Project Incorporation of Sea Level Rise – City of Newport Beach Approach for Balboa Islands, City of Newport Beach, California

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CMANC Annual Winter Meeting

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San Pedro, California

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The Team

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- Mr. Randy Mason

  URS Corporation

- Mr. Robert Stein

  City of Newport Beach

Background

- Aging seawalls in need of repair
- Both islands subject to flooding during high tide and high wave events
- Increased flood frequencies and damages with anticipated sea level rise
- Newport Beach seeks alternatives for repairing or replacing seawall

Image Source: Google Earth Pro

Overview

- Existing Conditions
  - Seawall cap and house first floor elevation survey
  - Structural inspection
- Incorporation of Sea Level Rise
  - Selection of sea level rise scenarios
  - Flood modeling
  - Tidal dynamic and wave overtopping
- Mitigation Alternatives

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Seawall Cap Extension

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Cracks, Corrosion, Repairs

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Sidewalk Separation from Seawall

Distressed Bulkhead Cap

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Seawall Condition

- Seawall Age: 73-82 years
- Overall Condition: Holding together well with universal cracking along with some concrete spawling and some evidence of corroding rebar.
- Estimated Useful Life: 10-25 years

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Waves Splashing over the Balboa Island Seawall

(December 22, 2010)

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Pumping Flood Water Back into the Bay

(December 22, 2010)

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Flooding at Balboa Island Ferry Landing

(2005 Flood Event)

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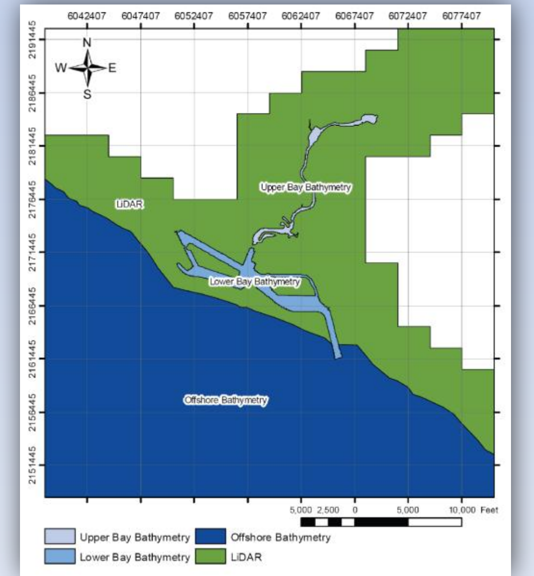
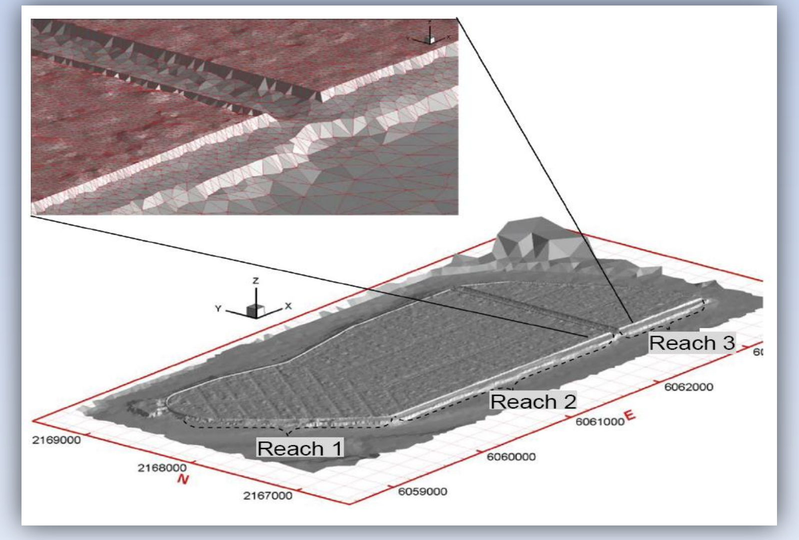
Flood Inundation Modeling

- Hydrodynamic model based on hydraulic principles
- Finite volume model based on the shallow water equation
- Account for both tide and wave overtopping
- Overtopping flows spread in accordance with local topography and the effects of gravity and friction

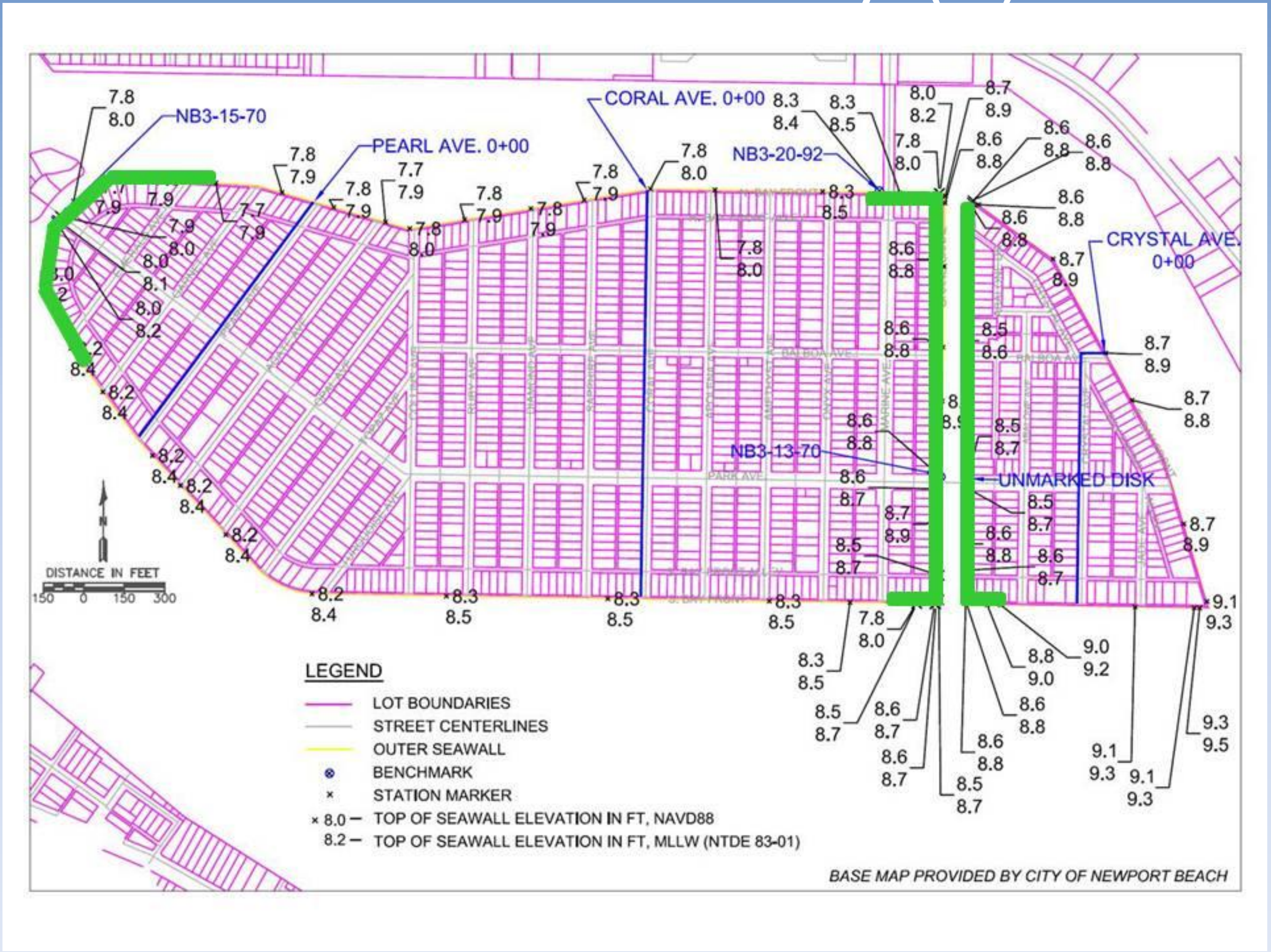
Model Domain – shaded areas



Fine Model Grid of Island Region



Top of Seawall and House First Floor Elevations Survey (ft)



