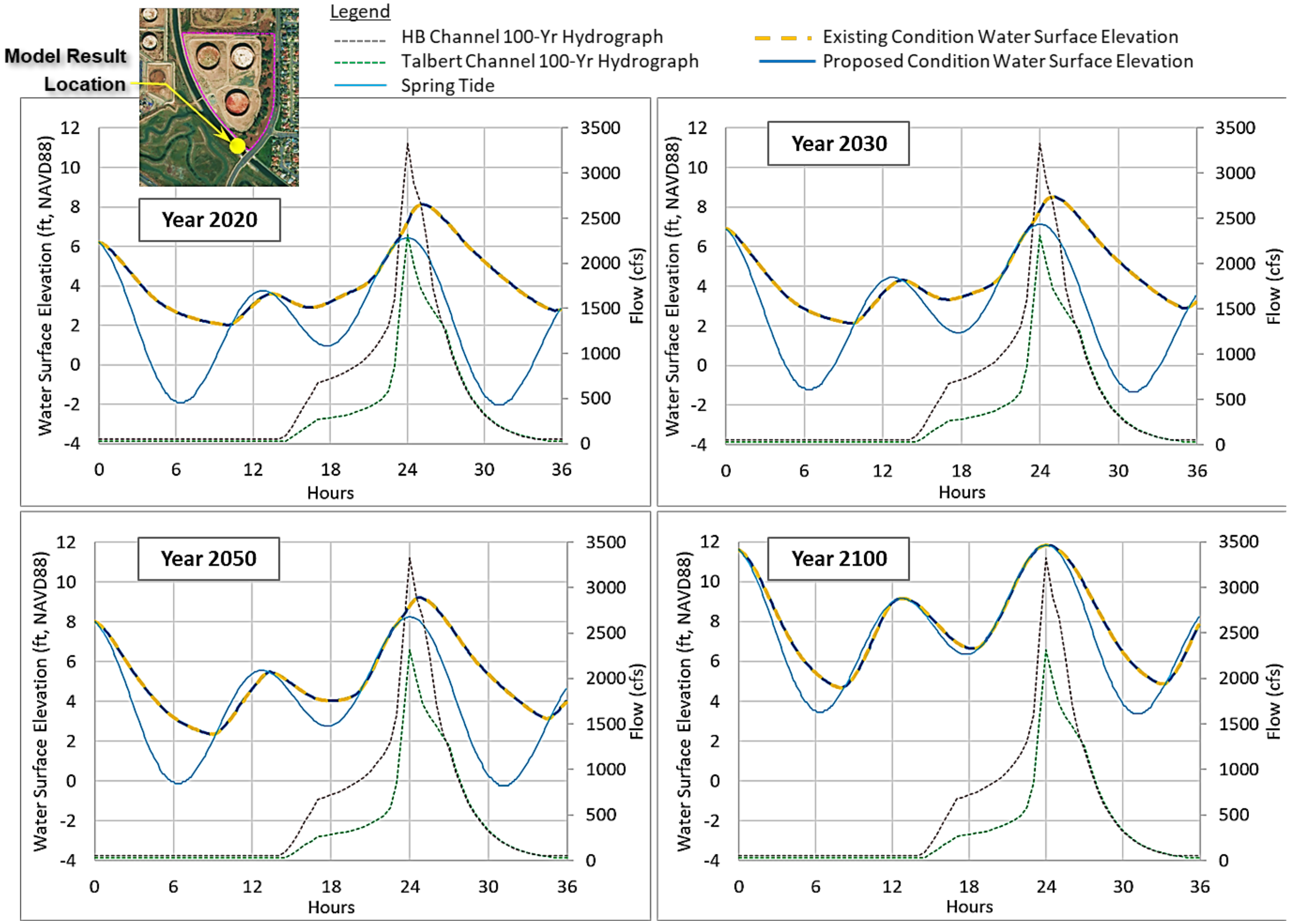


Results Comparison

The results for the Existing Condition (Without Project) and Proposed Condition (With Project) were plotted together to facilitate comparison of the two conditions. This comparison is presented in Figure 17, which depicts the water surface elevation results in four panels presented as time series plots for current conditions (without SLR) in Year 2020 as well as future conditions (with SLR) in Years 2030, 2050, and 2100. In each panel, the results are presented for the Existing Condition (Without Project) and Proposed Condition (With Project). The model input parameters (ocean tide and fluvial hydrographs of the two flood channels) are also plotted to show the peak water surface elevation occurrences relative to the highest tide and peak flow occurrences. The left axis of each graph provides unit readings for the water surface elevation and tide curves, and the right axis provides flow readings for the hydrographs. The results indicate that the maximum water surface elevations for the Existing Condition (Without Project) are visually identical to the maximum water surface elevations for the Proposed Condition (With Project). This pattern is consistent throughout the study period from Year 2020 to Year 2100.

