

# Santa Barbara County Coastal Resiliency Project

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**Coastal Hazard Modeling & Mapping**



**Vulnerability Assessment**



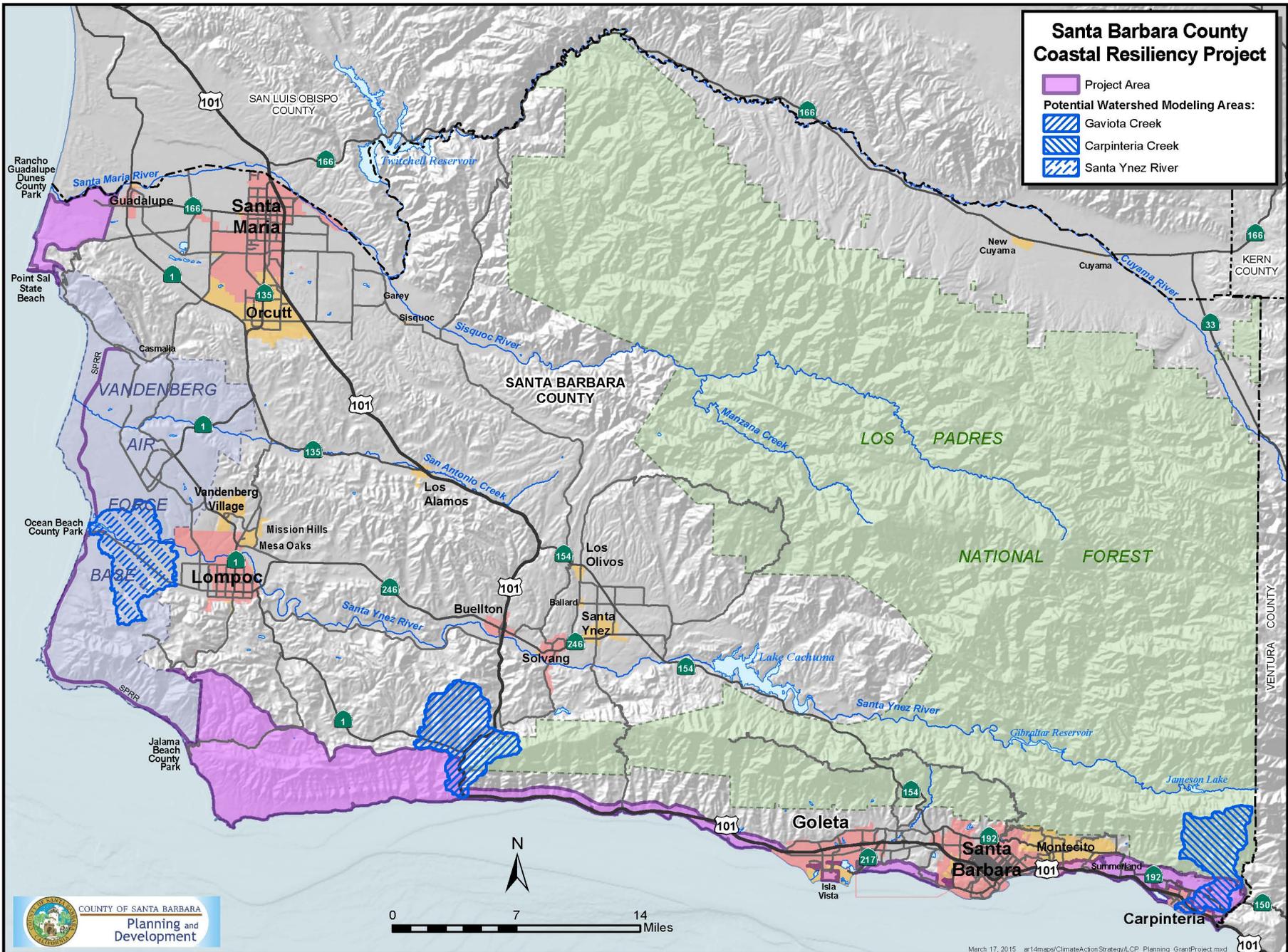
**Adaptation Plan**



**LCP Amendment**

# Santa Barbara County Coastal Resiliency Project

- Project Area
- Potential Watershed Modeling Areas:**
- Gaviota Creek
- Carpinteria Creek
- Santa Ynez River





# Phase 1 Project Background

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- ▶ Funded by the Coastal Conservancy's Climate Ready Grant Program
- ▶ Project Initiated:  
July 2014
- ▶ Proposed Completion:  
December 2015



*Photo David Revell*



# Phase 1 Scope of Work

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- ▶ Task 1 – Project Kick Off Meeting
- ▶ Task 2 – Stakeholder Meetings
- ▶ Task 3 – Develop Regional Resource Databases
- ▶ Task 4 – Model Coastal Hazards with Climate Scenarios
- ▶ Task 5 – Develop Policy & Planning Tool Database
- ▶ Task 6 – Analyze Social, Economic & Ecological Conditions
- ▶ Task 7 – Prepare a Coastal Hazard Vulnerability Assessment



# Coastal Hazard Modeling & Mapping

- ▶ Working with ESA and Revell Coastal
- ▶ Based on The Nature Conservancy's *Building Coastal Resilience for Disaster Risk Reduction and Climate Adaptation* project.



