COASTAL HAZARDS ANALYSIS
NEWPORT BEACH JUNIOR LIFEGUARD BUILDING
NEWPORT BEACH, CALIFORNIA

Prepared for
JEFF KATZ ARCHITECTURE
San Diego, California

Prepared by
TERRACOSTA CONSULTING GROUP, INC.
San Diego, California

Project No. 3134
November 9, 2020

TerraCosta Consulting Group

Geotechnical Engineering
Coastal Engineering
Maritime Engineering

Project No. 3134
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Mr. Jeff Katz
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San Diego, California 92120

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NEWPORT BEACH JUNIOR LIFEGUARD BUILDING
NEWPORT BEACH, CALIFORNIA

Dear Mr. Katz:

In accordance with your request, TerraCosta Consulting Group, Inc. (TerraCosta) has completed studies evaluating the coastal processes in the area of the Newport Beach Junior Lifeguard Building Project in Newport Beach, California.

The accompanying report describes our findings pertaining to the general coastal processes in the site vicinity, and our conclusions and recommendations for mitigating the potential for wave-induced scour at the project site.

We appreciate the opportunity to be of service and trust this information meets your needs. If you have any questions or require additional information, please give us a call.

Very truly yours,

TERRACOSTA CONSULTING GROUP, INC.

____
Walter F. Crampton, Principal Engineer
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TABLE OF CONTENTS

COASTAL HAZARDS ANALYSIS
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1 INTRODUCTION AND PROJECT DESCRIPTION

TerraCosta Consulting Group, Inc. (TerraCosta) has performed a coastal hazard analysis for the development of the Junior Lifeguard Building proposed to be located off of A Street southerly of Oceanfront East in Newport Beach, California, as shown in Figure 1. The proposed facility is to be constructed within the approximate footprint of the existing public parking lot east of the Balboa Pier and south of the Newport Balboa Bike Trail within Peninsula Park. As we understand, the proposed project will consist of a 7310 square foot, one-story, steel-framed building, with ancillary concrete flatwork and paved parking areas designed to support the new facility. The overall project layout is shown on the Architectural Schematic Design, Figure 2.

This report presents the results of our evaluation of the coastal processes in the site vicinity as they relate to the proposed project.

2 GENERAL SITE CONDITIONS

2.1 Existing Improvements

The project site is situated on the southerly, seaward side of a naturally-formed coastal bar (or “barrier”) of the type formed by a transgressive sea and littoral currents at the seaward edge of a stream delta or lagoon. The study area is bounded by a recreational sport field to the east; an asphalt parking lot to the north; a grassy park area and asphalt parking lot to the west; and a sandy beach with existing portable lifeguard facilities to the south.

2.2 Site Topography and Bathymetry

Elevations across the site range from approximately 12.1 feet at the northerly parking lot entrance/exit intersecting the Newport Balboa Bike Trail, ascending to approximately 14.8 feet near the westerly end of the parking lot at Balboa Pier. The sandy back beach area to the south, near the existing lifeguard facilities, is approximately 12.3 feet.

3 COASTAL HAZARDS

3.1 Shoreline Erosion

In evaluating the wave climate, which controls coastal erosion, considerable hindcast data is available to provide an indication of future trends and, hence, design criteria for design of coastal structures. Wave energy approaching the southern California coastline has been relatively benign during the first 80 years of the 20th Century (Seymour, et al., 1984). Extreme deep-water wave episodes exceeding 6 meters were reported on only eight occasions during the period 1900 to 1979, while the period from February 1980 through February 1984 experienced a total of ten storm events with deep-water waves exceeding 6 meters. It should be noted that the storm of January 17, 1987, produced the highest measured deep-water waves of record approaching the southern California coast since deployment of deep-water wave gauges by Scripps Institution of Oceanography, further corroborating a more energetic wave environment.

Continued coastal erosion, in part accelerated by more energetic wave activity during the last 40 years, has subjected the site vicinity to a progressively more severe wave environment than that experienced during the preceding 50+ years, suggesting more frequent severe winters and the likelihood for more severe coastal storm damage during the design life of the proposed structure.

3.2 Wave Climate and Water Levels

Waves provide nearly all of the energy input that drives shoreline processes along the California coast. As illustrated in Figure 3, incoming waves along the southern California coast fall into three main categories: Longer period northern and southern hemisphere swell, and locally generated short-period seas. North hemisphere swell from the North Pacific

Ocean dominate the winter wave conditions off California, while southern hemisphere swell is more important in the summer. Short-period seas are produced by storms sweeping through the area. The offshore islands, shallow banks, submarine canyons and generally complex bathymetry of southern California greatly complicate the wave climate at the coast.

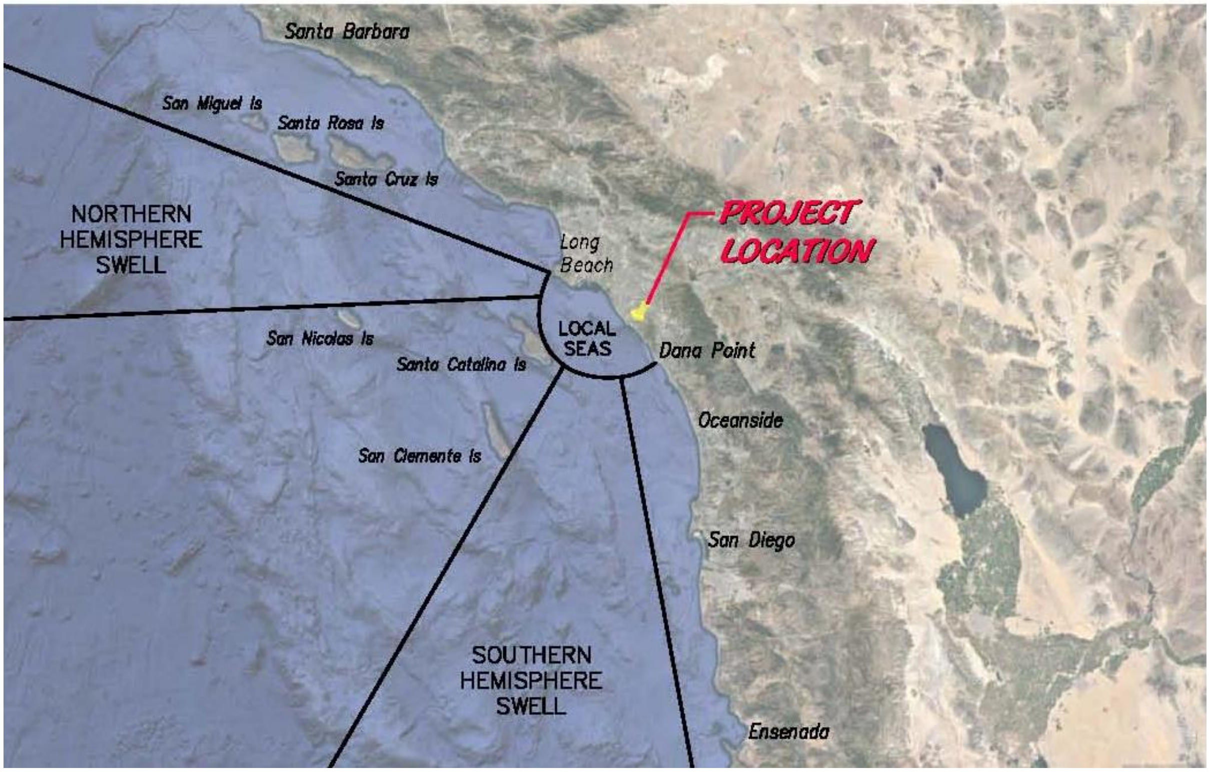


Figure 3. Map showing generalized wave exposure for Newport Beach, California.

Coastal orientation, and the islands and banks greatly influence the swell propagating toward shore by partially sheltering southern California, especially from northern hemisphere swell. Because of the complicated effects of bathymetry and island shadowing, the wave height at the shoreline is sensitive to relatively small changes in the incoming direction of the deep ocean waves.

While waves along the Orange County shoreline generally range in height from 1.5 to 3 feet, and typically from the west, deep water waves off the coast have been recorded with deep water significant wave heights reaching 33.5 feet (March 1, 1983) (City of Huntington Beach, 2014).