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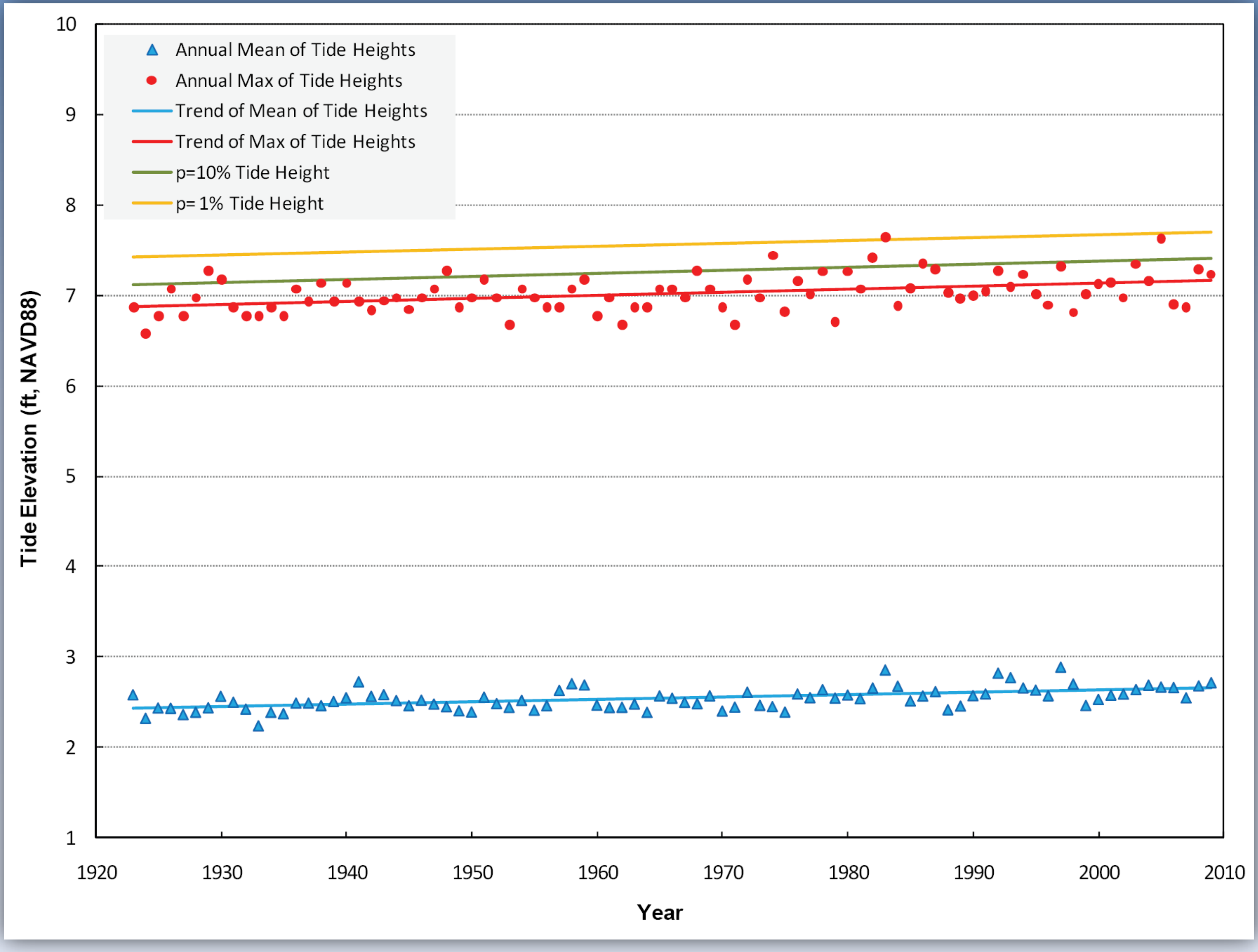
Tide Elevations, and Trends of Mean, Maximum, 10% and 1% Annual Exceedance-Probability Tide Heights, Los Angeles, 1923 – 2009



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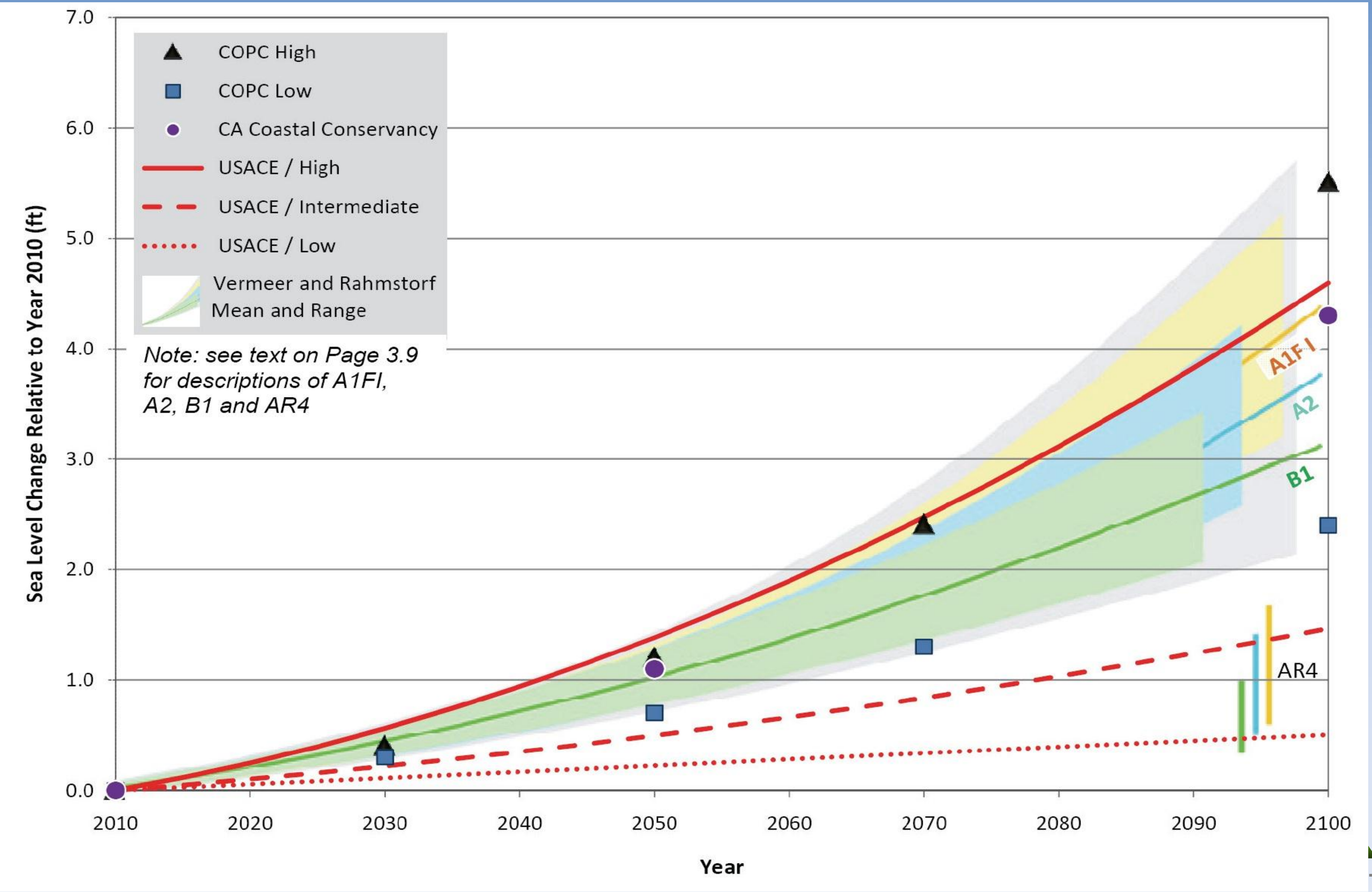
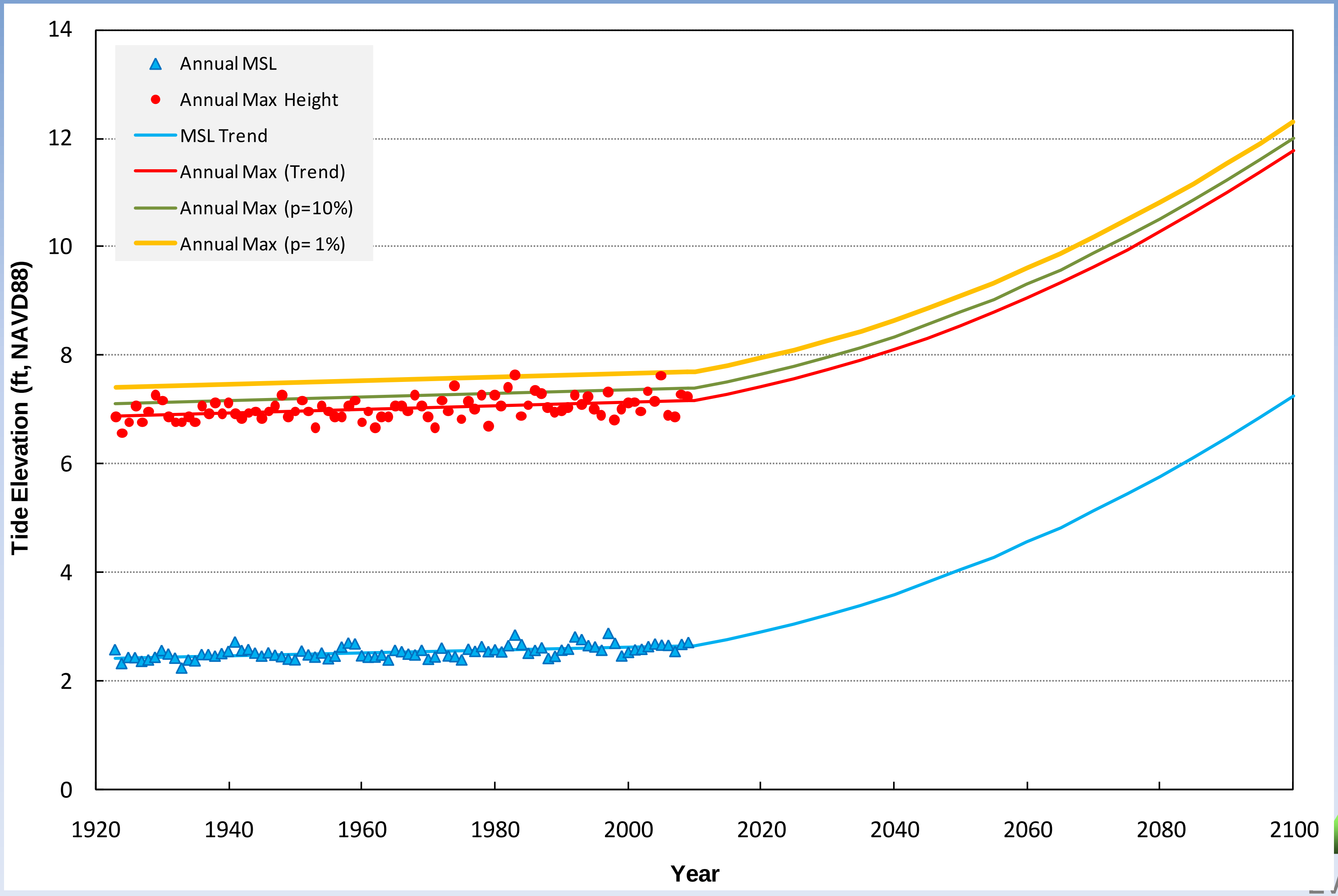
Sea Level Rise Projections