# Santa Barbara County Coastal Resiliency Project - Phase 1

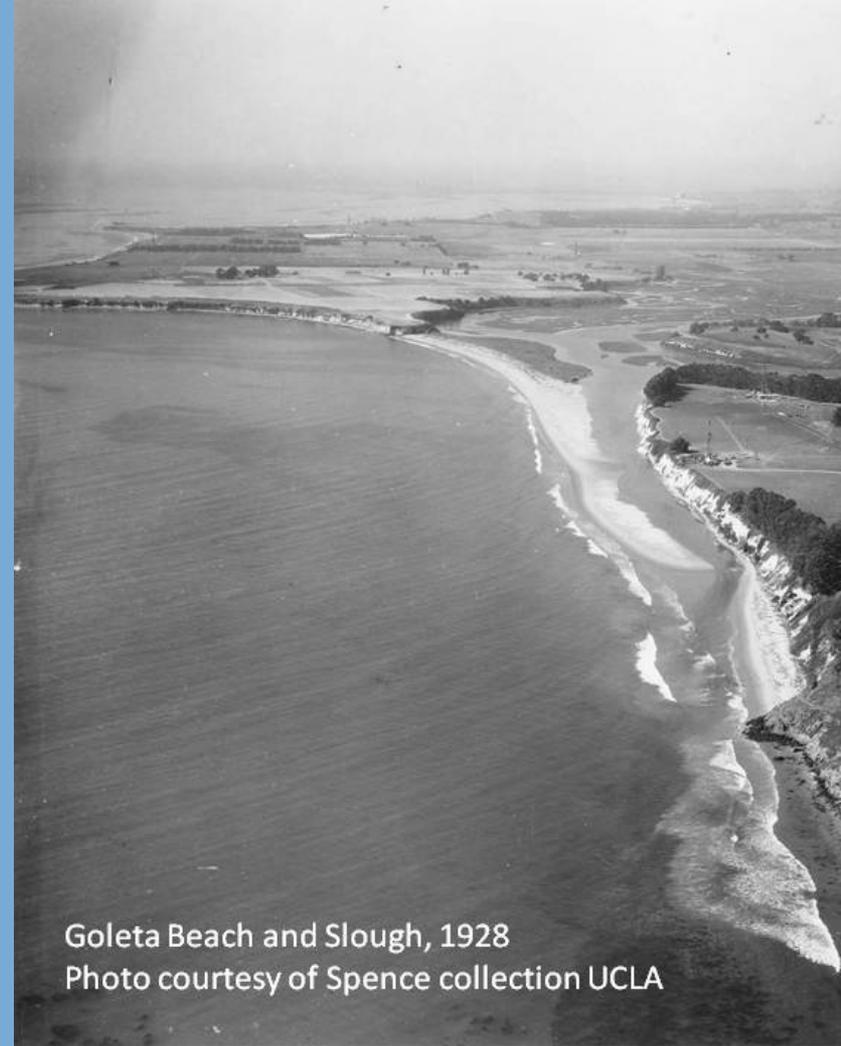
David Revell, PhD.

Bob Battalio, P.E.

James Jackson, E.I.T

Elena Vandebroek, P.E.

Jeremy Lowe



Goleta Beach and Slough, 1928  
Photo courtesy of Spence collection UCLA

ESA



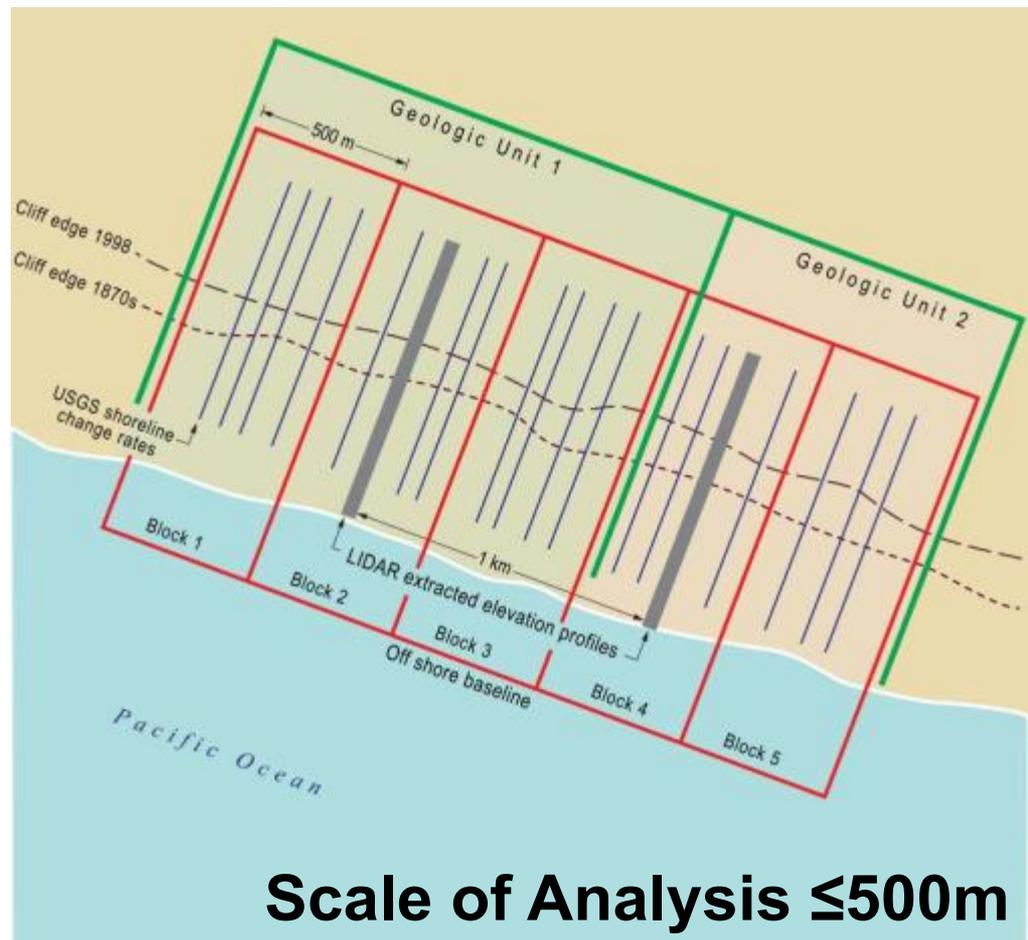
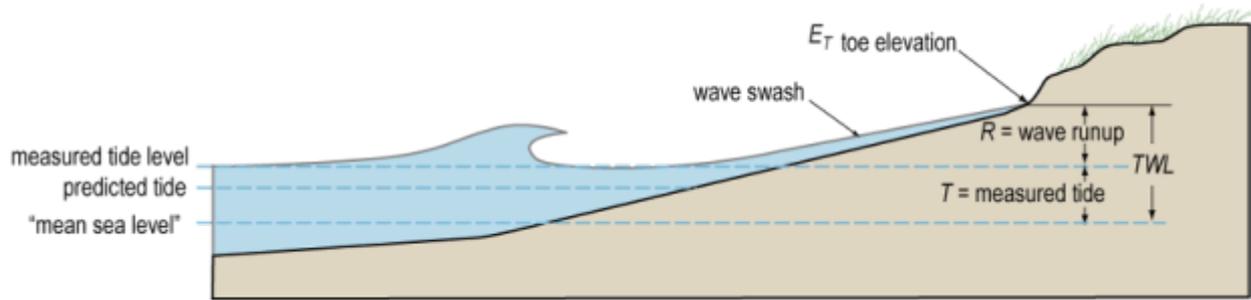
REVELL  
COASTAL