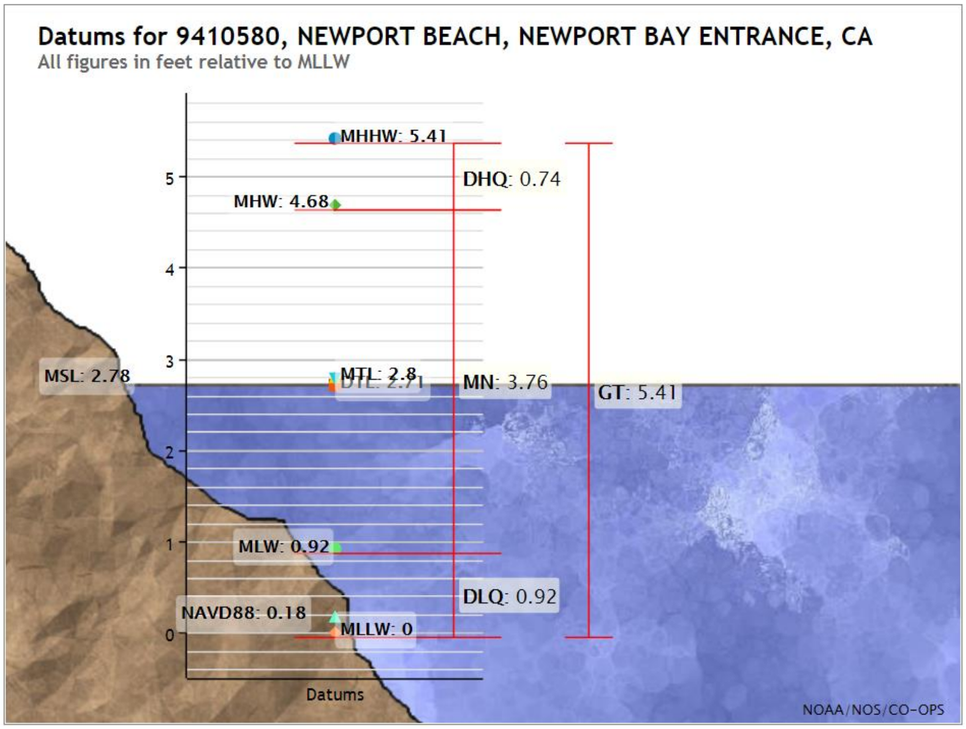
The Newport Beach tide gauge (NOAA #9410580) tidal datum provides the contemporary tidal information for this area of the coastline, reproduced below in Table 1 and illustrated in Figure 4.

Table 1. Tidal Datums (Station 9410580, 1983-2001 Tidal Epoch)

Description	Datum	Elevation (feet, MLLW)
Highest Observed Tide (1/28/1983)	Max Tide	7.67
Highest Astronomical Tide	HAT	7.18
Mean Higher-High Water	MHHW	5.41
Mean High Water	MHW	4.68
Mean Tide Level	MTL	2.80
Mean Sea Level	MSL	2.78
Mean Sea Level	NGVD 29	2.53
Mean Diurnal Tide Level	DTL	2.71
Mean Low Water	MLW	0.92
North American Vertical Datum of 1988	NAVD 88	0.18
Mean Lower-Low Water	MLLW	0.00
Lowest Astronomical Tide	LAT	-1.92
Lowest Observed Tide (1/20/1988)	Min Tide	-2.35
Station Datum	STND	-3.33
Great Diurnal Range	GT	5.41
Mean Range of Tide	MN	3.76

(*Source: NOAA 2020*)

Tide gauges measure total water level outside the breaker zone, which includes contributions from the tide, as well as storm surges and other factors that raise sea level over the short and long term, including the effects of El Niño. Waves produced by tsunamis, both from local sources and distant sources, may produce significant waves, causing localized flooding.



Tidal and geodetic datum relationships for the latest (1983-2001) tidal epoch at Los Angeles.
These are applicable to the open-coast of the Los Angeles/Orange County region.

Figure 4. Sea Level Datums

4 FEMA MAPPING

We conducted a review of the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for the study area (Figures 5A and 5B). The proposed project falls within a VE Zone (Coastal High Hazard Area), having a base flood elevation (BFE) of 21 feet NAVD 88. Notably, to qualify for FEMA's flood insurance, flood protection is required up to an elevation of 2 feet above the BFE or up to 23 feet, or about 9 feet above existing grade.

5 COASTAL FLOOD AND EROSION HAZARD MAPPING

The Pacific Institute has developed coastal flood and erosion hazard zone maps addressing the impacts of sea level rise on the California coast by the year 2100 under funding by the California Energy Commission, the California Department of Transportation, and the Ocean Protection Counsel. The Impacts of Sea Level Rise on the California Coast report (Pacific

Institute, 2009) concludes that sea level rise will inevitably change the character of the California coast and that adaptation strategies must be evaluated, tested, and implemented if the risks defined in the impacts of sea level rise on the California coast report are to be reduced or avoided. Populations and critical infrastructure at risk are shown on detailed maps prepared by the Pacific Institute. A close-up portion of the coastal flood hazard map for the Newport Beach Quadrangle projected out to the year 2100 is shown on Figure 6, with the study area entirely inundated under the current 100-year base flood and seaward of the erosion high hazard zone in 2100. If the viewer is interested in examining the Pacific Institute's map in more detail, this map can be viewed and enlarged at: http://www2.pacinst.org/reports/sea_level_rise/hazmaps.html.

5.1 **Tsunamis**

As the site lies on the coast, it is our opinion that the risk associated with tsunamis is the same as all projects located along the shoreline of the City of Newport Beach. Studies performed by Legg, Borrero, and Synolakis (2004) suggest that this area of the coastline may be affected by both earthquake- and subaqueous landslide-generated tsunamis with wave heights of 2+ meters and wave runup of 4+ meters. As such, the site may be affected by a tsunami under certain critical conditions. As we understand, the City of Newport Beach already has a tsunami contingency plan and evacuation routes in place.

The University of Southern California Tsunami Research Center, funded through the California Emergency Management Agency, has developed tsunami inundation maps for emergency planning for the entire state of California. The tsunami inundation map for the Newport Beach quadrangle is shown on Figure 7A, with an enlargement showing the study area provided on Figure 7B, along with an enlargement of the map text provided on Figure 7C describing the methodology and data sources used in the model. Although the tsunami inundation map provides almost no detailed information on the inundation area along the shoreline, Figure 7A indicates an extensive inundation of the peninsula, including the proposed lifeguard facility. While exact inundation elevations are not available through the University of Southern California Tsunami Research Center, tsunami inundation elevations can be approximated by comparing actual ground surface elevations along the tsunami inundation limits in the vicinity of Newport Beach, with an estimated inundation elevation, using this admittedly somewhat crude approach, being on the order of 12 to 18 feet NGVD29.

5.2 Sea Level Rise

Past and possible future changes in mean sea level (MSL) are of interest in design and planning for all coastal cities, as well as for any engineering activities on the coast. Figure 8 shows the time history of maximum monthly sea level observed at the La Jolla tide gauge from 1924 to 2011. These data are routinely tabulated by the National Oceanic and Atmospheric Administration (NOAA) as part of their national tide gaging program (Flick *et al.*, 2003). Peak observed values (relative to NAVD 88) are 7.56 feet (January 2005) and 7.55 feet (November 1997).

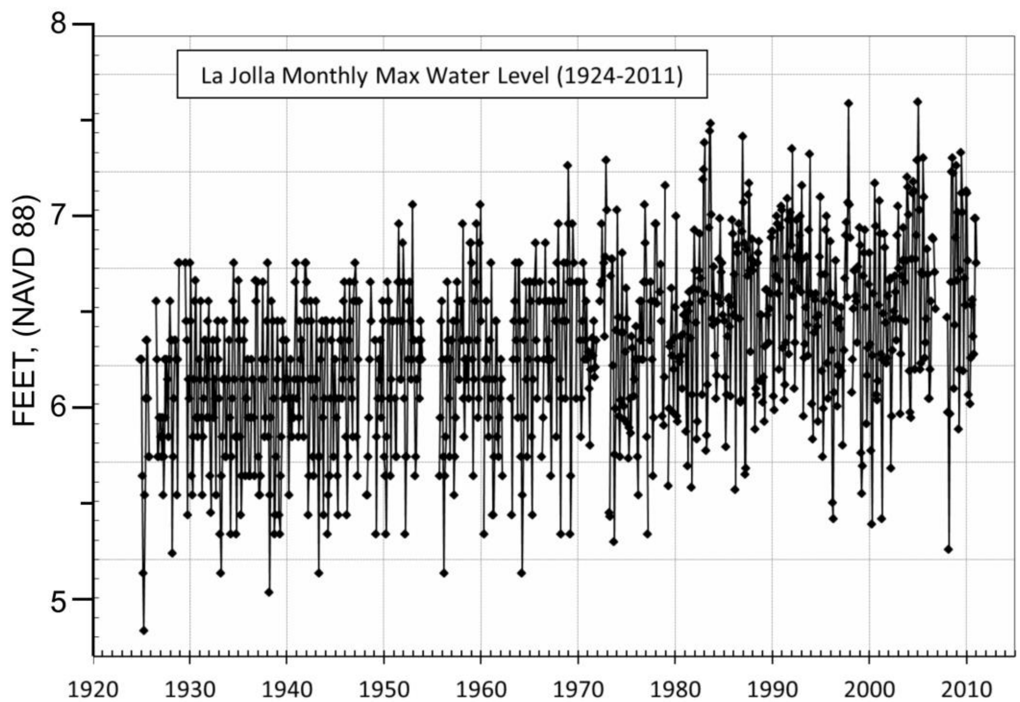


Figure 8. Time history of maximum monthly sea level observed at the La Jolla tide gauge 1924-2011.