A comparison of the maximum water surface elevation results in Figure 15 for the Existing Condition (Without Project) and Figure 16 for the Proposed Condition (With Project) indicate that there would be no flooding within the project site for current conditions (without SLR) in Year 2020 as well as future conditions (with SLR) in Years 2030 and 2050. In Year 2100 SLR condition, some flooding would occur within the project site for the Existing Condition (Without Project) and Proposed Condition (With Project). Nevertheless, the results show that the extent and magnitude of this flooding would be less under the Proposed Condition (With Project).

Figure 17
Water Surface Elevation Time Series under Current Timeframe (Year 2020 Without SLR) and Future Timeframes (Years 2030, 2050, and 2100 with SLR) for Existing Condition (Without Project) and Proposed Condition (With Project)

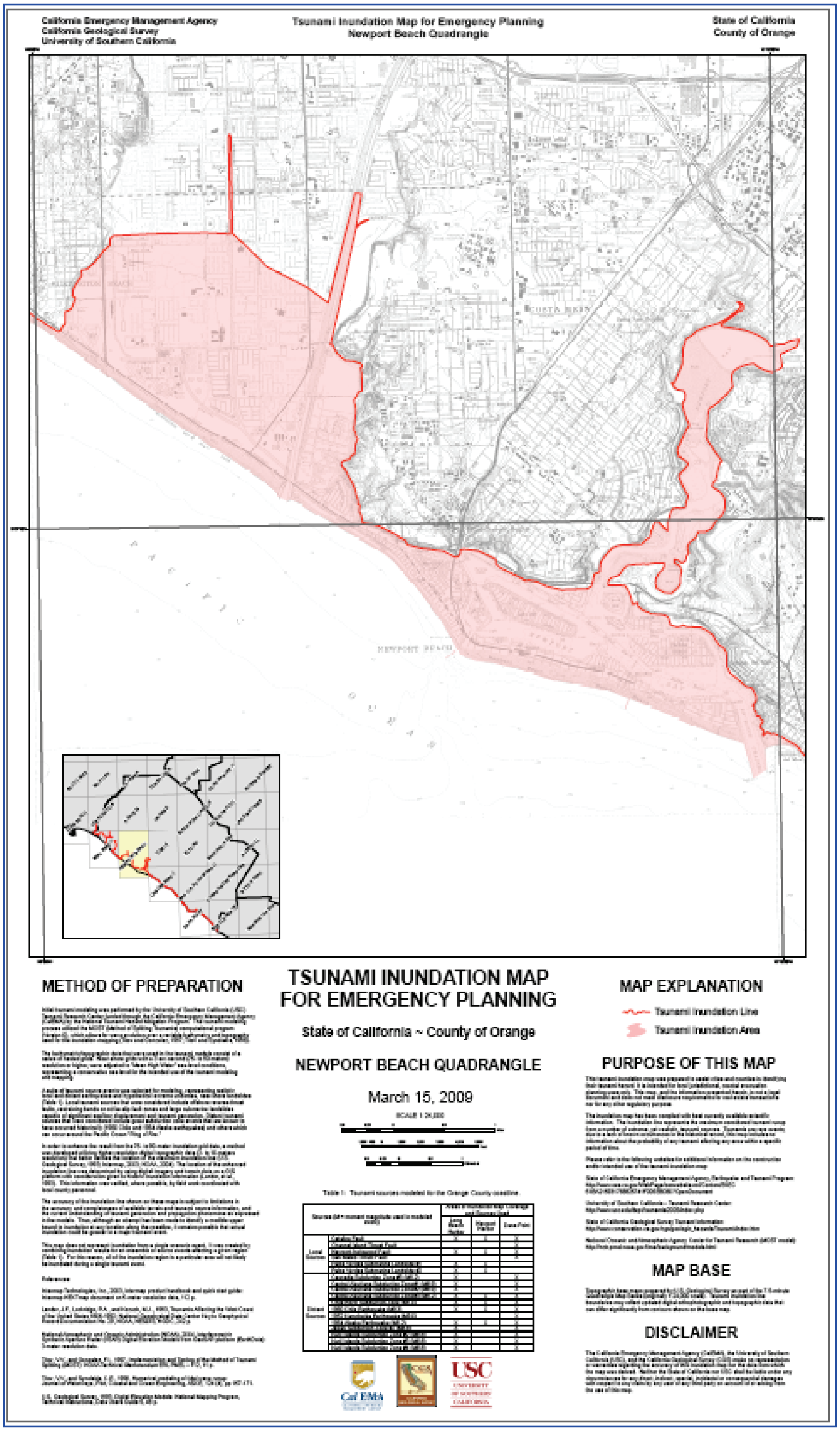


2.6 Tsunamis

To analyze potential coastal hazards associated with tsunamis, the California coastline tsunami inundation maps prepared by the California Emergency Management Agency, California Geological Survey, and University of Southern California were used (http://www.conservation.ca.gov/cgs/Documents/Tsunami/Maps/Tsunami_Inundation_NewportBeach_Quad_Orange.pdf). The downloaded tsunami inundation map (Newport Beach Quadrangle), which was dated March 1, 2009, does not include consideration of SLR, so the map represents inundation under existing (2009) conditions. The tsunami inundation map prepared by the State is shown in Figure 18.