State of California  
Coastal Conservancy 

The Nature  
Conservancy   
Protecting nature. Preserving life.®

# Inputs

- Physical Forces
  - Offshore wave/ climate “scenarios”
  - Transformed nearshore waves
  - Tides
  - Total Water Levels
- Backshore Characterization
  - Geology
  - Geomorphology (slopes, heights)
  - Backshore type (cliff, dune, inlet, armored)
  - Historic erosion rates (short term, long term)
  - Coastal Armoring
  - Topography



# Outputs

## 1. Erosion Hazards

*Future erosion increases hydraulic connection and risk of flooding*

## 2. Coastal Flooding

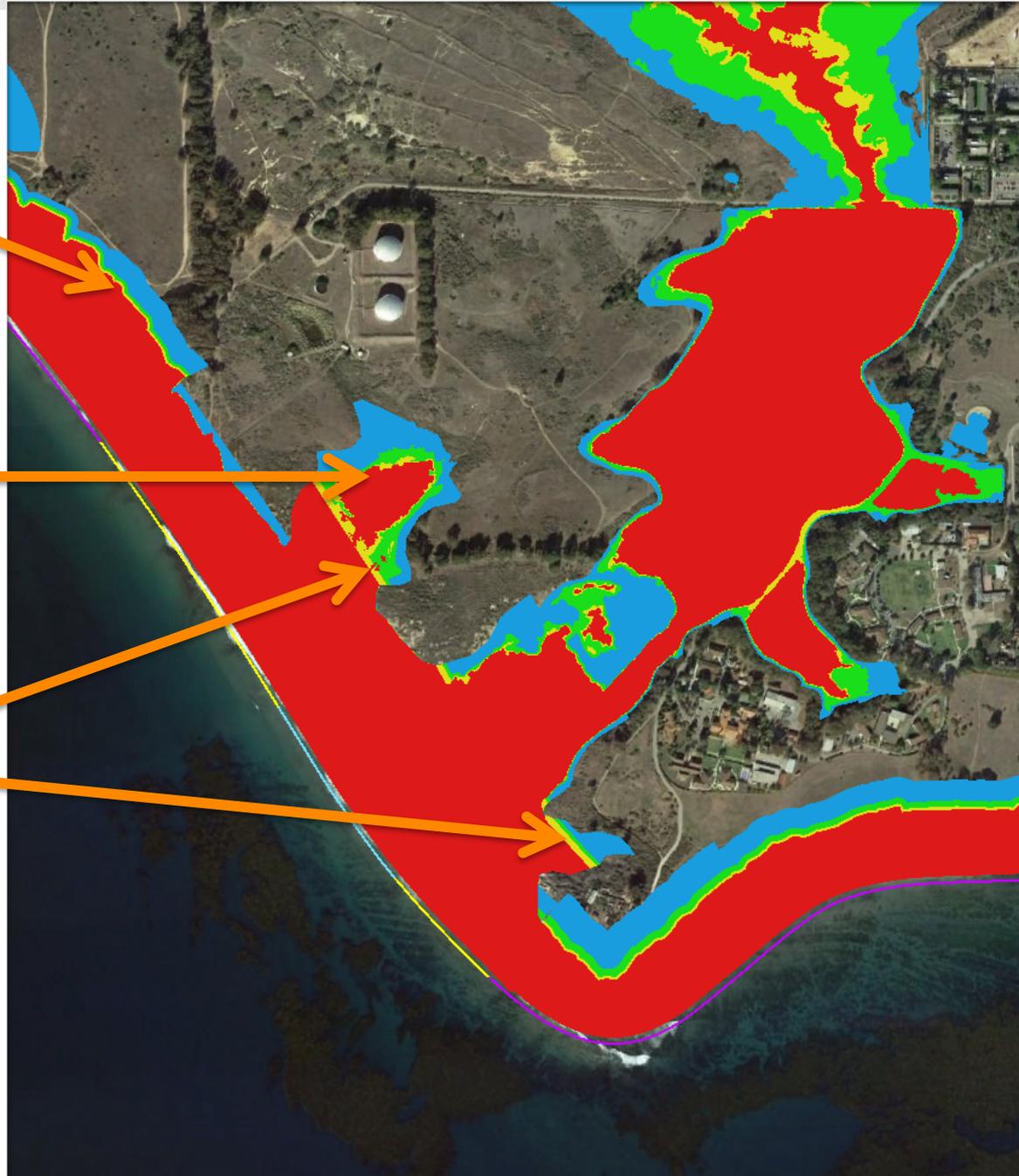
*inundation during extreme coastal events (integrated with erosion)*

## 3. Wave Velocity

*zone of wave momentum (similar to FEMA V-Zone)*

## 1. Rising Tides

*inundation during monthly extreme tides [not shown]*



A photograph of a cliffside with houses and a staircase leading down to the ocean. The houses are built on a steep, rocky cliff. A concrete staircase with metal railings leads down from the cliff to the ocean. The ocean is turbulent with white foam. The sky is overcast.