Projections of Mean Sea Level and Extreme Tide Heights Through Year 2100



Wave Overtopping

$$q_{wo} = \begin{cases} q_{wo}^{\max}\left(\dfrac{h - h_{q0}}{h_{wall} - h_{q0}}\right) & if \quad h_{q0} \le h \le h_{wall} \\ 0 & otherwise \end{cases}$$

Where

$q_{wo}^{\max}$ = maximum rate of wave overtopping based on all possible water levels
h_{wall} = height of the wall
h_{q0} = tide height corresponding to the onset of overtopping

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Flood Inundation Modeling Scenarios

- Water Level
  - 1% and 10% extreme tide
  - Present and with sea level rise (Year 2025, 2050, 2100)
- With and Without Waves
- Seawall Elevation
  - Existing
  - With 6-inch cap extension
  - New seawall at Elev. 10.0‘ MLLW

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Flood Inundation Modeling Scenarios

Scenario	Seawall Condition	Year	Sea Level Rise From 2010	Tide Height (Annual Exceedance Probability)	Wave Scenario
1	Existing Conditions	2010	NA	10%	No Waves
2	Existing Conditions	2010	NA	10%	Wind Waves
3	Existing Conditions	2010	NA	10%	Ocean Swell
4	Existing Conditions	2010	NA	1%	Wind Waves
5	Existing Conditions	2025	0.40 ft	10%	Wind Waves
6	Existing Conditions	2025	0.40 ft	10%	Ocean Swell
7	Existing Conditions	2025	0.40 ft	1%	Wind Waves
8	Existing Conditions	2050	1.38 ft	10%	No Waves
9	Existing Conditions	2050	1.38 ft	1%	No Waves
10	Existing Conditions	2100	4.60 ft	10%	No Waves
11	6-inch extension	2010	NA	1%	Wind Waves
12	6-inch extension	2025	0.40 ft	1%	Wind Waves
13	10 ft (MLLW) seawall	2010	NA	1%	Wind Waves
14	10 ft (MLLW) seawall	2025	0.40 ft	1%	Wind Waves
15	10 ft (MLLW) seawall	2050	1.38 ft	1%	Wind Waves
16	10 ft (MLLW) seawall	2050	1.38 ft	10%	Wind Waves
17	10 ft (MLLW) seawall	2100	4.60 ft	1%	Wind Waves

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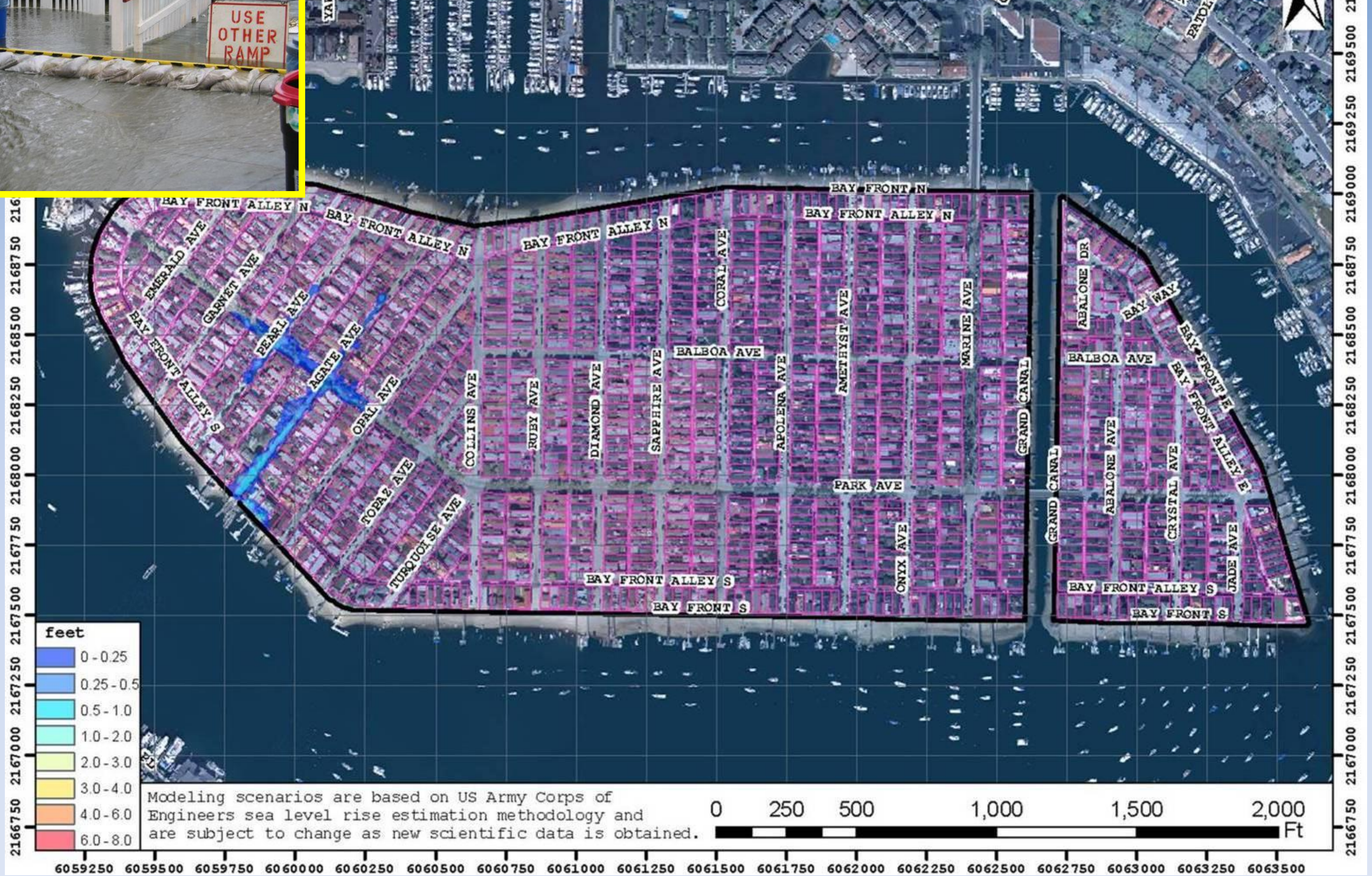
Existing Seawall, Year 2010, 10% Tide, No Waves