Global mean sea level rose at least 300 feet, and perhaps as much as 400 feet, during the past 18,000 years or so (CLIMAP, 1976). Sea level, both globally and along California, rose approximately 0.7 foot over the past century, as shown in Figure 8. Furthermore, evidence suggests that the rate of global mean sea level rise has accelerated since the mid-1800s, or even earlier (Church and White, 2006; Jevrejeva, et al., 2008), and that it has now reached a rate of about 1 foot per century over the past decade or so (Nerem, et al., 2006).

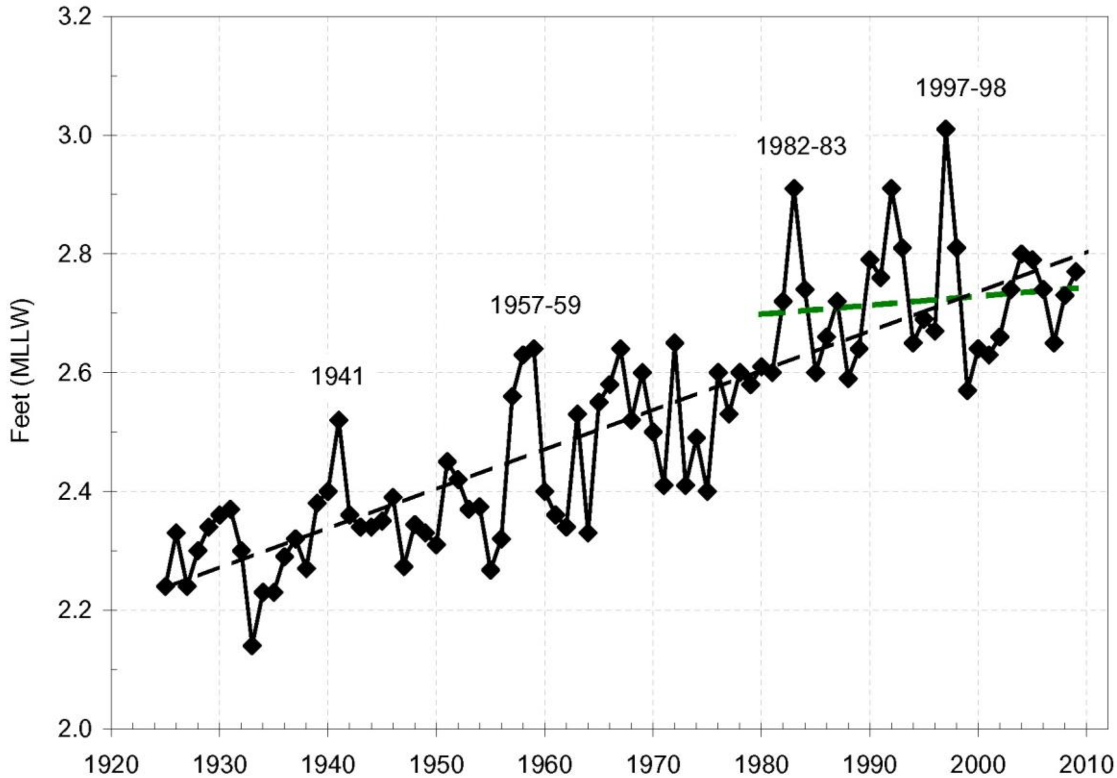


Figure 9. Annual average sea level history at La Jolla, 1925-2007. Broken line shows linear trend of 0.7 feet/century rise.

Figure 9 is a plot of the annual mean sea levels measured at the La Jolla tide gauge starting in 1925. The linear trend indicates the approximate 0.7 foot per century sea level rise. Also noticeable are the enhanced sea levels during the El Niño episodes of 1941, 1957-59, 1982-83, and 1997-98 (respectively labeled).

A notable feature of the sea level history at La Jolla is the leveling-off of sea level rise since about 1980 (Figure 9). The green broken line shows a much reduced trend of about 0.15 foot per century between 1980 and 2009, or about 4.5 times smaller than the overall trend of 0.67 foot per century. A similar reduction in the rate of sea level rise has been noted at San Francisco, which has a similar overall appearance as the La Jolla record, but is a much longer record extending back to 1856.

Figure 10 shows the global distribution of the rate of sea level change for the period of 1993-2005 (Nerem, 2005). Note that warm colors (yellow-orange-red) show areas of sea level rise (positive rates), while cool colors (green- blue) indicate falling sea level (negative rates) over the record. Inspection of the North Pacific reveals that sea levels in the western Pacific, especially in the lower latitudes, have risen at a rate of 3-9 mm/year (equivalent to 30-90 cm per century, or about 1-3 feet per century). Conversely, sea levels in the eastern Pacific, extending from Central America north to Washington State, have fallen at a rate of 0-3 mm per year (0-30 cm per century, or 0-1 foot per century). This may explain the coastal tide gauge observations (La Jolla sea level history; Figure 9) described above.

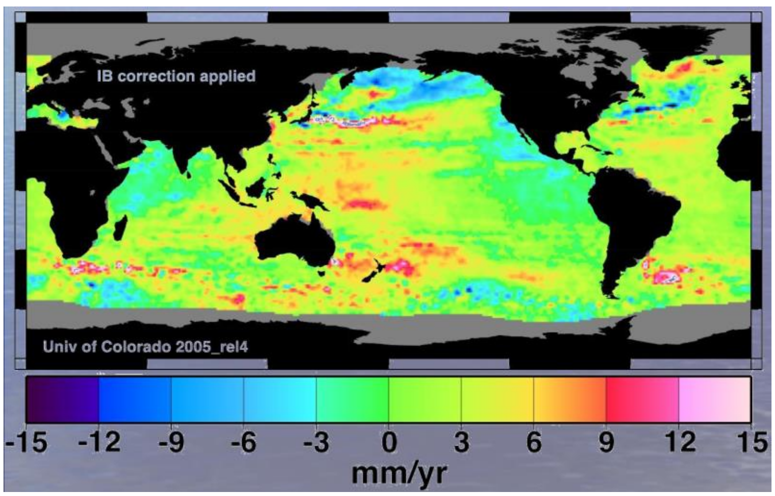
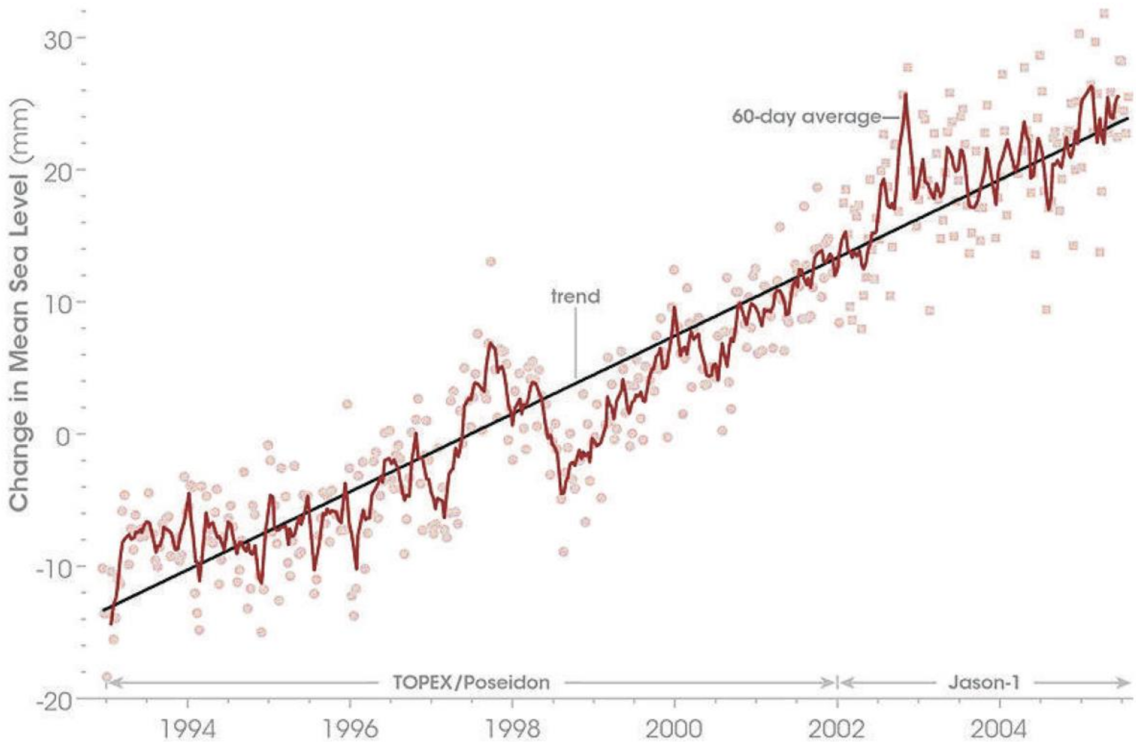


Figure 10. Global sea level change rates 1993-2005 as derived from satellite altimetry measurements, following Nerem (2005).