# Selected Conditions

Planning Horizons

Sea Level Rise

Lagoon Management

Coastal Armoring

Sediment Management

# Scenarios

## Planning Horizons:

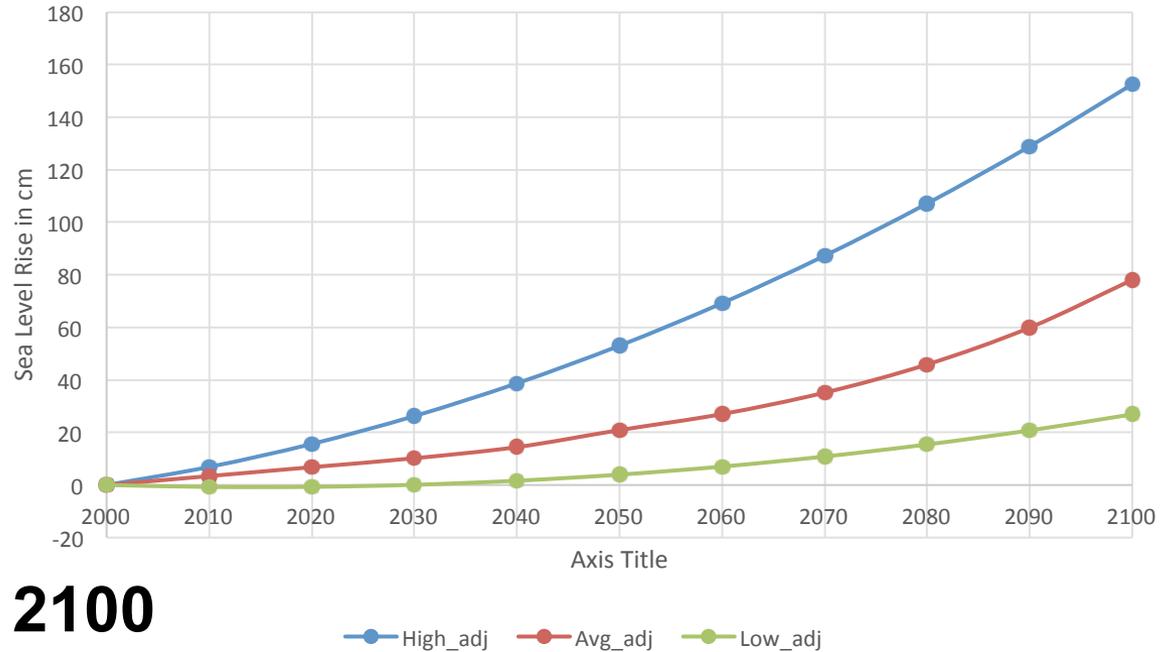
- 2010, 2030, 2060, 2100

## Sea Level Rise:

- **High: 1.52 meters by 2100**
- Medium: 0.78 meters by 2100
- Low: 0.27 meters by 2100

## Waves:

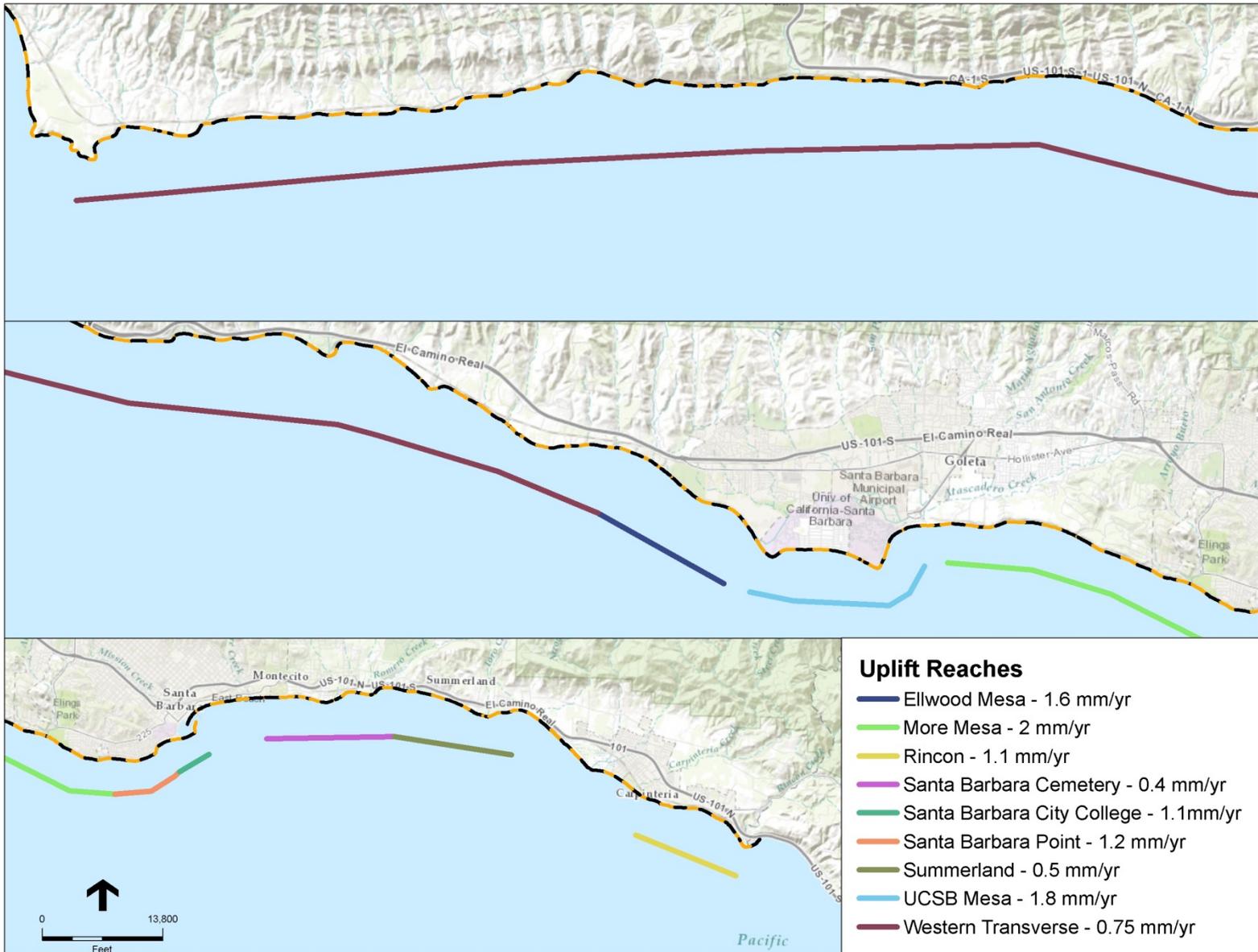
- **Existing wave data repeated**
- COSMOS 3.0 RCP 4.5
- COSMOS 3.0 RCP 8.5