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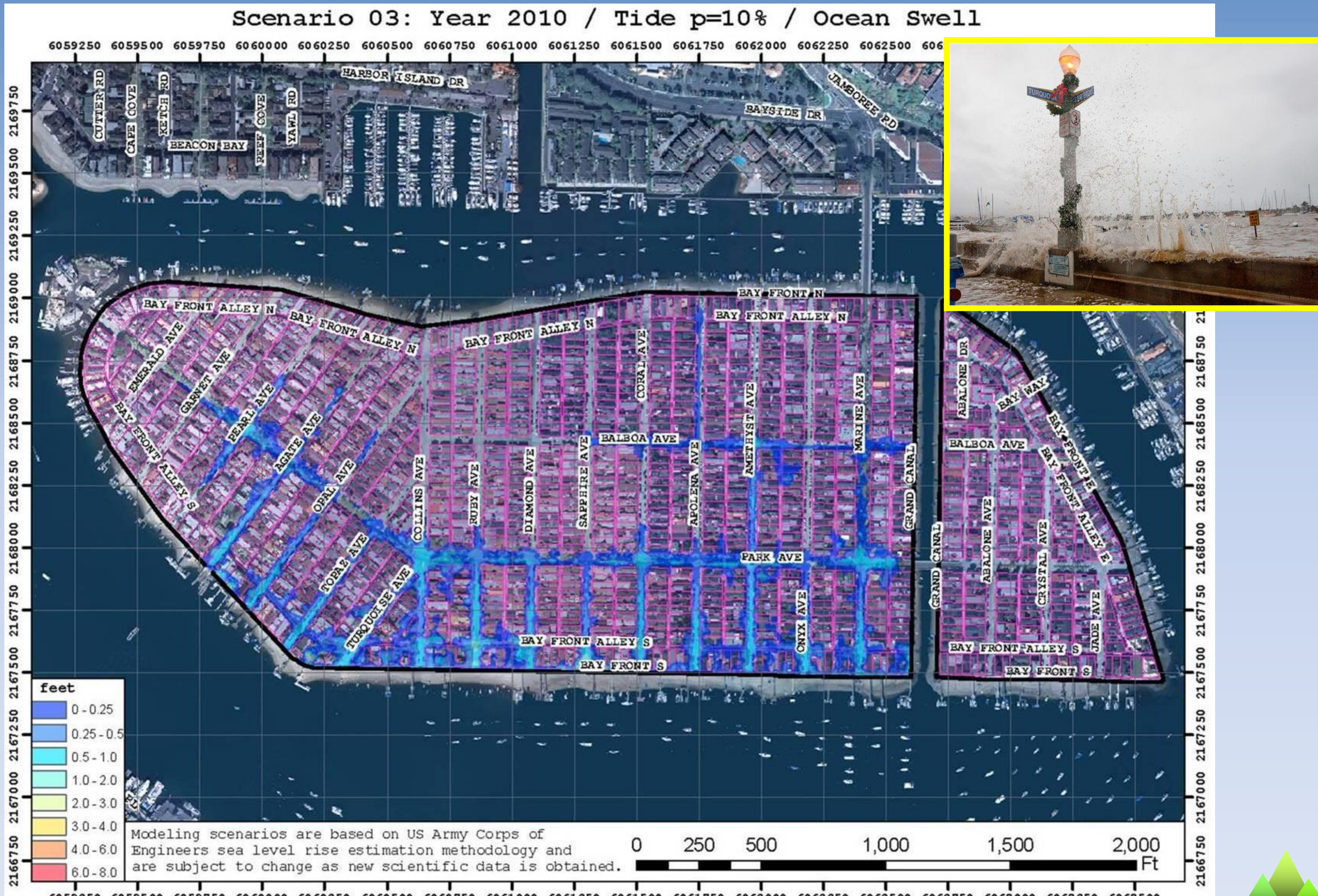
Existing Seawall, Year 2010, 10% Tide, Swell



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Equilibrium (bathtub) Model vs. Hydrodynamic Model

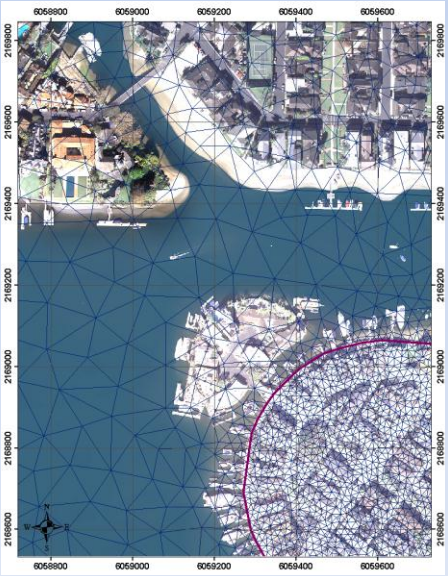
Equilibrium

- Efficient, rapid implementation
- Used for large SLR assessments
- Connectivity?
- Instantaneous filling

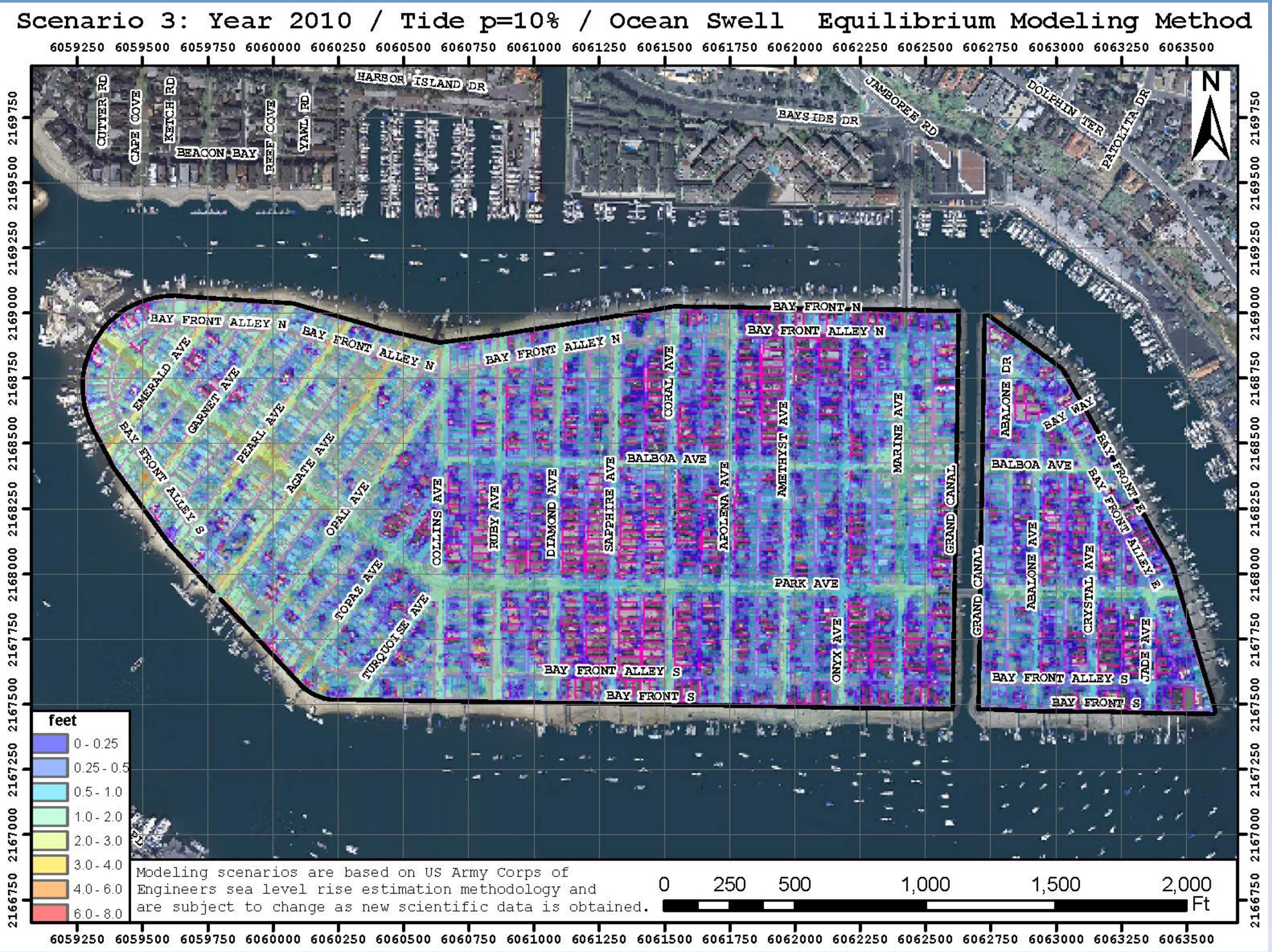
Reproduced from Gallien and Sanders

Hydrodynamic

- Responsive to connectivity
- Wall may be explicitly resolved
- Temporal variability