Bromirski *et al*. (2011) determined that increases in wind stress over large parts of the Pacific Basin are largely responsible for a "dynamical suppression" of MSLR as part of a major regime-shift that occurred in the late 1970s. Any flooding or beach erosion that has occurred on this coast since about 1980 has not been affected by MSLR as future events are expected to be. In fact, it is reasonable to conclude that MSLR will resume and likely accelerate along the California coast over the next few decades (Bromirski *et al*., 2012).

In sharp contrast to the recent decrease in sea level rise rates along the California coast, including La Jolla, the global mean sea level rise rate over the past two decades has increased over the rate observed for the past century, and has reached about 1 foot per century (32 cm per century). This is indicated from satellite data reporting and trend analysis shown in

Figure 11 (Nerem, 2005). The exhibit illustrates how sea level change trends may vary globally and that the impacts of sea level rise may affect regions differently.



Satellite-derived global sea level elevation change from 1993-2005 after Nerem (2005). Slope of the trend line is about 1 foot per century (32 cm per century).

FIGURE 11

Figure 12 summarizes MSLR scenarios developed in a National Research Council (NRC 2012) study that the California Ocean Protection Council had developed guidance for state and local agencies.

When considering the effects of future sea level rise, the National Research Council National Academy of Sciences (NRC, 2012) presents a possible global, west-coast, and state-wide future Mean Sea Level Rise (MSLR) for California, Oregon, and Washington (Figure 12, dots) and its range (Figure 12, bars). These are based on the IPCC (2007) mid-range Green House Gas emissions scenarios for the ocean steric (warming) expansion component added to the results of new research projecting the likely contributions of future ice-melt. The resulting projected global MSLR relative to 2000 ranged from 0.08-0.23 m (0.26-0.75 ft) by

2030; 0.18-0.48 m (0.59-1.6 ft) by 2050; and 0.50-1.4 m (1.6-4.6 ft) by 2100 (Figure 12, red bars). The global estimates were adjusted for vertical crustal movement (uplift north of Cape Mendocino and down-drop in the south) resulting in the orange bars, also shown in Figure 12.

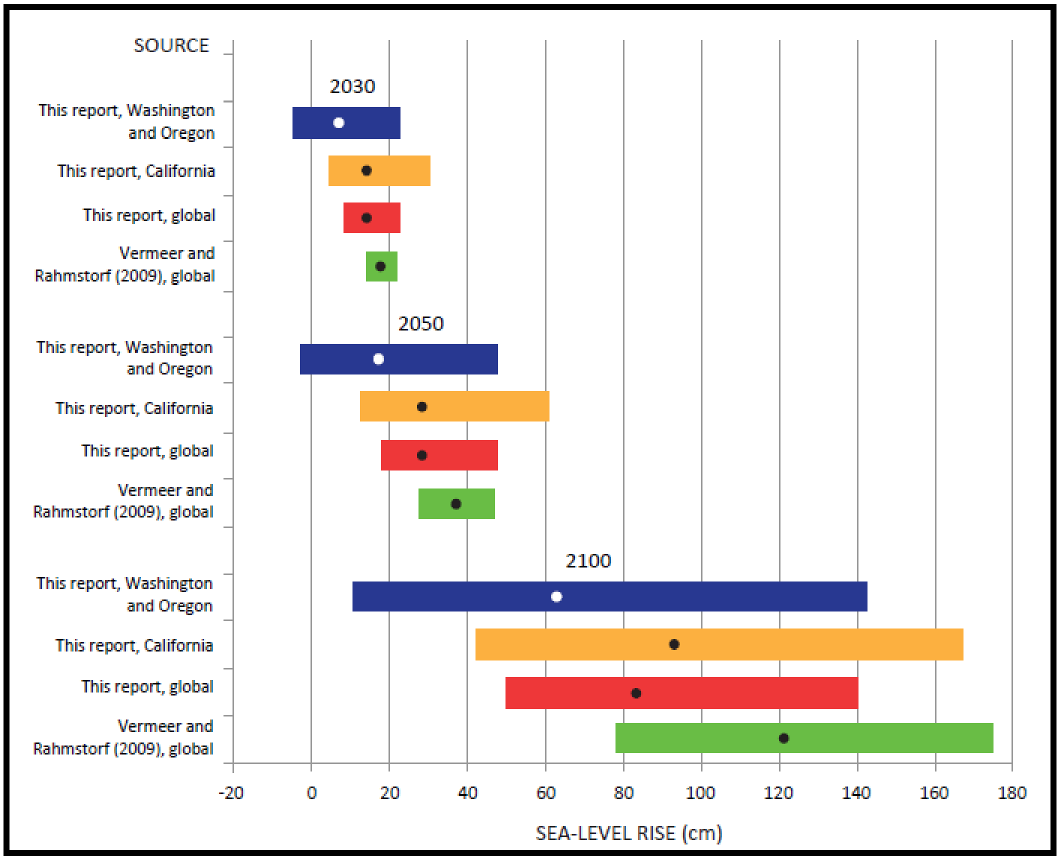


Figure 12. NAS (2012) summary of global, Washington, Oregon, and California (south of Cape Mendocino) MSLR projections for 2030, 2050, and 2100 relative to 2000.

While many sea-level rise scenarios have been published, the California Coastal Commission, on August 12, 2015, adopted their Sea Level Rise Policy Guidance document, which provides sea level rise projections from the Third National Climate Assessment (NCA; Melillo, et al.), released in 2014, providing a set of four global sea level rise scenarios ranging from 8 inches to 7 feet by the year 2100, reflecting different amounts of future greenhouse gas emissions, ocean warming, and ice sheet loss.

The OPC (2018) update offered a new strategy by presenting MSLR trajectories as functions of emission scenarios as well as probability of occurrence. An extreme trajectory with unknown probability was also added. For example, the low-emissions 2100 endpoint value of 1.3 feet of MSLR has a 50 percent chance of being exceeded, while the corresponding high-emissions 2100 endpoint is 2.2 feet. In another way to look at it, the low-emissions 2100 MSLR value has a 66 percent chance of lying between 0.7 and 2.1 feet, while the high-emissions range is 1.3 to 3.2 feet. There is a 5 percent chance that MSLR will be 3.0 feet (low) or 4.1 feet (high) by 2100, and a 0.5 percent chance of 5.4 feet (low) or 6.7 feet (high). Finally, the extreme scenario postulates 9.9 feet MSLR by 2100 in case of rapid Antarctic ice loss.

OPC (2018) contains a description of the best available science to support planning; MSLR projections; guidance on how to select projections; and recommendations for planning and adaptation. Projections for two greenhouse gas emissions scenarios are provided for 12 locations with long-term tide-gauge data in California, from Crescent City south to San Diego. OPC (2018) employs the highest and lowest of the four emissions scenarios used by the Intergovernmental Panel on Climate Change's Fifth Assessment Report: RCP 8.5 and RCP 2.6, respectively.

Each RCP (representative concentration pathway) denotes a family of possible underlying socioeconomic conditions, policy options, and technological considerations that span from the low-end RCP 2.6, which requires significant emissions reductions, to the high-end, "business-as usual" fossil-fuel-intensive evolution, RCP 8.5. For further details, see IPCC (2014). These two high and low-end pathways were chosen by OPC (2018) to bracket the current best-estimate of the range of possible futures. However, even the "high" probabilistic projections may underestimate the chances of extreme MSLR, resulting, for example, from designated "H++." The probability of this scenario is currently unknown, but presumably very small.