A review of the tsunami inundation map indicates that the entire coast of HB would likely be inundated by a tsunami of the magnitude and duration analyzed in the study. Specific to the proposed project, the results indicate that the project site would be vulnerable to tsunami inundation under existing conditions (i.e., without SLR). As mentioned above, the tsunami hazard mapping analysis conducted by the State did not include an evaluation of tsunami hazards in the future with SLR. However, because the entire project site is in a tsunami hazard area under existing conditions, it is reasonable to assume the entire area would be in a tsunami hazard area in the future with SLR. In addition, the magnitude of inundation would likely be higher in the future for a given tsunami event due to the higher water elevations associated with SLR.

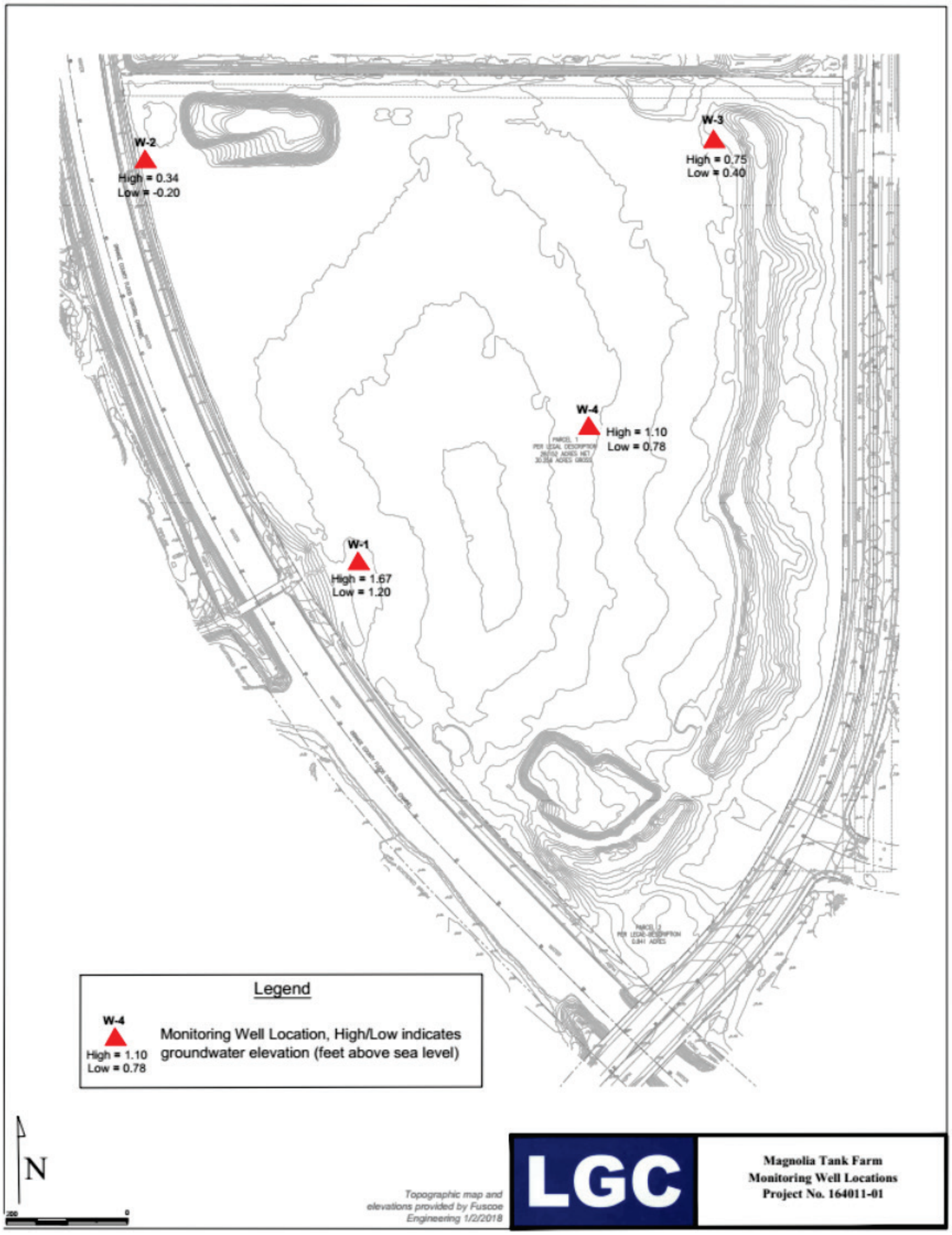
Figure 18
Tsunami Inundation Map – Newport Beach Quadrangle