Same Scenario – Equilibrium (Bathtub) Model



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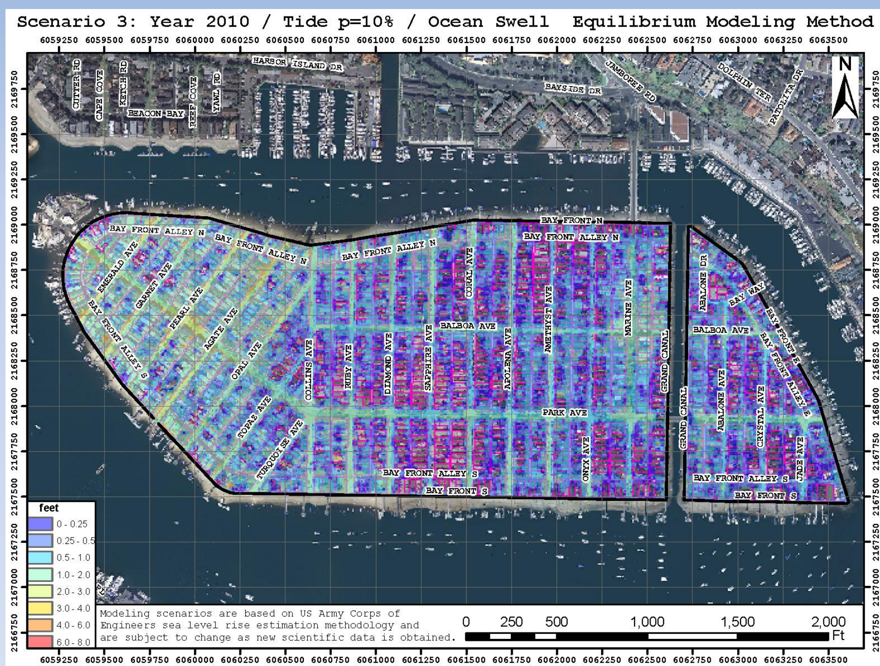
Equilibrium (bathtub) Model vs. Hydrodynamic Model

- Equilibrium



- Hydrodynamic

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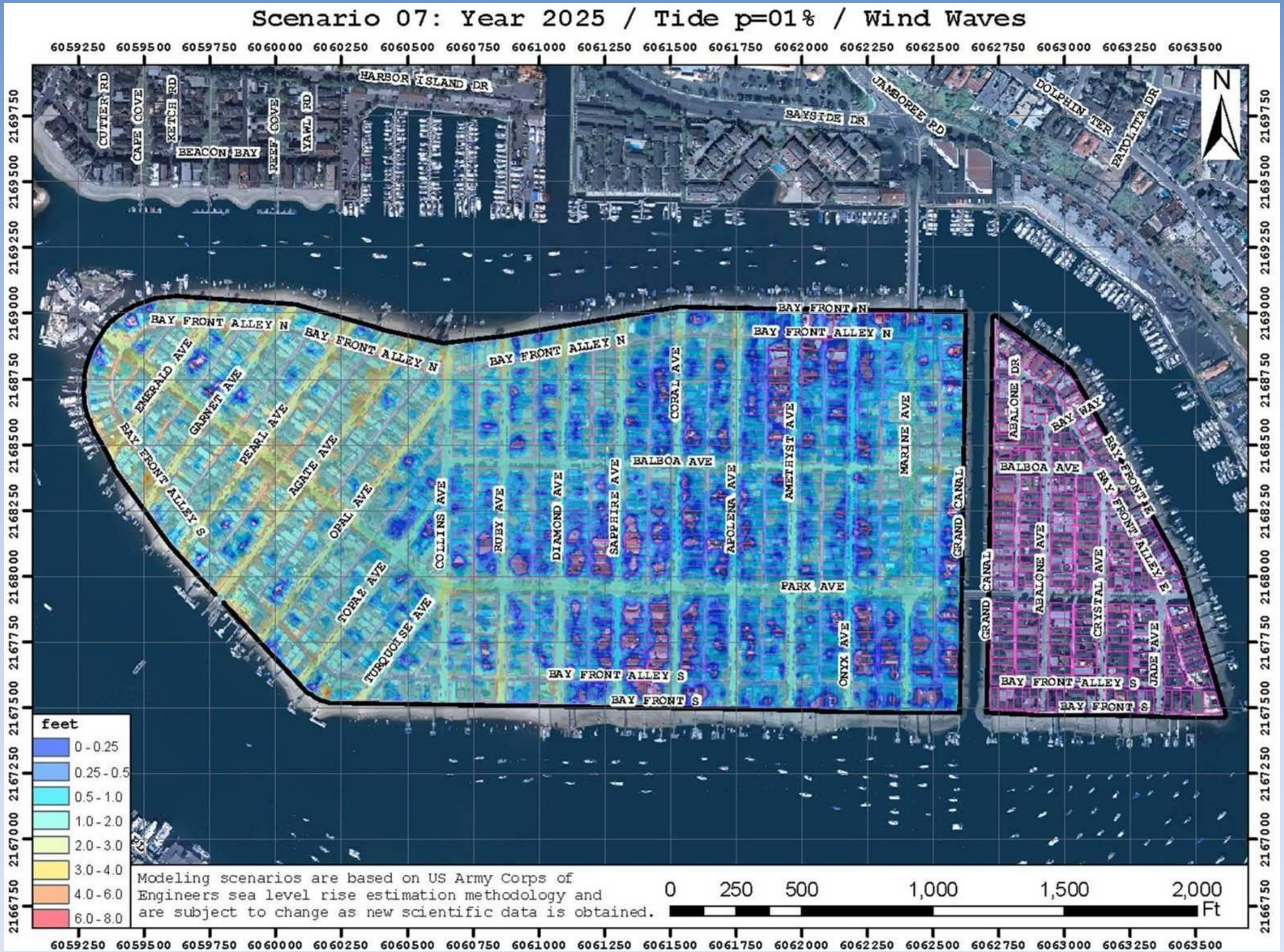
Existing Seawall, Year 2025, 1% Tide, Wind Waves



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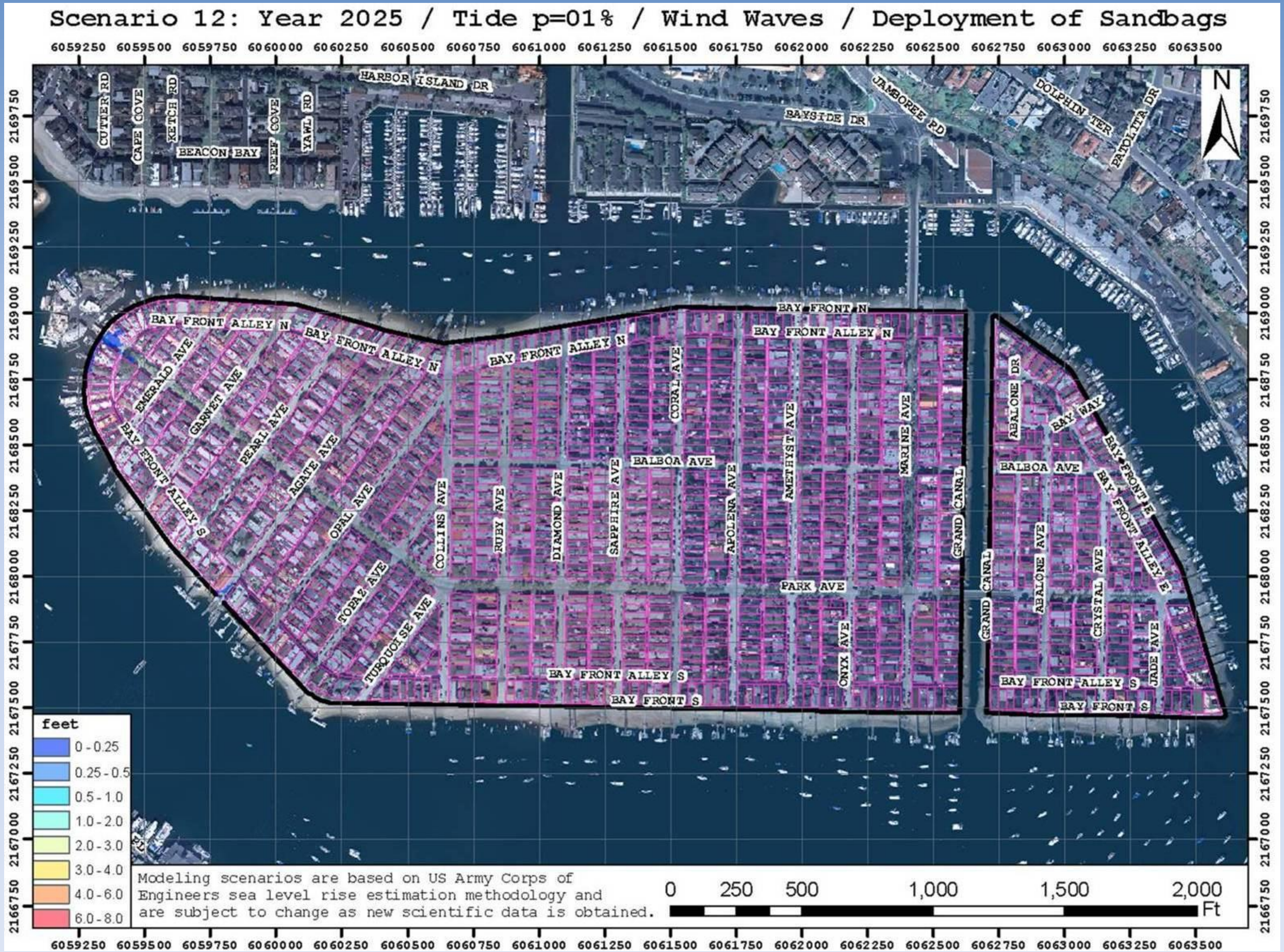
6 inch Cap Extension, Year 2025, 1% Tide, Wind Waves