OPC (2018) presents results for each location in a series of tables that specify several time sequences of MSL from 2030-2150, where each series has a specified probability or range of probabilities of occurrence associated with it. The MSLR projections assume 2000 as the base year and project MSLR in specified future years relative to MSL in 2000. There is a table for each scenario, low and high. The OPC (2018) MSL elevation projections for Los Angeles from 2000-2150 are reproduced in Table 2.

5.3 Wave-Induced Scour

In the coming decades, a significant potential exists for wave-induced scour to undermine and damage/destroy the lifeguard facility. Adequate scour protection is critical to the long-term performance and service life of the proposed facility. Although a variety of foundation alternatives is possible, the typical preferred alternative includes the construction of a low height bulkhead some distance seaward of the facility to protect the foundation soils from wave-induced scour. Although severe wave overtopping may still occur, saturating the foundation soils, decreasing foundation bearing capacity, and creating hydrostatic pressures that would load the bulkhead, this alternative protects the structure's foundation soils from being eroded, which would otherwise damage or worst-case destroy the structure.

For long-term protection of the new lifeguard building against marine erosion, we recommend the installation of a low-height sheet-pile bulkhead around the seaward portion of the facility, with a sufficient extension along its sides to allow both beach scour and wave runup to extend around and beyond the building without compromising the structure. We would suggest using a semi-circular sheet-pile bulkhead with its landward ends a minimum of 30 feet beyond the proposed structure to enable the placement of additional temporary protection under a worst-case storm condition that might displace a significant portion of the back beach away from the proposed facility. In this regard, we recommend that the sheet-pile bulkhead be of cantilever design and designed to accommodate a maximum scour depth at the front face of the structure of 14 feet, consistent with a design scour elevation of +1 foot, NAVD 88. The low-height sheet-pile bulkhead should incorporate an architectural concrete cap to maintain its architectural appearance.

Notably, the recommended detached semi-circular sheet-pile bulkhead should not be considered a permanent structure, as it is relatively easy to install using a vibratory hammer, and similarly relatively easy to remove at a later date if considered necessary, again using a vibratory hammer. The detached bulkhead should incorporate an architectural concrete cap, which is also relatively easily removable at a later date, if considered necessary.

Beach Nourishment Alternative

Beach nourishment is always a viable project alternative and a wide protective sand beach is clearly the most efficient form of shoreline protection, and particularly well suited for Newport Beach, recognizing that the project site is located a mile upcoast from the Newport Harbor North Jetty, thereby minimizing sand loss downcoast of the Harbor entrance. Simply stated, a sufficiently wide beach would not allow waves to impact directly upon shore-based structures. Severe storms will, however, displace considerable sand, thus the need for a sufficiently wide sacrificial cross section of beach to allow erosion and displacement of the transient sandy beach materials. The Resources Agency of the State of California (1997) recognizes that beach renourishment, especially for low-lying areas, is by far the best approach to shoreline protection. Undeniably, beach nourishment provides both increased shoreline protection and recreational benefits. An ongoing commitment to beach nourishment and capitalizing on available opportunistic sand sources will reduce the potential for an extreme storm event damaging the new lifeguard facility. The proposed erosion barrier merely provides a last line of defense during those infrequent periods when storm surf scours the back beach. Given sufficient artificial beach renourishment, the proposed bulkhead would be unnecessary. However, until sufficient artificial beach renourishment occurs, the proposed structure merely provides additional protection to the new facility.

FEMA NFPI Requirements

FEMA provides a design manual for retrofitting flood-prone residential structures, originally published in 1986 (FEMA 114), with the third edition published in January 2012 (FEMA P-259). Figure 13 is an illustration from FEMA 114, showing a waterproof closure secured to a flood wall, with guidance providing adaptive strategies for mitigating potential flooding, whether the result of riverine flooding or offshore storms.

Figure 13. Illustrative flood wall and watertight closure from FEMA 114.

All new development should consider implementing minimum National Flood Insurance Program (NFIP) regulatory requirements, to the extent practical. These requirements are summarized as follows:

- Buildings must be:
  - Designed (or modified) and anchored to prevent flotation, collapse, and lateral movement of the building resulting from hydrodynamic and hydrostatic loads,
  - Constructed with materials resistant to damage from immersion in flood waters,
  - Constructed with methods and practices that minimize flood damage, and
  - Constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within their components during conditions of flooding.

- All utilities and facilities, such as sewer, gas, electrical, and water systems for any proposed new development must be located and constructed to minimize or eliminate flood damage;
- Adequate drainage must be provided for all new development in order to reduce exposure to flood hazards; and
- All new and replacement sanitary sewage systems must be designed to minimize or eliminate infiltration of flood waters into the systems and discharges from the systems into flood waters.

6 LIMITATIONS

Coastal engineering and the earth sciences are characterized by uncertainty. Professional judgments presented herein are based partly on our evaluation of the technical information gathered, partly on our understanding of the proposed construction, and partly on our general experience. Our engineering work and judgments rendered meet the current professional standards. We do not guarantee the performance of the project in any respect.

We have investigated only a small portion of the pertinent soil, rock, and groundwater conditions of the subject site. The opinions and conclusions made herein were based on the assumption that those rock and soil conditions do not deviate appreciably from those encountered during our field investigation. We recommend that a soil engineer from our office observe construction to assist in identifying soil conditions that may be significantly different from those encountered in our borings. Additional recommendations may be required at that time.

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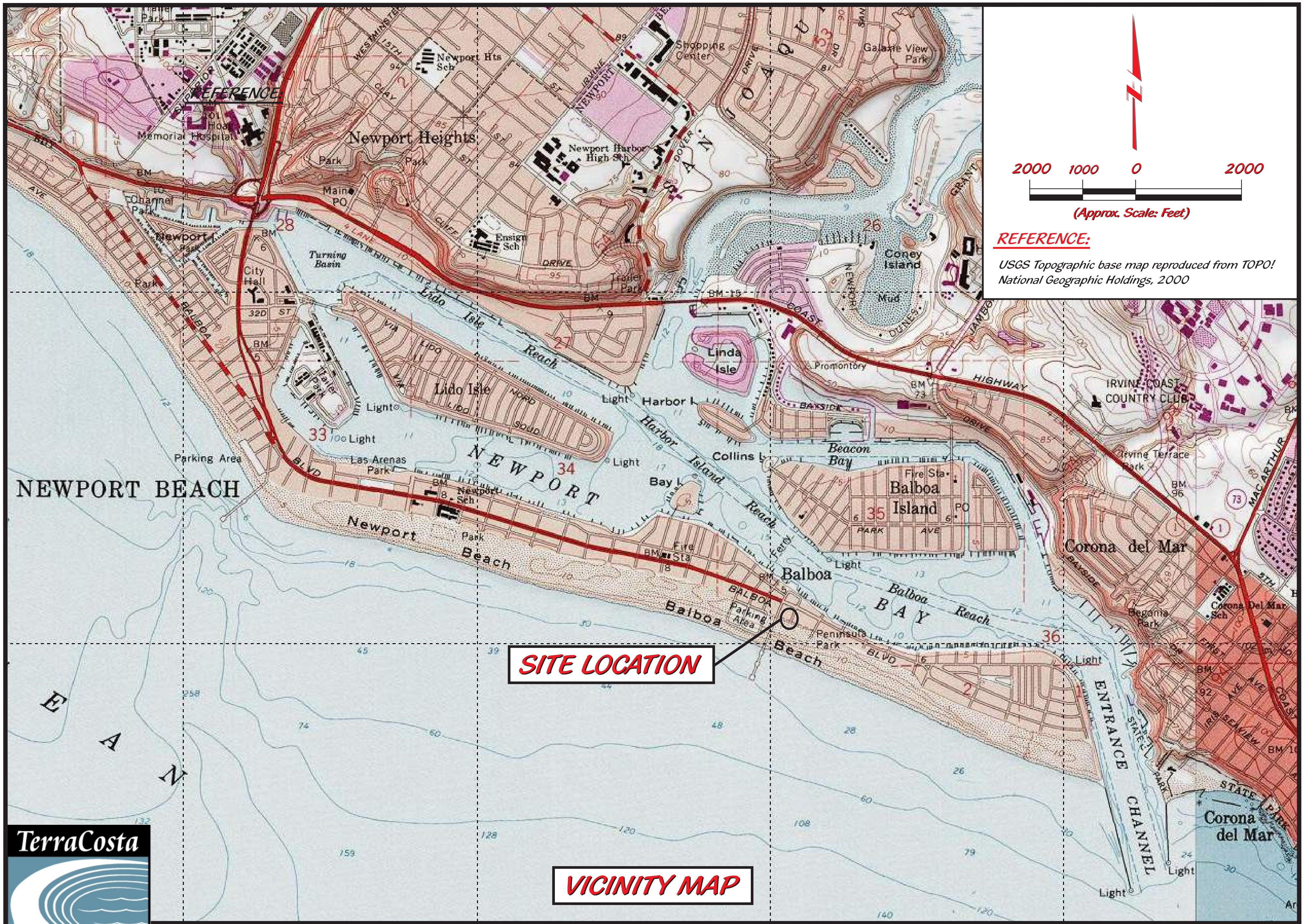
TABLE 2