2.7 Groundwater Increases and Saltwater Intrusion

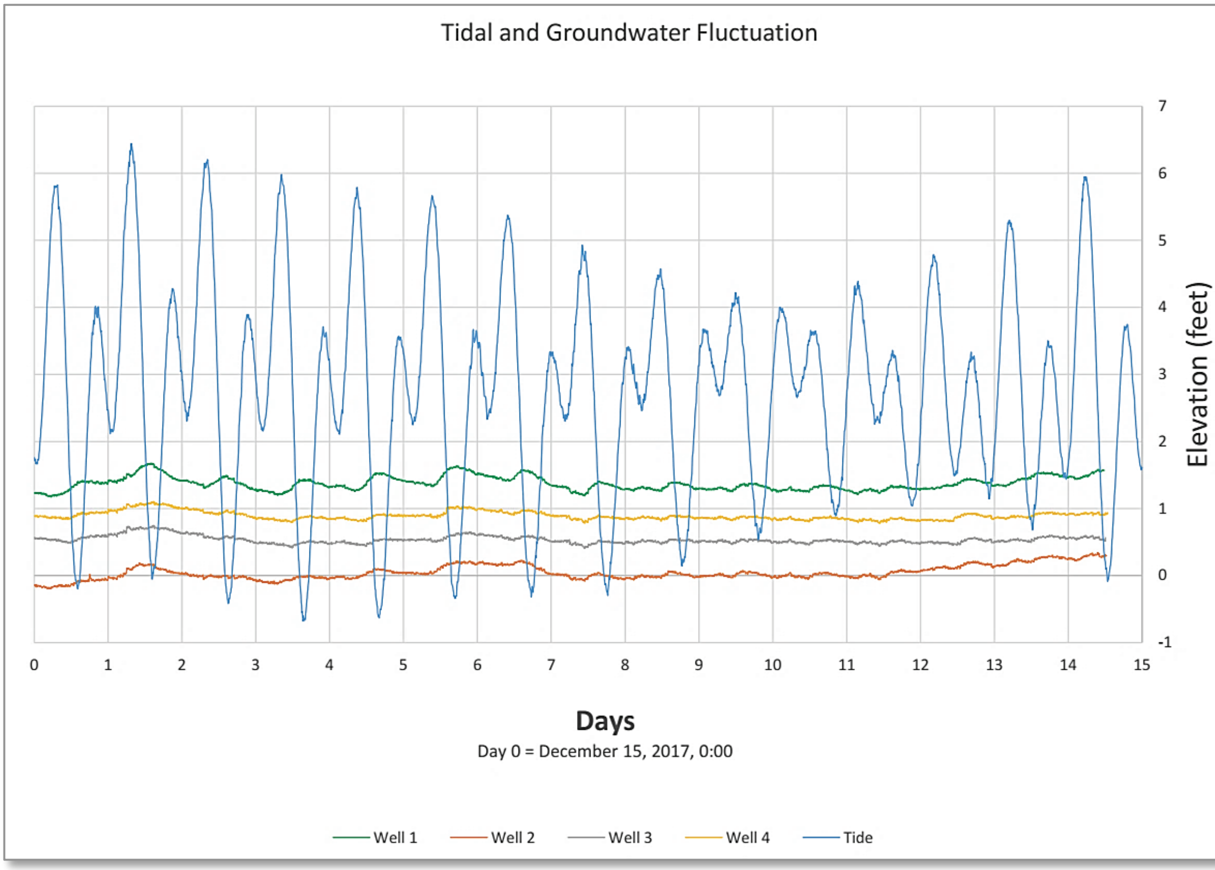
In December 2017, LGC Valley, Inc. (2018a) implemented a groundwater monitoring program across the project site to provide an estimate of the range in groundwater levels during the wet season as well as to determine if the groundwater levels beneath the project site are influenced by tides. This program involved the installation of four monitoring wells across the project site as shown in Figure 19. Groundwater levels were monitored in the four wells over a 2-week period from December 15 to 29, 2017. The groundwater level measurements recorded at each of the four wells are shown in Figure 20, along with the measured ocean tide levels recorded at the nearest NOAA tide gauge station (Los Angeles Outer Harbor). The maximum groundwater levels measured beneath the project site ranged from +0.4 to +1.7 feet NAVD88 across the site during the monitoring period. The highest groundwater levels were measured at Well 1, which was the monitoring well located closest to the HBW. The minimum groundwater levels measured beneath the project site ranged from -0.2 to +1.2 feet NAVD88 across the site during the monitoring period. The lowest groundwater levels were measured at Well 3, which was the monitoring well located farthest from the HBW. In general, groundwater levels decreased with distance from the HBW. The minimum and maximum groundwater levels measured beneath the project site during the monitoring period were -0.2 and +1.7 feet NAVD. The results also revealed that the groundwater levels are tidally influenced as indicated by the groundwater level oscillations that roughly match the frequency of the ocean tide oscillations, albeit with a small delay in timing and large reduction in magnitude.