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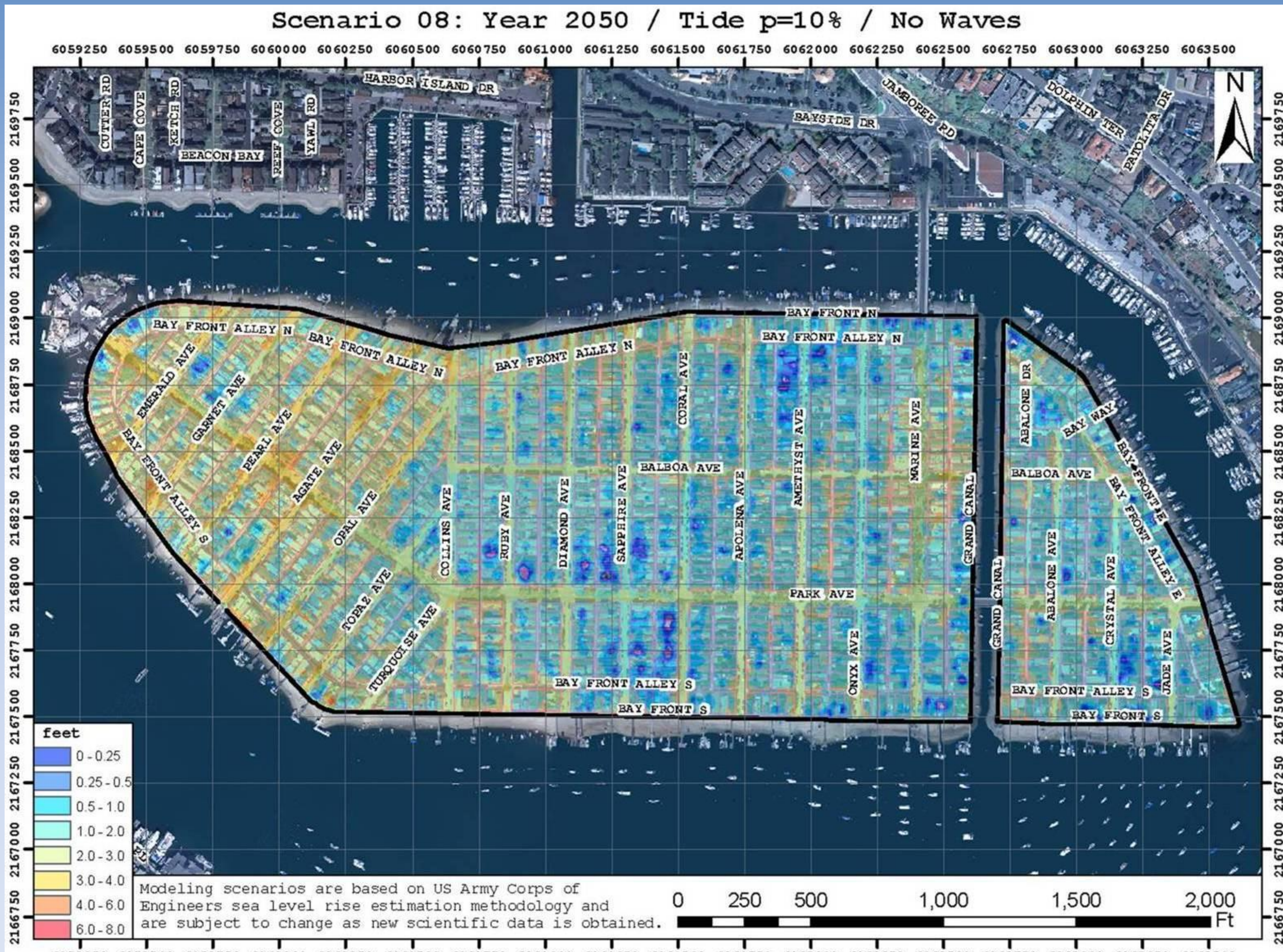
Existing Seawall, Year 2050, 10% Tide, No Waves



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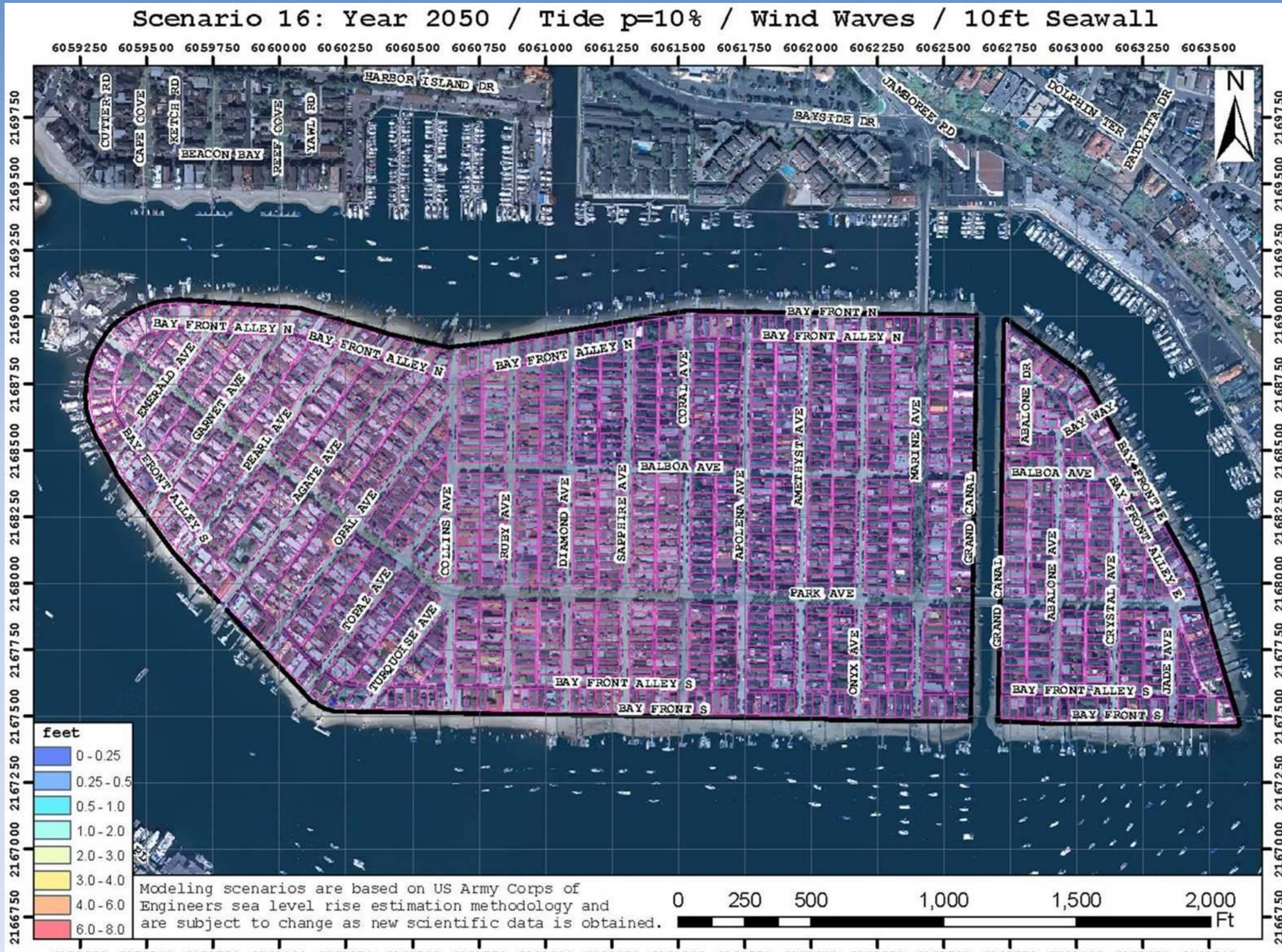
Seawall at +10 ft MLLW, Year 2050, 10% Tide