## Vertical Land Motion:

Removed South of Cape Mendocino subsidence rates from NRC 2012 report

# 9 uplift reaches in Santa Barbara



# SB – Medium SLR scenario alternatives

NRC LA Medium Curve with SB Uplift reaches

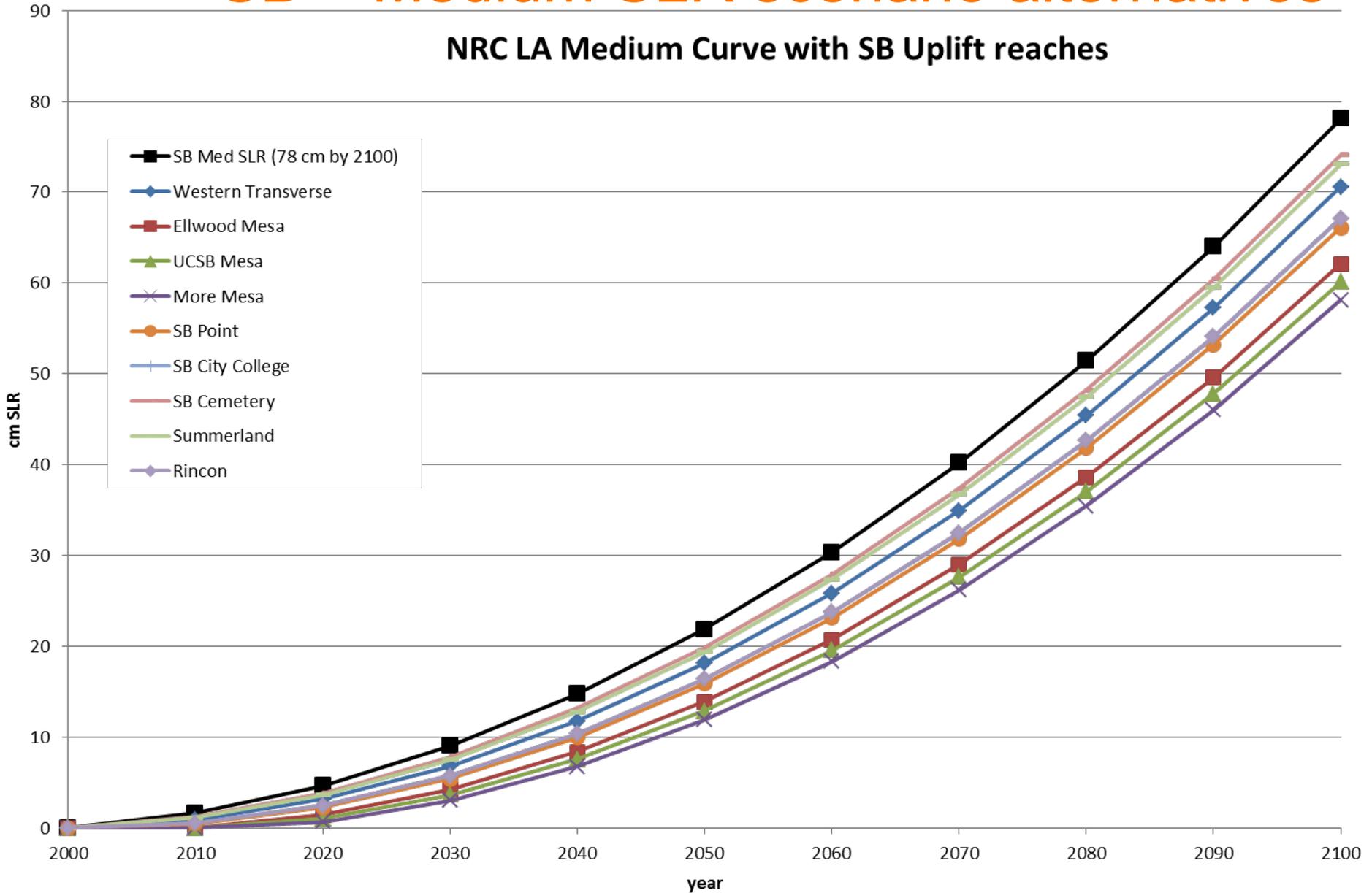




Photo [www.californiacoastline.org](http://www.californiacoastline.org)



Photo City of Goleta



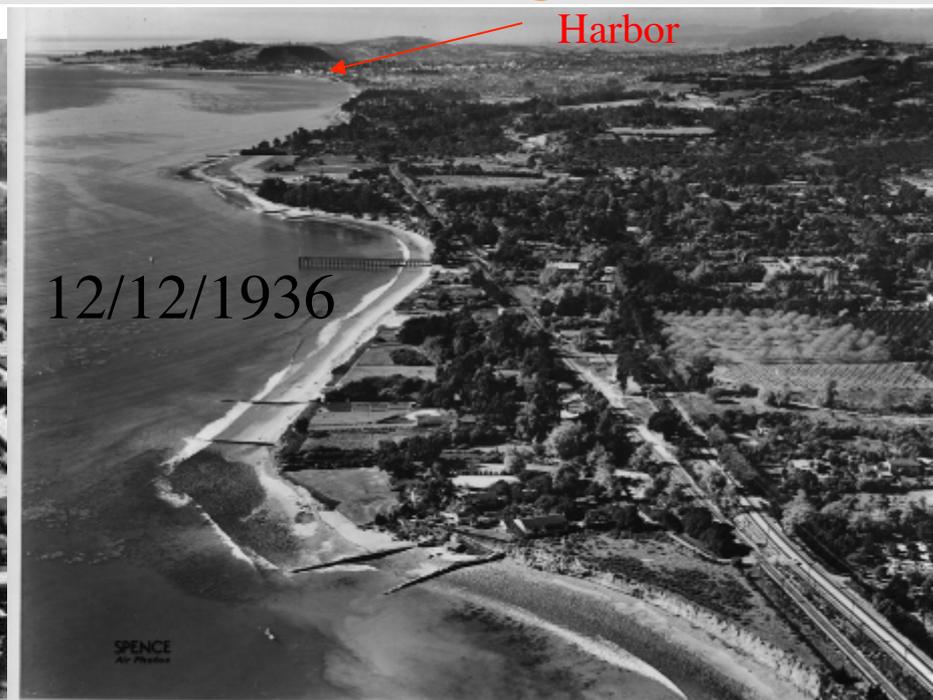
Photo David Revell

1927



Harbor

12/12/1936



1934

*Sandyland, a beachfront area near Carpinteria once known for its sand dunes, has received its fair share of harsh weather over the years.*