Projected Sea-Level Rise (in feet) for Los Angeles

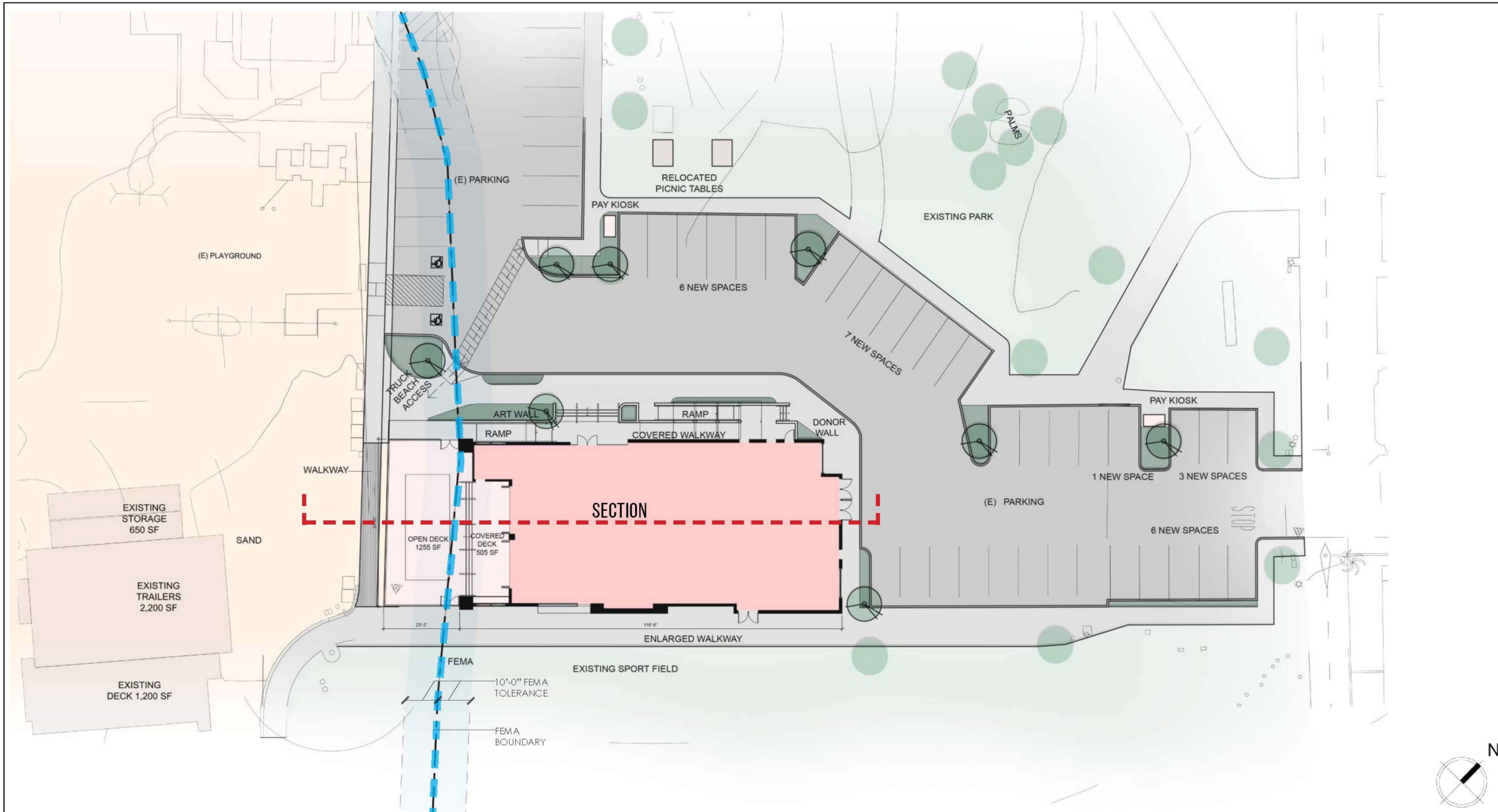
Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE		1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...		5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
				Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.3	0.2 -	0.5	0.6	0.7	1.0
	2040	0.5	0.4 -	0.7	0.9	1.2	1.7
	2050	0.7	0.5 -	1.0	1.2	1.8	2.6
Low emissions	2060	0.8	0.5 -	1.1	1.4	2.2	
High emissions	2060	1.0	0.7 -	1.3	1.7	2.5	3.7
Low emissions	2070	0.9	0.6 -	1.3	1.8	2.9	
High emissions	2070	1.2	0.8 -	1.7	2.2	3.3	5.0
Low emissions	2080	1.0	0.6 -	1.6	2.1	3.6	
High emissions	2080	1.5	1.0 -	2.2	2.8	4.3	6.4
Low emissions	2090	1.2	0.7 -	1.8	2.5	4.5	
High emissions	2090	1.8	1.2 -	2.7	3.4	5.3	8.0
Low emissions	2100	1.3	0.7 -	2.1	3.0	5.4	
High emissions	2100	2.2	1.3 -	3.2	4.1	6.7	9.9
Low emissions	2110*	1.4	0.9 -	2.2	3.1	6.0	
High emissions	2110*	2.3	1.6 -	3.3	4.3	7.1	11.5
Low emissions	2120	1.5	0.9 -	2.5	3.6	7.1	
High emissions	2120	2.7	1.8 -	3.8	5.0	8.3	13.8
Low emissions	2130	1.7	0.9 -	2.8	4.0	8.1	
High emissions	2130	3.0	2.0 -	4.3	5.7	9.7	16.1
Low emissions	2140	1.8	0.9 -	3.0	4.5	9.2	
High emissions	2140	3.3	2.2 -	4.9	6.5	11.1	18.7
Low emissions	2150	1.9	0.9 -	3.3	5.1	10.6	
High emissions	2150	3.7	2.4 -	5.4	7.3	12.7	21.5

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*



Project: Newport Beach Junior Lifeguard Building | Project No. 3134 | Figure 1



TerraCosta Consulting Group	**TERRACOSTA CONSULTING GROUP** ENGINEERS AND GEOLOGISTS 4455 MURPHY CANYON ROAD, SUITE 100 SAN DIEGO, CA 92123 (858) 573-6900	FIGURE NUMBER 2
	PROJECT NAME NEWPORT BEACH JUNIOR LIFEGUARD BUILDING	PROJECT NUMBER 3134
	ARCHITECTURAL SCHEMATIC DESIGN	