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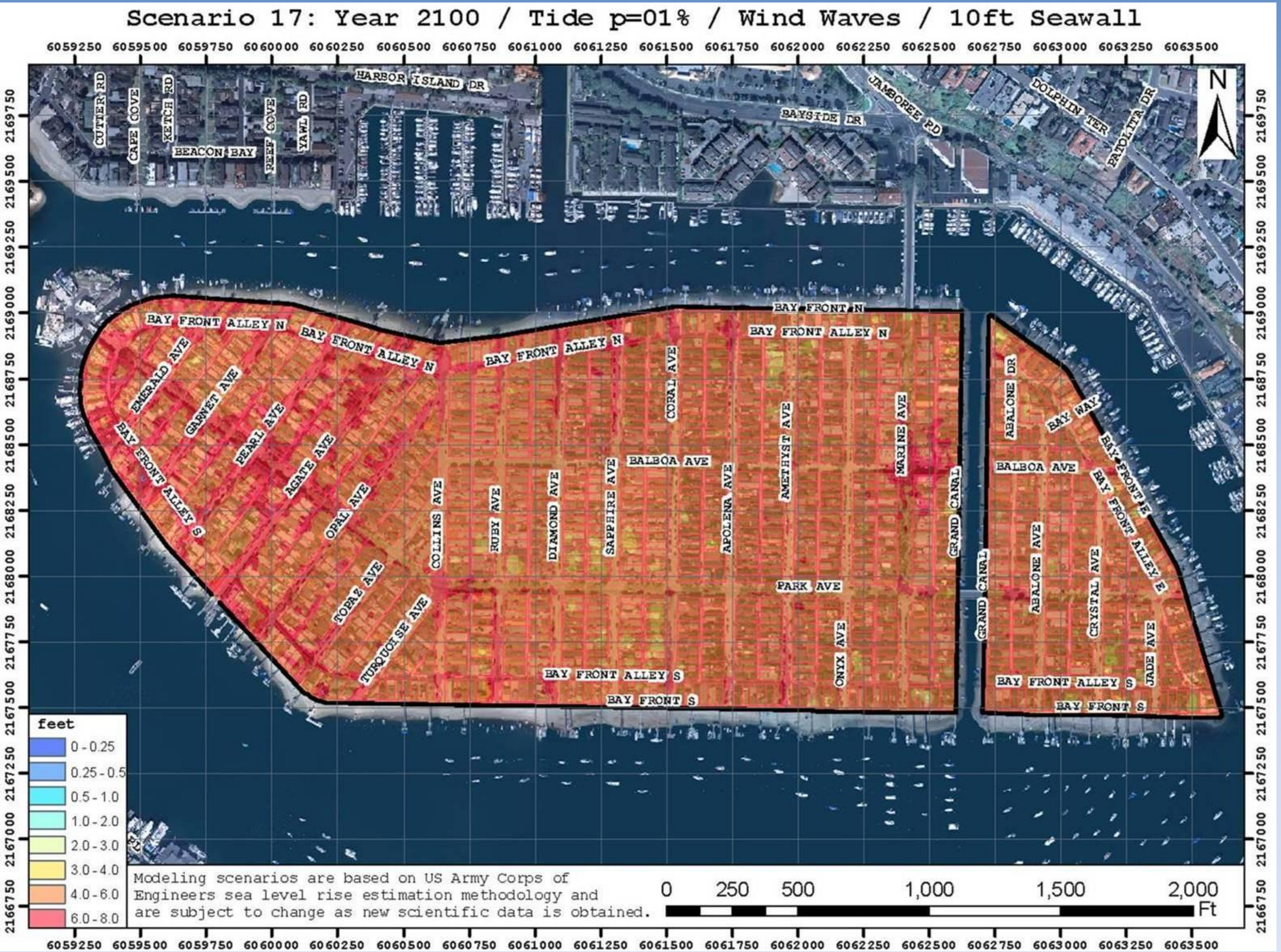
Year 2100, +10 ft MLLW Seawall



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Flood Depth, Parcel and Building Impacts

Scenario	Year	Tide Height (Annual Exceedance Probability)	Wave Scenario	Average * Flood Depth (ft)	Impacted** Parcels (number)	Parcels Impacted (%)	Impacted*** Buildings (number)	Impacted Buildings (%)
Existing Condition Scenarios								
1	2010	10%	No Waves	0.26	61	4.0	3 ± 2	0.2
2	2010	10%	Wind Waves	0.26	61	4.3	3 ± 2	0.2
3	2010	10%	Ocean Swell	0.29	514	36.5	24 ± 5	1.7
4	2010	1%	Wind Waves	0.36	324	23.0	22 ± 4	1.5
5	2025	10%	Wind Waves	0.48	681	48.3	66 ± 7	4.7
6	2025	10%	Ocean Swell	0.79	1,176	83.4	235 ± 13	16.6
7	2025	1%	Wind Waves	1.16	1,179	83.6	420 ± 14	29.8
8	2050	10%	No Waves	1.84	1,410	100.0	894 ± 17	63.4
9	2050	1%	No Waves	2.15	1,410	100.0	1047 ± 15	74.3
10	2100	10%	No Waves	5.02	1,410	100.0	1410 ± 1	100.0
6-inch Extension Scenarios								
11	2010	1%	Wind Waves	0.03	0	0.0	0	0.0
12	2025	1%	Wind Waves	0.12	12	0.9	0-1	<0.1
10-foot Seawall Scenarios								
13	2010	1%	Wind Waves	0	0	0.0	0	0.0
14	2025	1%	Wind Waves	0	0	0.0	0	0.0
15	2050	1%	Wind Waves	0	0	0.0	0	0.0
16	2050	10%	Wind Waves	0	0	0.0	0	0.0
17	2100	1%	Wind Waves	5.30	1,410	100.0	1410 ± 1	100.0

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Protection Option: Seawall Extension

1. Extend existing cap 6 inches
2. Remove existing cap and replace with 6-inch taller cap
3. Add sandbags or geotextile bags

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New Seawall – Option 1
H-piles and Concrete Wall (Lag) Panels

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New Seawall – Option 2
Steel Sheet Pile Bulkhead

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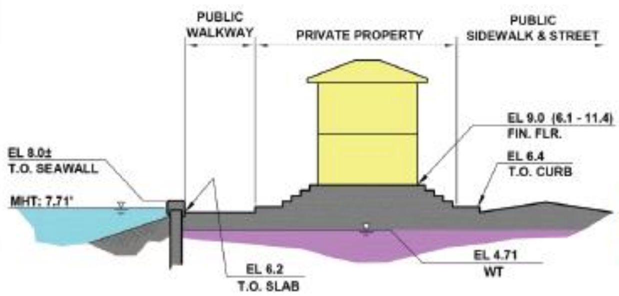
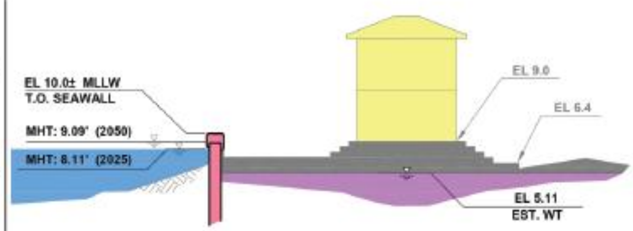
Conceptual Seawall Replacement Implementation Plan



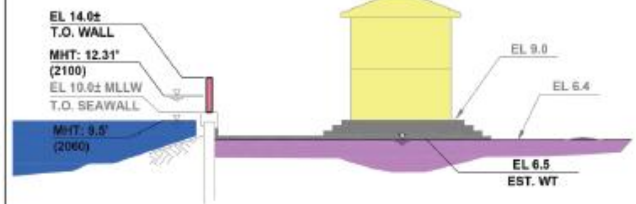
Existing Sample Condition
(Baseline - 2010)

1



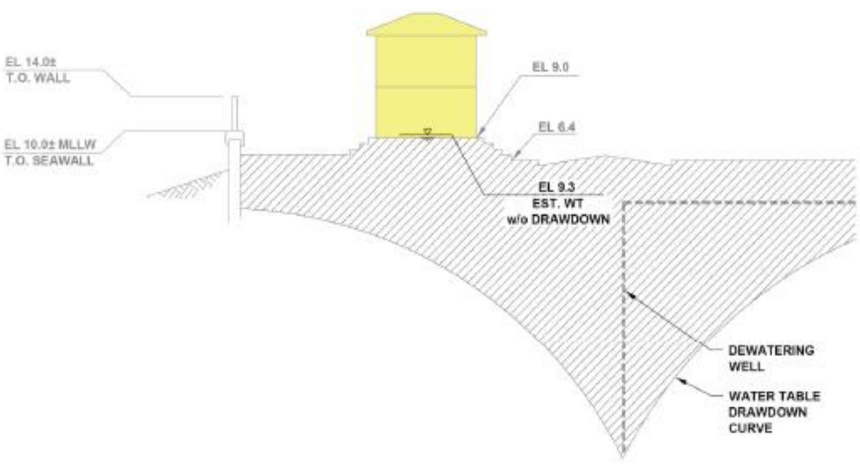
New Seawall
(Within 10 Years)

2



Seawall Extension
(Est. 2050 - 2060, or as req'd)