1938



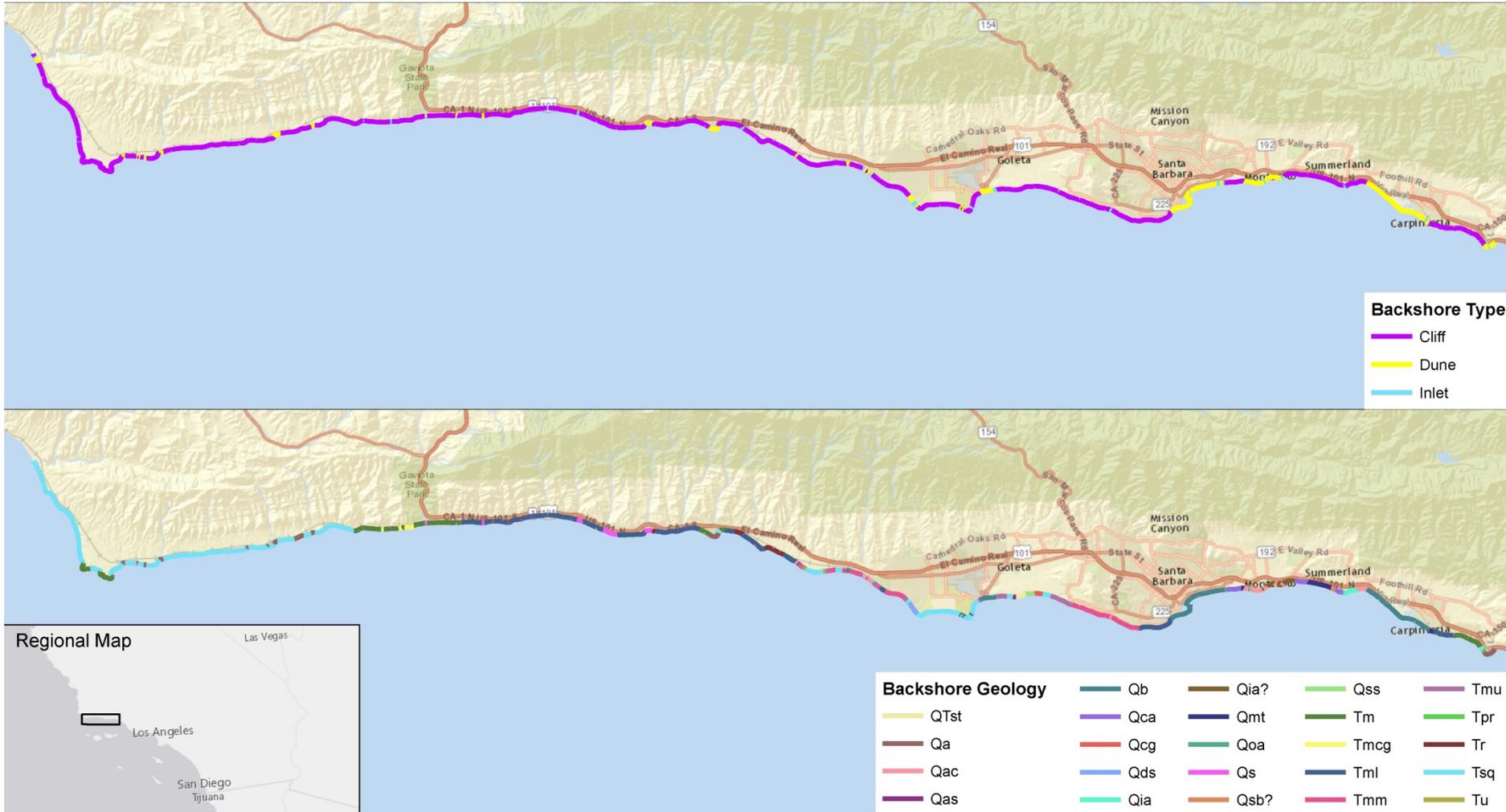
## Selected conditions

- Geology (USGS, Steve Campbell, Ed Keller, Larry Gurrolla)
- Shoreline armoring (Coastal Commission)
- Erosion Rates (USGS, Revell PhD, LiDAR)
- No inclusion of management strategies (e.g. armoring)<sup>\*\*\*</sup>
  - Erosion allowed despite armoring
  - Historic erosion rates at armoring replaced with geologic rates
- Topography from 2009 LIDAR