Figure 19
Magnolia Tank Farm Groundwater Monitoring Well Locations



Source: LGC Valley, Inc. 2018a

Figure 20
Groundwater Monitoring Well Water Elevation Measurements in Feet NAVD88



Source: LGC Valley, Inc. 2018a

At locations such as the project site, where groundwater levels are tidally influenced, it is expected that groundwater levels would be impacted by rising sea levels; hence, such areas would be vulnerable to SLR. There are many factors that affect how much and how fast groundwater levels at a given location would change with increasing sea level. Groundwater modeling under existing and future conditions (with SLR) would provide the most accurate estimate of the groundwater level response to SLR; however, such modeling would likely need to extend beyond the project area to capture the full area that would be affected by SLR. The development and application of a regional groundwater model would be appropriate for such an analysis; however, the scale of the MTF project and this project-specific SLR VAAP do not require a regional groundwater modeling effort. A simple method was employed to estimate the increases in groundwater levels associated with increases in sea level. For this simple method, it was assumed that groundwater levels at the project site would increase directly with increases in sea level (e.g., a 1-foot SLR would increase groundwater levels by 1 foot). Consequently, the SLR projections associated with the low-risk-aversion scenario were added to the range in groundwater levels measured at the project site in December 2017. The results, presented in Table 5, show the estimated ranges in groundwater levels across the site for the low-risk-aversion SLR projections presented in Table 2. These values should be considered first-order estimates because the actual groundwater levels could vary with SLR depending on how the level of hydraulic connectivity between the ocean, wetlands, and groundwater would change with SLR.

To support conceptual design at this time, a conservative approach is suggested, whereby it is assumed that the groundwater level at the project site under existing conditions is equal to the ocean mean sea level (i.e., +2.6 feet NAVD88). Even though the measured groundwater levels are substantially lower, this assumption allows for the possibility that the levels would be higher if the measurements were conducted over a longer period, thereby capturing the effects of factors (e.g., less pumping, increased rainfall, and high ocean water levels due to sea level anomalies such as El Niño) that might significantly increase groundwater levels compared to the levels measured during the monitoring period (December 15 to 29, 2017). The corresponding groundwater levels in the future with SLR would be +4.4, +4.8, and +8.0 feet NAVD in Years 2050, 2060, and 2100, respectively. These values are presented in Table 5. If the accuracy of groundwater levels in the future with SLR is important for final design, then a more rigorous analysis would be conducted at that time to support the engineering analyses.

Table 5
Potential Groundwater Levels in the Future with the Medium-High-Risk-Aversion SLR Projections

Time Period*	Based on Measured Data (feet NAVD88)	Based on Assumed Ocean Mean Sea Level (feet NAVD88)
By 2030	+0.5 to +2.4	+2.6
By 2050	+1.6 to +3.5	+4.4
By 2060	+2.0 to +3.9	+4.8
By 2100	+5.2 to +7.1	+8.0

Note:
*Baseline is Year 2000.

No conductivity, salinity, or total dissolved solids (TDS) measurements of the groundwater under the project site were available; however, measured data were found for the ASCON landfill site located immediately adjacent to the project site on the northern border. Monitoring conducted at the ASCON landfill site by Geosyntec Consultants in 2004 found TDS levels ranging from 4,600 to 26,000 milligrams per liter (Geosyntec Consultants 2007), which would indicate a water quality (salinity) of brackish to saline according to the Water Quality Association designations. Given the close proximity to the project site, it is reasonable to assume that these values were representative of the groundwater quality under the project site in 2004. It is also reasonable to assume that the TDS has not changed substantially between 2004 and 2017, given that the only major change at or near the area since 2004 was the restoration of the HBW which would tend to increase salinity through increased exposure to ocean water. Although the project site is vulnerable to saltwater intrusion associated with SLR, this vulnerability poses no risk to the water quality of this groundwater resource in terms of water use. From an engineering and landscaping standpoint, saline groundwater can pose a challenge due to corrosion and plant survival if the proposed structural elements and plants are close enough to the groundwater to be impacted. These potential vulnerabilities are addressed under the SLR adaptation plan (Section 3).