3



GROUND WATER DEWATERING SYSTEM

4

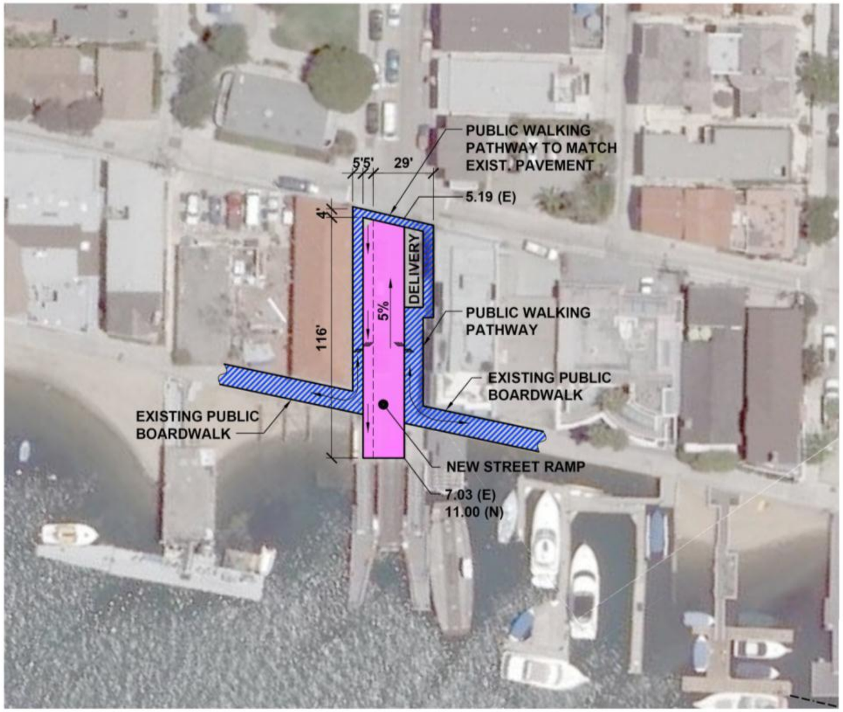
LEGEND:

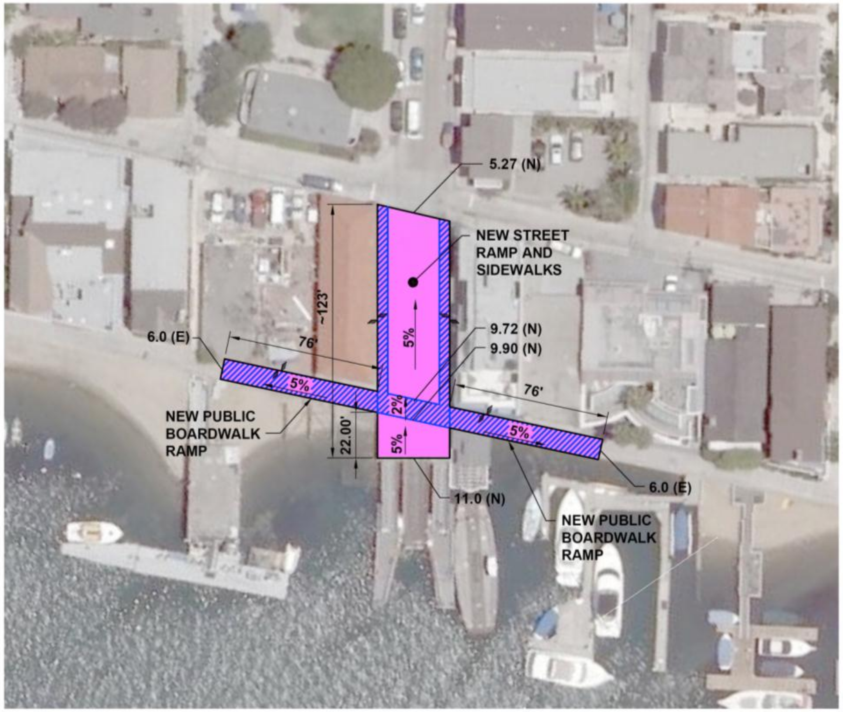
MHT	MAXIMUM HIGH TIDE PER FLOW SIMULATION, LLC REPORT OF 4/7/10
WT	WATER TABLE
MLLW	MEAN LOWER LOW WATER, 1983-2001 DATUM
NAVD88	NORTH AMERICAN VERTICAL DATUM 1988 (NAVD88 = 0.18' MLLW)
EST.	ESTIMATED
T.O.	TOP OF
FIN. FLR.	FINISH FLOOR, TOP OF

NOTES:

1. ALL ELEVATIONS SHOWN ARE NAVD88 DATUM UNLESS OTHERWISE NOTED (SEE Fig.1).
2. WATER TABLE (WT) IS ASSUMED AT 3 FEET BELOW TIDE LEVEL.

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





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

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

0 10' 20' 30' 60'
GRAPHIC SCALE

Datum: NAVD 88

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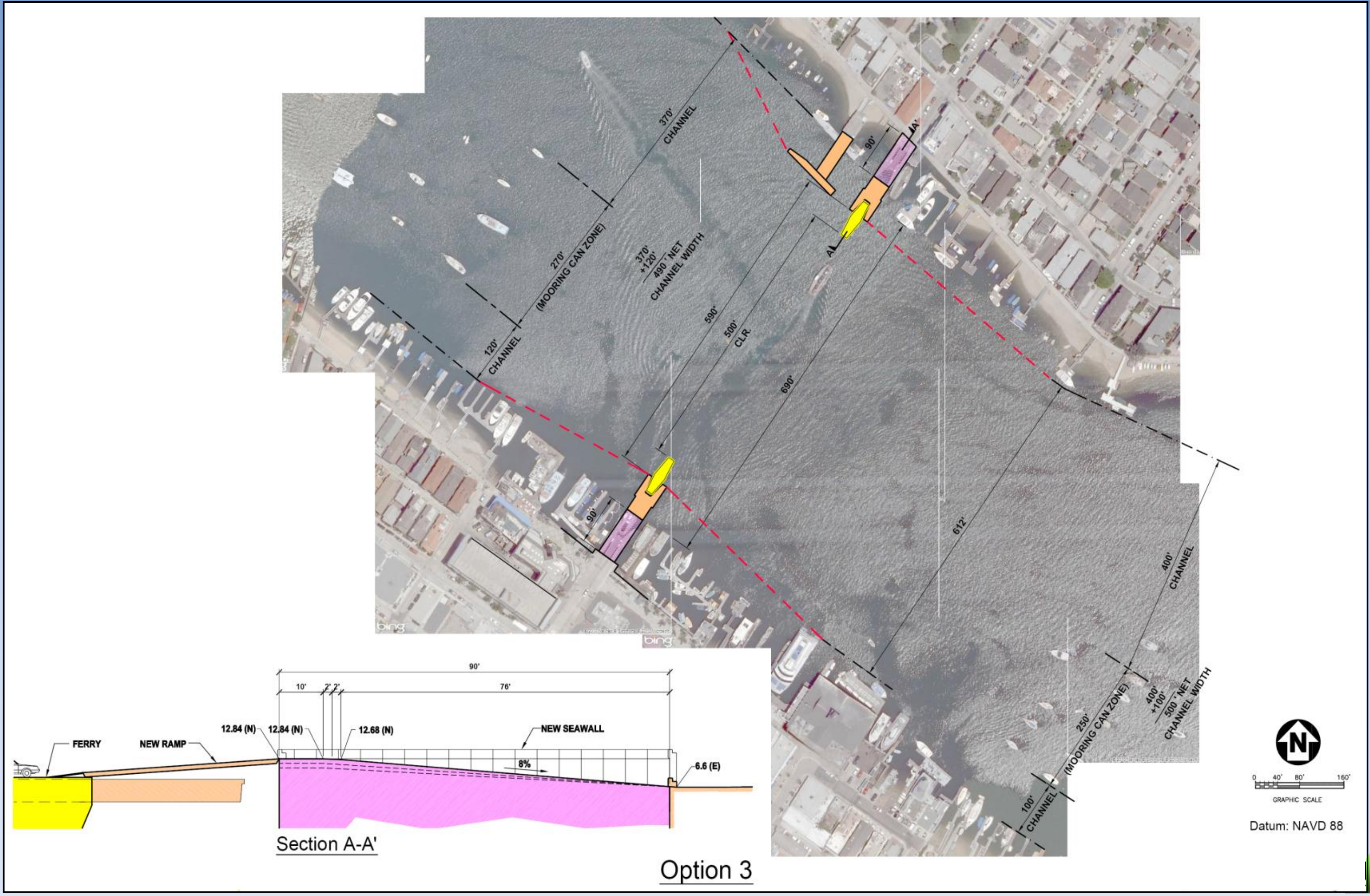
Balboa Island Ferry Modification



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Summary

- Aging seawalls at Balboa Island and Little Balboa Island are in need of repair
- A good example of how sea level rise can be incorporated in alternative development

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Recommendations

1. 2011-2020
   a. Review of codes, standards & policies
   b. Implement a community awareness program
   c. Establish new lowest floor elevation
   d. Harbor-wide planning for new seawalls at minimum 10 feet MLLW
   e. Balboa Islands seawall design and permitting
   f. Design for new ferry boat landing
   g. Assessment District Formation

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Recommendations

2. 2021-2035
   a. Replace seawalls w/ 10’ high seawalls
   b. Extend seawalls as needed while new seawalls are being constructed

3. 2050-2060
   a. Extend new seawalls if necessary to 13 or 14 feet MLLW
   b. Possible groundwater dewatering system or other means to address groundwater

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Thank You

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