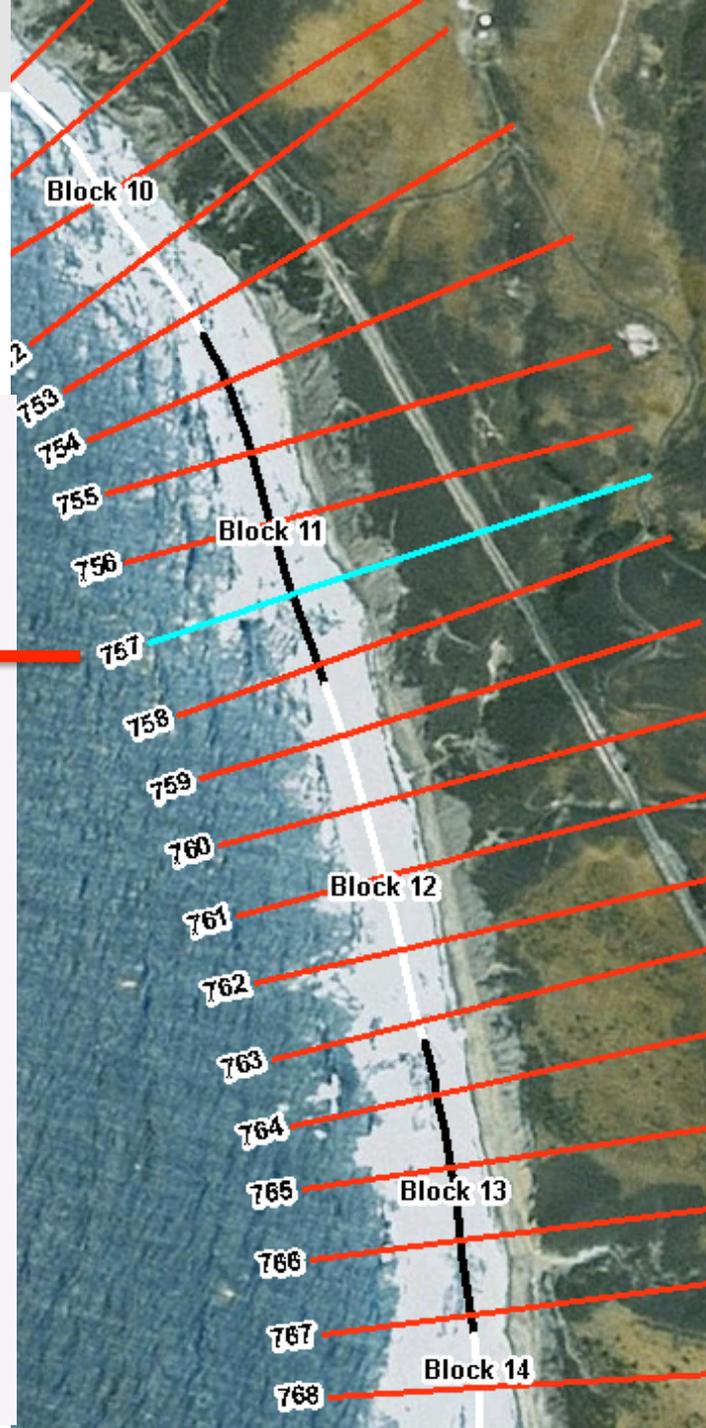
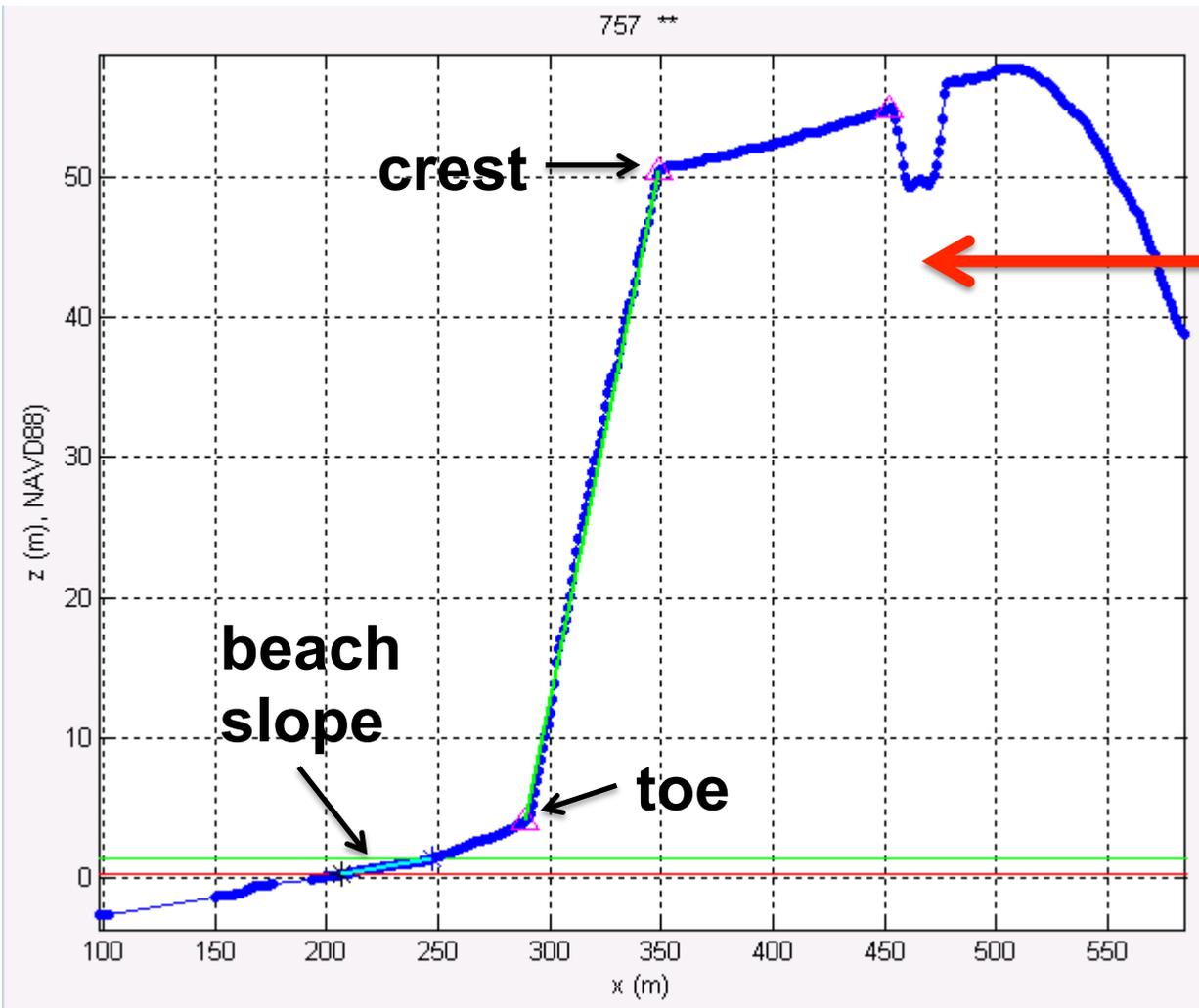
*Photo: A. Bermond*