2.8 Geologic Stability

Potential hazards related to geologic stability, such as landslides, slope failure, liquefiable soils, lateral spreading, and seismic activity, need to be considered in site selection, site preparation, and project design. An evaluation of potential hazards related to geologic stability was conducted by the project geologist and project geotechnical engineer, LGC Valley, Inc. The purpose, methods, results, and conclusions of that work are presented in the geotechnical investigation (LGC Valley, Inc. 2018b).

2.9 Summary

The results of the SLR vulnerability assessment are summarized in Table 6. The results revealed that the project site would not be vulnerable to coastal erosion or tidal inundation between now and Year 2100. The project site would not be vulnerable to coastal wave storm flooding or fluvial flooding between now and Year 2060. By Year 2100, the project site would not be vulnerable to coastal wave storm flooding, but it would be vulnerable to fluvial flooding. However, the fluvial flooding vulnerability would be less under the Proposed Condition (With Project) than under the Existing Condition (Without Project). Consequently, implementation of the MTF Redevelopment Project would not increase coastal hazards associated with fluvial flooding now or in the future with SLR. The project site is vulnerable to tsunamis now and would continue to be vulnerable through Year 2100. Finally, the project site would be vulnerable to uplift/buoyancy impacts related to groundwater level increases associated with SLR as well as impacts to corrosion and plant survival related to increases in groundwater salinity. SLR adaptation measures are presented in Section 3 to address SLR vulnerabilities identified in Section 2.

Table 6
SLR Coastal Hazards Vulnerability Assessment Summary

Time Period[1]	Coastal Erosion	Tidal Inundation	Coastal Wave Storm	Fluvial Flooding	Tsunami
Existing Conditions	No	No	No	No	Yes
By 2030	No	No	No	No	Yes
By 2060	No	No	No	No	Yes
By 2100	No	No	Possible[2]	Yes[3]	Yes

Notes:

1. Baseline is Year 2000.
2. CoSMoS results indicate vulnerability; however, the model did not include the existing floodwall, which would eliminate or reduce vulnerability.
3. Vulnerability is less with implementation of the Project.

3 Sea Level Rise Adaptation Plan

3.1 Overview

As summarized in Table 6, the results of the SLR vulnerability assessment indicate that the project site would potentially be vulnerable to some coastal hazards now and in the future with SLR. Adaptation measures are needed to address these SLR vulnerabilities that would occur over different time periods. The formulation of adaptation measures is presented below, using the recommended guidance presented in the 2015 CCC SLR Policy Guidance.

3.2 Design Constraint Assessment

There are no known design constraints related to SLR adaptation measure development for the project site. The lot size and existing ground slopes do not limit future construction and maintenance of adaptation measures. No environmentally sensitive habitat areas (ESHAs) or wetlands exist within the project site now that would limit such activities, and no ESHAs or wetlands are anticipated in the future. Finally, there are no geologic stability or seismic issues that would pose any design constraints for SLR adaptation measures within the project site.

3.3 Adaptation Measures and Project Modifications

The floodwall provides protection for the project site from coastal hazards associated with high tides, coastal wave storms, and fluvial flooding under Existing Conditions (Without Project). The floodwall is part of a flood control system (HB Channel and Talbert Channel) that provides flood protection for a large part of the City. Some of the area protected by this system is characterized by low ground elevations that would be subject to flooding in the absence of the flood control system. This flood control system is important from a regional (i.e., portion of city) as well as a local (i.e., project site and surrounding area) standpoint. Consequently, an adaptation strategy focused on protection has been pursued for this region over the past 50 years to address past and current coastal hazards associated with high tides, coastal wave storms, and fluvial flooding. Coastal hazard vulnerability associated with tsunamis was and is an unmitigated risk associated with the local area and region.

In the future, as sea level rises, low-lying residential neighborhoods surrounding the project site would be vulnerable to coastal hazards (coastal wave storms and fluvial flooding) sooner than the Project under different risk aversion SLR scenarios. The City is planning to prepare an updated Local Coastal Program (LCP) in the future, and it is anticipated that an updated SLR VAAP would be prepared for the entire City at that time to support the LCP update. Given the relatively large amount of infrastructure and structures protected by the existing flood control system that would be vulnerable to future SLR, it is anticipated that the City would continue to pursue an adaptation strategy focused on protection, at least for the near future (e.g., now through Year 2060) when SLR is not expected to result in extensive vulnerability. Beyond Year 2060, the City may choose to pursue an adaptation strategy involving a hybrid mixture of protection, accommodation, and retreat (e.g., relocate or remove existing structures, and new development limitations). Given this background, several specific adaptation measures were developed for the Project. These measures are presented below with consideration given to the time period and risk aversion level of each SLR scenario.