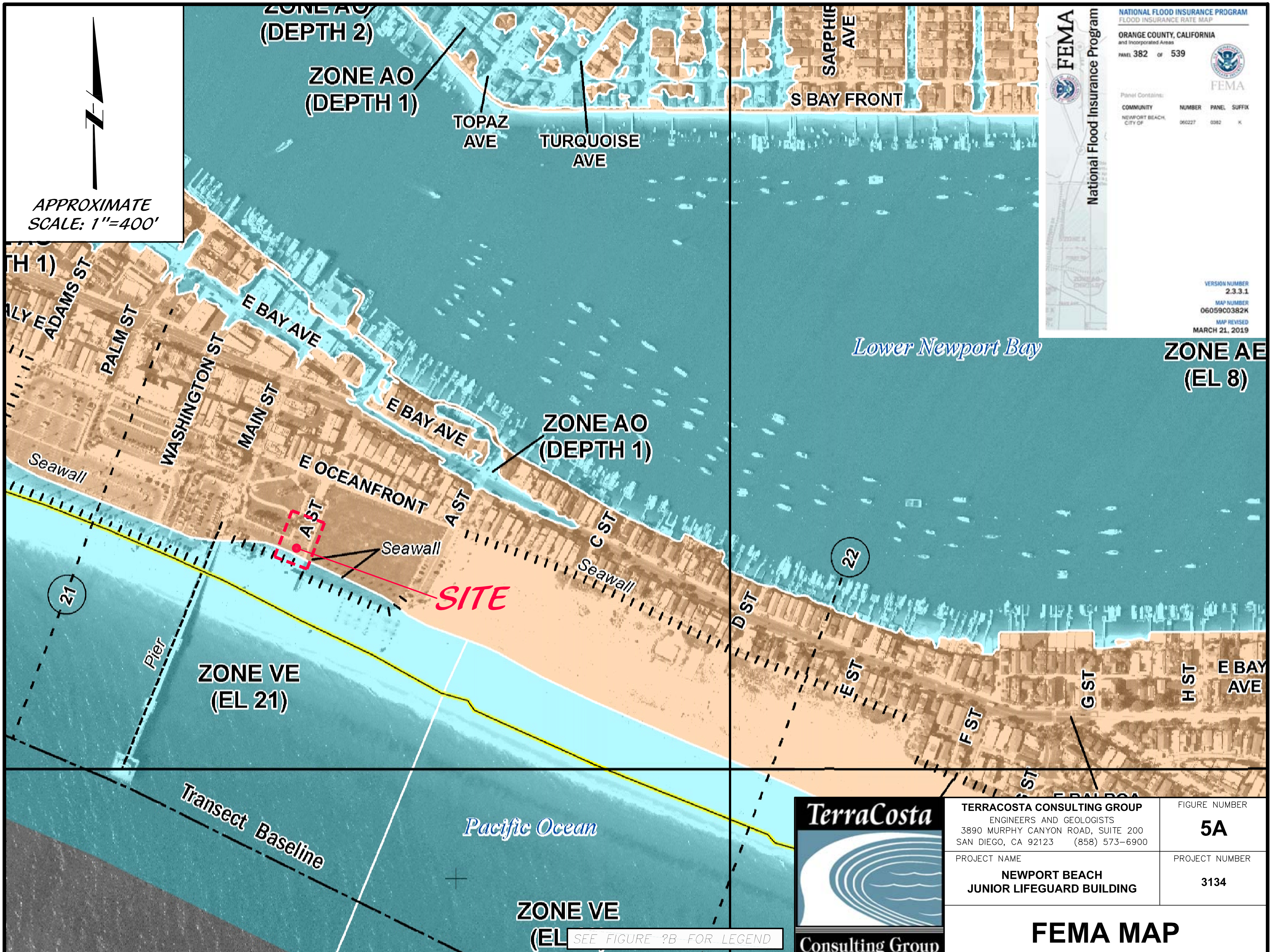


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FIGURE NUMBER
5A

PROJECT NAME
NEWPORT BEACH JUNIOR LIFEGUARD BUILDING

PROJECT NUMBER
3134

FEMA MAP

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT

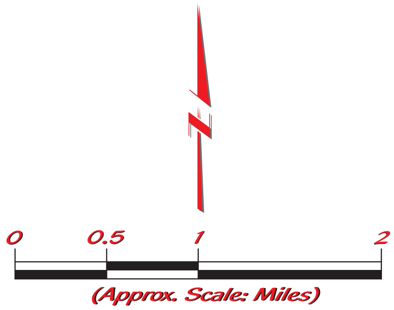
HTTPS://MSC.FEMA.GOV

SPECIAL FLOOD HAZARD AREAS	Without Base Flood Elevation (BFE) *Zone A,V, A99*
	With BFE or Depth *Zone AE, AO, AH, VE, AR*
	Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
	Future Conditions 1% Annual Chance Flood Hazard *Zone X*
	Area with Reduced Flood Risk due to Levee See Notes. *Zone X*
	Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN — Area of Minimal Flood Hazard *Zone X*
	Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES	Channel, Culvert, or Storm Sewer
	Levee, Dike, or Floodwall
OTHER FEATURES	(E) 18.2 / 17.5 — Cross Sections with 1% Annual Chance Water Surface Elevation
	(8) — Coastal Transect
	Coastal Transect Baseline
	Profile Baseline
	Hydrographic Feature
	513 — Base Flood Elevation Line (BFE)
	Limit of Study
	Jurisdiction Boundary

TerraCosta Consulting Group

TERRACOSTA CONSULTING GROUP ENGINEERS AND GEOLOGISTS 3890 MURPHY CANYON ROAD, SUITE 200 SAN DIEGO, CA 92123 (858) 573-6900	FIGURE NUMBER	**5B**
PROJECT NAME **NEWPORT BEACH JUNIOR LIFEGUARD BUILDING**	PROJECT NUMBER	**3134**

FEMA MAP LEGEND



Source:

Reproduced from "Pacific Institute California Flood Risk: Sea Level Rise, Newport Beach OE S Quadrangle," 2009

- Interstate
- US Highway
- State Highway
- County Highway
- Current Coastal Base Flood (approximate 100-year flood extent)
- Sea Level Rise Scenario Coastal Base Flood + 1.4 meters (55 inches)
- Landward Limit of Erosion High Hazard Zone in 2100
- Coastal Zone Boundary

This information is being made available for informational purposes only. Users of this information agree by their use to hold blameless the State of California, and its respective officers, employees, agents, contractors, and subcontractors for any liability associated with its use in any form. This work shall not be used to assess actual coastal hazards, insurance requirements, or property values and specifically shall not be used in lieu of Flood Insurance Studies and Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA).

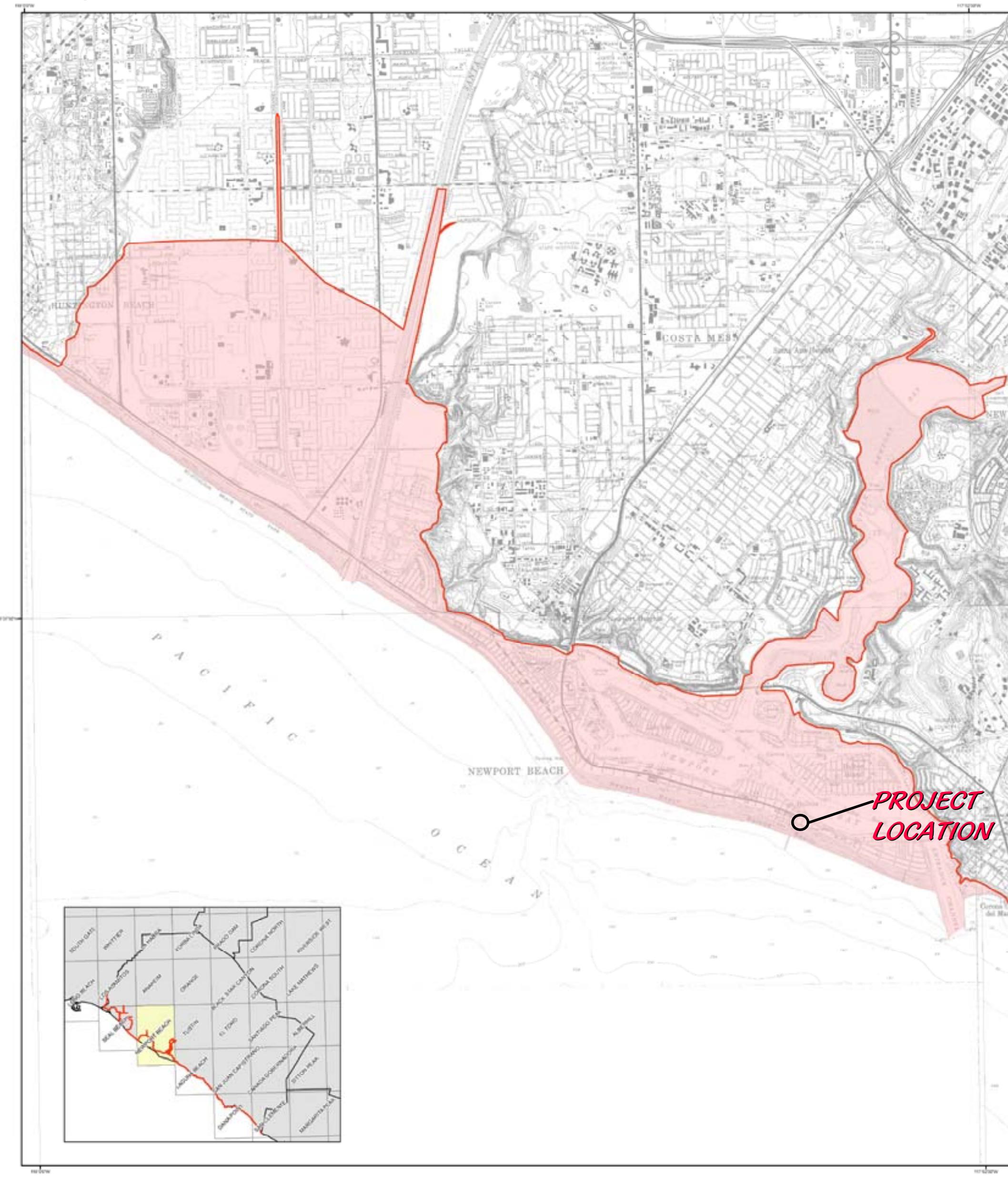
Data Sources: US Geological Survey, Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Coastal ServicesCenter (CSC), Scripps Institution of Oceanography, Phillip WIlliams and Associates, Inc. (PWA), US Department of Agriculture (USDA), California Coastal Commission, and National Aeronautics and Space Administration (NASA). Imagery from ESRI and i-cubed.