The overall ground elevation of the project site would be raised by about 2.5 feet to an average ground elevation of +10.5 feet NAVD88. This adaptation measure would address the vulnerability of project components to increased groundwater elevations that could impact structural stability (e.g., foundation buoyancy/uplift) and increased saltwater exposure that could lead to structural component oxidation (e.g., rebar rusting). This adaptation measure would also address the vulnerability of project landscaping (plants) to brackish water or saline water. In addition, raising the ground elevation would reduce the depth of flooding that would occur if the floodwall were overtopped. The building pads would be raised an additional 1 to 2 feet above the elevation of the roads within the interior of the project site. This adaptation measure would provide additional flood protection to the residential properties in the event of floodwall overtopping.

Drainage of local on-site stormwater runoff (i.e., runoff from the project site) is another coastal hazard that needs to be addressed now and in the future with SLR. Existing low-lying areas within the City rely on channel and pipe systems to collect and route runoff to pump stations where the runoff is then pumped to nearby flood control channels such as the HB Channel and Talbert Channel. The Project would feature a similar system to address such local flooding now and in the future with SLR. Under the Project, all project site runoff would be collected and drain via gravity into the HB Channel. Each outlet into the HB Channel would be fitted with a tide gate to prevent flows in the channel from entering the project site storm drain system. During rain events, the hydraulic head from the runoff in the storm drain would exceed the pressure on the other side of the tide gate and runoff would enter the HB Channel.

As sea level rises, the height of the water level in the HB Channel may ultimately prohibit project site runoff from entering the HB Channel via gravity. This would be evidenced by more localized flooding during rain events and longer durations for on-site stormwater to drain after a rain event. To address this future potential drainage condition, the project would include manholes near the HB Channel to allow for pumps to be retrofitted into the storm drain to provide the necessary pressure to drain the project site during storm events in the future. It is anticipated that the pumps would be required between Years 2060 and 2100.

Another SLR adaptation measure would be future improvement of the HB Channel, including floodwall elevation increases and/or upstream flow reductions to reduce flood elevations throughout the region and at the project site. It is anticipated that the City would support future efforts spearheaded by Orange County to develop and implement a comprehensive flood protection strategy for the region and local area. This strategy would likely either address all SLR vulnerability out to Year 2100 or address SLR vulnerability out to Year 2060 with other adaptation measures coming into play during later years. Because this is a regional as well as local hazard, it seems most appropriate that it be addressed via a regional solution. That said, it is understood that the timing for implementation of a regional solution is uncertain, so there is a temporal risk of SLR vulnerability that increases with time until such a solution (i.e., adaptation measure) is implemented.

To address this temporal risk, an adaptation measure was developed to address the SLR vulnerability risk associated with coastal wave storms and fluvial flooding that might occur before a regional flood strategy is implemented at some time in the future. The open space buffer located along the floodwall would remain open space with native upland habitat and limited human access. The area would be managed to preclude the establishment of sensitive habitats (e.g., ESHAs and wetlands) such that the area could be used for future implementation of SLR adaptation measures aimed at protecting the site. The elevation along this area could be raised in the future to provide protection from coastal wave storm and fluvial floods. This could be done by importing soil to raise the ground elevation across the area to create a protective berm that would then be covered with native plants and, possibly, a trail system. Alternatively, the elevation could be increased via construction of a permanent or temporary floodwall located on the side of the open space buffer closest to the HB Channel. The temporary floodwall would consist of elements that would be deployed in advance of storm conditions expected to cause flooding and then removed (e.g., wall lowered or equipment stored) following passage of the storm. These adaptation measures are currently used throughout the United States, so this adaptation measure is feasible from an engineering and construction standpoint. This adaptation measure would not be implemented as part of the initial construction (i.e., Year 2026) but, rather, in future years if and when it is needed. Implementation of this adaptation measure now could result in changes to flood elevations for the surrounding area that could negatively impact flood risk for those areas. Consequently, if this adaptation is ultimately needed, it should be implemented in the future when it is required to provide protection to the project site.

4 Conclusions

An SLR vulnerability assessment was conducted for the MTF Redevelopment Project. The results of the SLR vulnerability assessment revealed that the project site would be subject to some coastal hazards now and in the future as sea level rises. Under existing conditions, the project site is vulnerable to tsunamis and, like other locations throughout coastal HB, would likely continue to be vulnerable to tsunamis in the future as sea level rises. The results of the SLR vulnerability assessment revealed that the project site would not be vulnerable to coastal erosion between now and Year 2100 due primarily to the distance between the project site and Pacific Ocean. In addition, the results of the SLR vulnerability assessment revealed that the project site would not be vulnerable to tidal inundation (high tide flooding in the absence of storm conditions) between now and Year 2100. The results revealed that the project site would not be vulnerable to coastal wave storms in Year 2100, but the results indicated that the project would be vulnerable to fluvial flooding in that year. That said, comparison of the results for the Existing Condition (Without Project) and Proposed Condition (With Project) revealed that the project would not have any measurable impact on fluvial flood levels both now (Year 2020) and in the future with SLR (Years 2030, 2050, and 2100). Based on these results, it is concluded that implementation of the MTF Redevelopment Project would not increase coastal hazards associated with fluvial flooding now or in the future with SLR.

An SLR adaptation plan was developed to address the vulnerability to coastal wave storms and fluvial flooding that would be expected to start occurring in Year 2060. The SLR adaptation plan involves several components that would be implemented at different points in time. As part of the initial project construction, the overall ground elevation would be increased and the pad elevations of the residential structures would be raised to provide protection from flood waters that might enter the project site. The project would allocate space for future SLR adaptation measures that might be implemented as a local SLR adaptation project (property owners and City) and/or regional flood control project (e.g., Orange County). With implementation of these SLR adaptation measures, the project would achieve and maintain an acceptable level of risk related to coastal hazards from the time construction is complete (Year 2026) through Year 2100.

5 References

CCC (California Coastal Commission), 2015. *California Coastal Commission Sea Level Rise Policy Guidance, Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits*. Unanimously Adopted August 12, 2015.

CNRA and OPC (California Natural Resources Agency and California Ocean Protection Council), 2018. *State of California Sea-Level Rise Guidance: 2018 Update*. Approved by Ocean Protection Council on March 14, 2018.

Erikson, L.H., 2017. Regarding: CoSMoS 3.0 Question. Email to: David Cannon (Everest) . October 5, 2017.

Erikson, L.H., P.L. Barnard, A.C. O'Neill, S. Vitousek, P. Limber, A.C. Foxgrover, L.H. Herdman, and J. Warrick, 2017. *CoSMoS 3.0 Phase 2 Southern California Bight: Summary of Data and Methods*. U.S. Geological Survey. Available at: http://dx.doi.org/10.5066/F7T151Q4.

FEMA (Federal Emergency Management Agency), 2016. Flood Insurance Rate Map, Orange County, California and Incorporated Areas. National Flood Insurance Program. August 2016.

FEI (Fuscoe Engineering, Inc.), 2017. AutoCAD files with root drawing file named, "X1293-007-SV.dwg" transmitted by Fuscoe Engineering Inc. to Everest on August 22, 2017.

FEI, 2018. AutoCAD files with root drawing file named, "1293-007xh-Mass Grading Exhibit-SP with Int St-EX TOPO.dwg" transmitted by Fuscoe Engineering Inc. to Everest on June 19, 2018.

Geosyntec Consultants, 2007. *Groundwater Remedial Investigation Report (Revision 1.0) ASCON Landfill Site, Huntington Beach, California*. Prepared for ASCON Site Responsible Parties. Project No. SB0320. June 14, 2007.

Griggs, G., J. Arvai, D. Cayan, R. DeConto, J. Fox, H.A. Fricker, R.E. Kopp, C. Tebaldi, and E.A. Whiteman, 2017. *Rising Seas in California: An Update on Sea-Level Rise Science*. Prepared by the California Ocean Protection Council Science Advisory Team Working Group. April 2017.

LGC Valley, Inc., 2018a. *Groundwater Investigation at 21845 Magnolia Street within the City of Huntington Beach, California*. Prepared for SLF-HB Magnolia, LLC. Project No. 164011-01. January 17, 2018.

LGC Valley, Inc., 2018b. *Revised Geotechnical Study for the Preparation of an Environmental Impact Report for the Proposed Development Located at 21845 Magnolia Street within the City of Huntington Beach, California*. Prepared for SLF-HB Magnolia, LLC. Project No. 164011-01. February 23, 2018.

Moffatt & Nichol, 2004. *Hydrologic and Hydraulic Baseline Report.* Prepared for Huntington Beach Wetlands Conservancy. August 18, 2004.

Moffatt & Nichol, 2014. *Sea-Level Rise Vulnerability Assessment Methods and Results for the Shoreline Planning Areas.* Prepared for the City of Huntington Beach. December 2014.

NOAA (National Oceanic and Atmospheric Administration), 2018a. National Ocean Service Center for Operational Oceanographic Products and Services. Data for December 3 and 4, 2017. Accessed June 2018. Available at: https://tidesandcurrents.noaa.gov/waterlevels.html?id=9410660.

NOAA, 2018b. Data Access Viewer. Accessed June 2018. Available at: https://www.coast.noaa.gov/dataviewer/#/lidar/.

NRC (National Research Council), 2012. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*. Washington, DC: National Academies Press.

USACE (U.S. Army Corps of Engineers), 2016. *HEC-RAS River Analysis System 2D Modeling User's Manual.* Version 5.0. U.S. Army Corps of Engineers, Hydrologic Engineering Center. February 2016.