Project: Newport Beach Junior Lifeguard Building *Project No. 3134* *Figure No. 6*

California Emergency Management Agency
California Geological Survey
University of Southern California

Tsunami Inundation Map for Emergency Planning
Newport Beach Quadrangle

State of California
County of Orange



METHOD OF PREPARATION

Initial tsunami modeling was performed by the University of Southern California (USC) Tsunami Research Center funded through the California Emergency Management Agency (CalEMA) by the National Tsunami Hazard Mitigation Program. The tsunami modeling process utilized the MOST (Method of Splitting Tsunamis) computational program (Version 0), which allows for wave evolution over a variable bathymetry and topography used for the inundation mapping (Titov and Gonzalez, 1997; Titov and Synolakis, 1998).

The bathymetric/topographic data that were used in the tsunami models consist of a series of nested grids. Near-shore grids with a 3 arc-second (75- to 90-meters) resolution or higher, were adjusted to "Mean High Water" sea-level conditions, representing a conservative sea level for the intended use of the tsunami modeling and mapping.

A suite of tsunami source events was selected for modeling, representing realistic local and distant earthquakes and hypothetical extreme undersea, near-shore landslides (Table 1). Local tsunami sources that were considered include offshore reverse-thrust faults, restraining bends on strike-slip fault zones and large submarine landslides capable of significant seafloor displacement and tsunami generation. Distant tsunami sources that were considered include great subduction zone events that are known to have occurred historically (1960 Chile and 1964 Alaska earthquakes) and others which can occur around the Pacific Ocean "Ring of Fire."

In order to enhance the result from the 75- to 90-meter inundation grid data, a method was developed utilizing higher-resolution digital topographic data (3- to 10-meters resolution) that better defines the location of the maximum inundation line (U.S. Geological Survey, 1993; Intermap, 2003; NOAA, 2004). The location of the enhanced inundation line was determined by using digital imagery and terrain data on a GIS platform with consideration given to historic inundation information (Lander, et al., 1993). This information was verified, where possible, by field work coordinated with local county personnel.

The accuracy of the inundation line shown on these maps is subject to limitations in the accuracy and completeness of available terrain and tsunami source information, and the current understanding of tsunami generation and propagation phenomena as expressed in the models. Thus, although an attempt has been made to identify a credible upper bound to inundation at any location along the coastline, it remains possible that actual inundation could be greater in a major tsunami event.

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TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

State of California ~ County of Orange

NEWPORT BEACH QUADRANGLE

March 15, 2009

SCALE 1:24,000

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

MAP EXPLANATION

Tsunami Inundation Line

Tsunami Inundation Area

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51BA215931768825741F005E8D80?OpenDocument

University of Southern California – Tsunami Research Center:
http://www.usc.edu/dept/tsunamis/2005/index.php

State of California Geological Survey Tsunami Information:
http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/index.htm

National Oceanic and Atmospheric Agency Center for Tsunami Research (MOST model):
http://nctr.pmel.noaa.gov/time/background/models.html

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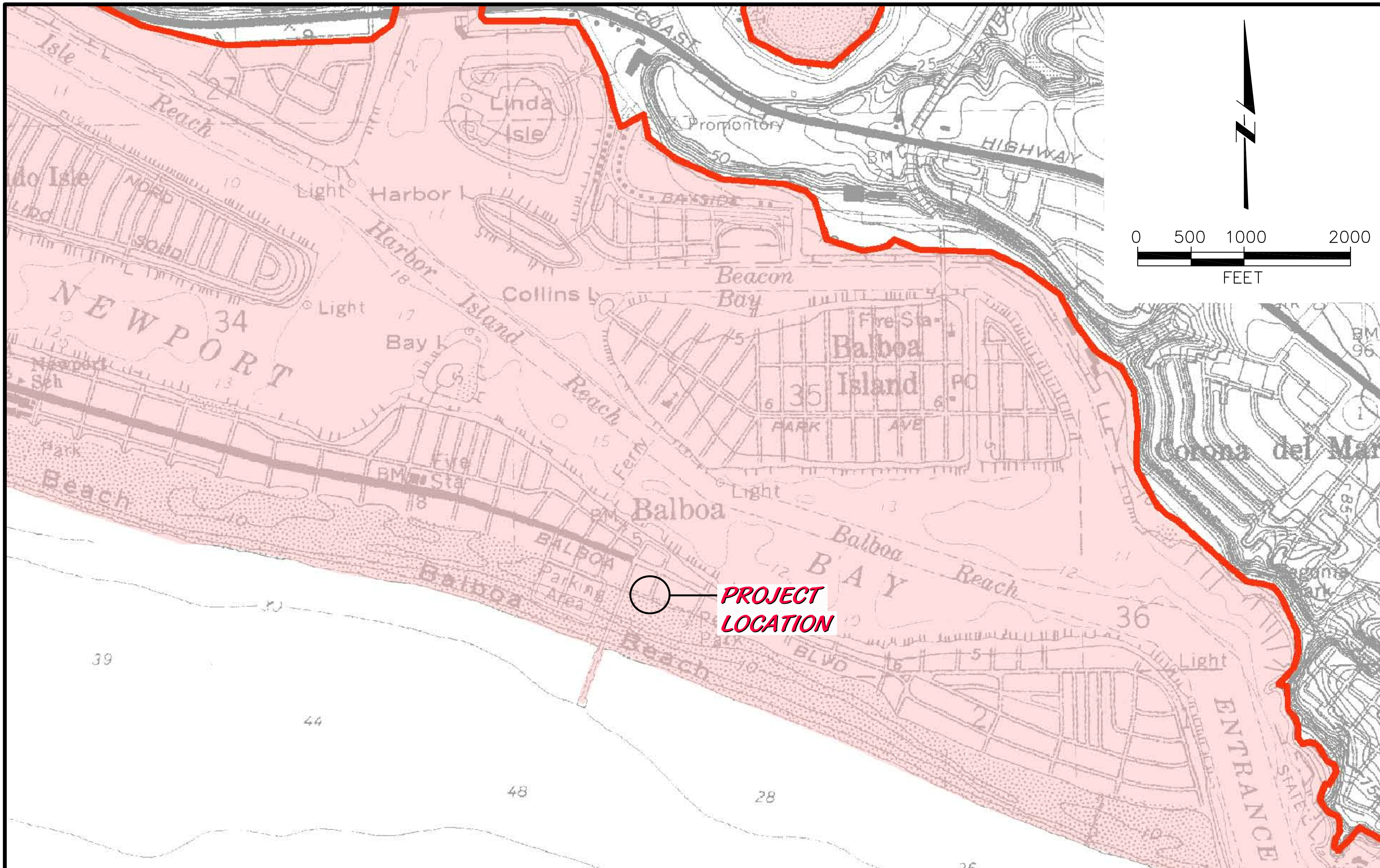
FIGURE NUMBER
7A

PROJECT NUMBER
3134

TSUNAMI INUNDATION MAP
NEWPORT BEACH QUADRANGLE



Reproduced from: "Tsunami Inundation Map for Emergency Planning, Newport Beach Quadrangle," by the State of California, County of Orange, dated March 15, 2009.

TerraCosta Consulting Group	**TERRACOSTA CONSULTING GROUP** ENGINEERS AND GEOLOGISTS 3890 MURPHY CANYON ROAD, SUITE 200 SAN DIEGO, CA 92123 (858) 573-6900	FIGURE NUMBER **7B**
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	TSUNAMI INUNDATION MAP	

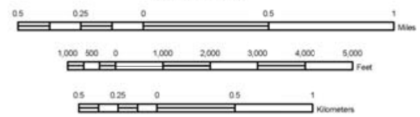
TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

State of California ~ County of Orange

NEWPORT BEACH QUADRANGLE

March 15, 2009

SCALE 1:24,000



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	Chile North Subduction Zone (M9.4)	X	X	X
	1960 Chile Earthquake (M9.3)	X	X	X
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	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
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Tsunami Inundation Line

Tsunami Inundation Area

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FIGURE NUMBER 7C

PROJECT NAME NEWPORT BEACH JUNIOR LIFEGUARD BUILDING

PROJECT NUMBER 3134

TSUNAMI INUNDATION MAP LEGEND