# Backshore Characterization



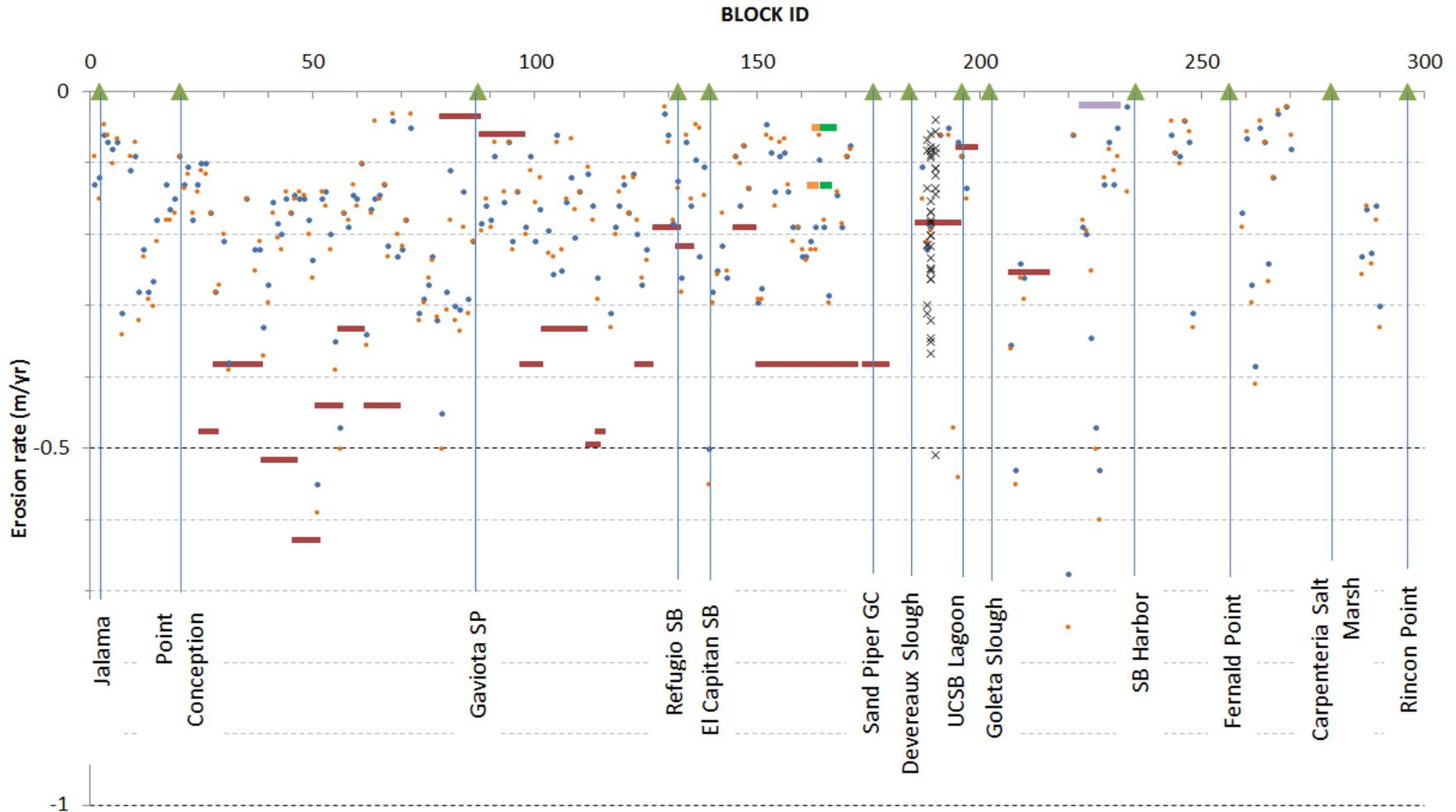
# Profile Analysis

~1100 profiles  
4-5 per block

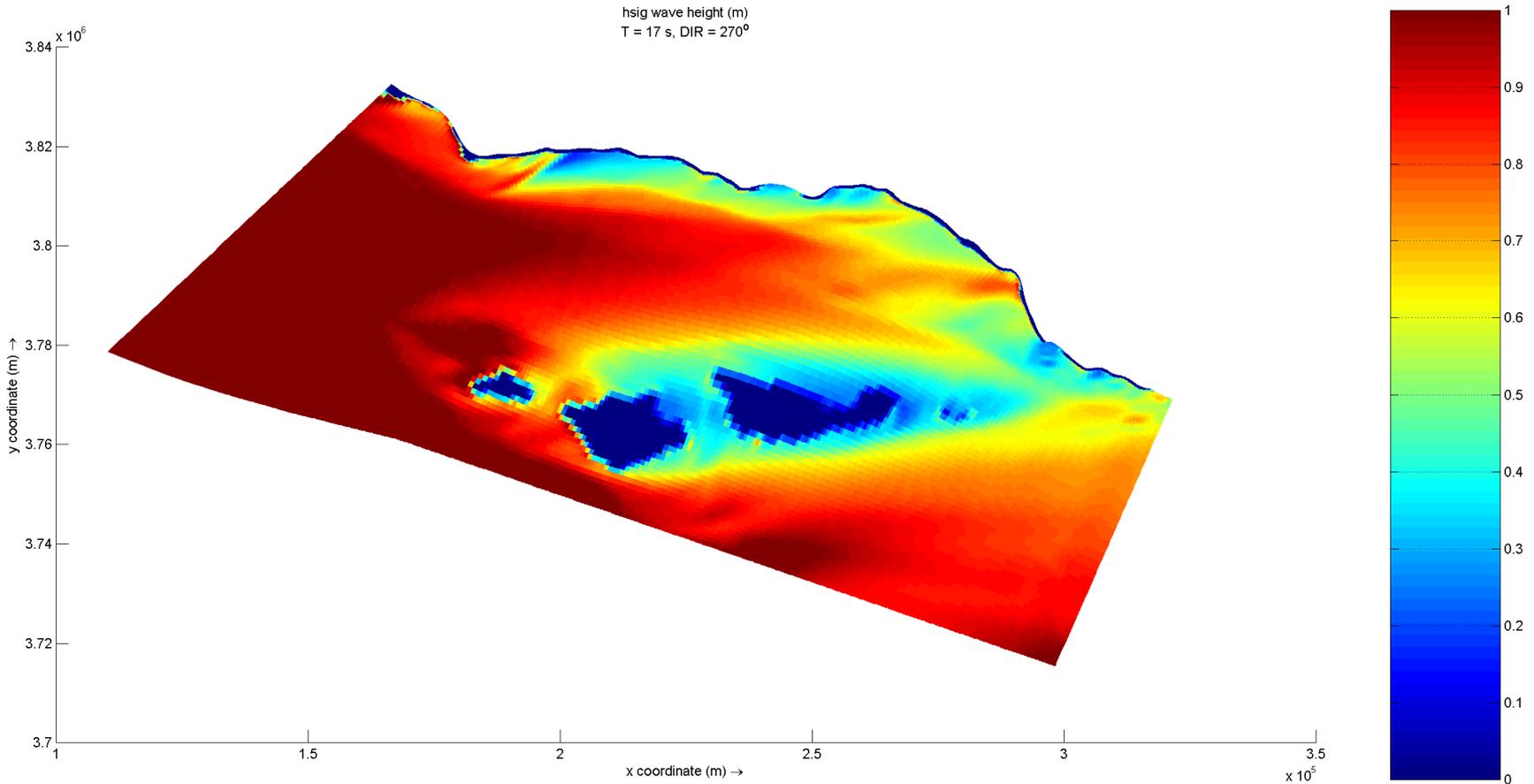


# Cliff Erosion Rates - This study compared to consultant reports

- ▲ reference mark, label at bottom
- USGS cliff erosion LRR
- USGS '33 to '98 EPR
- Safety Element Mesa Rates
- Diener (2000)
- Makar 58
- Makar 59
- × Consultant IV Rates



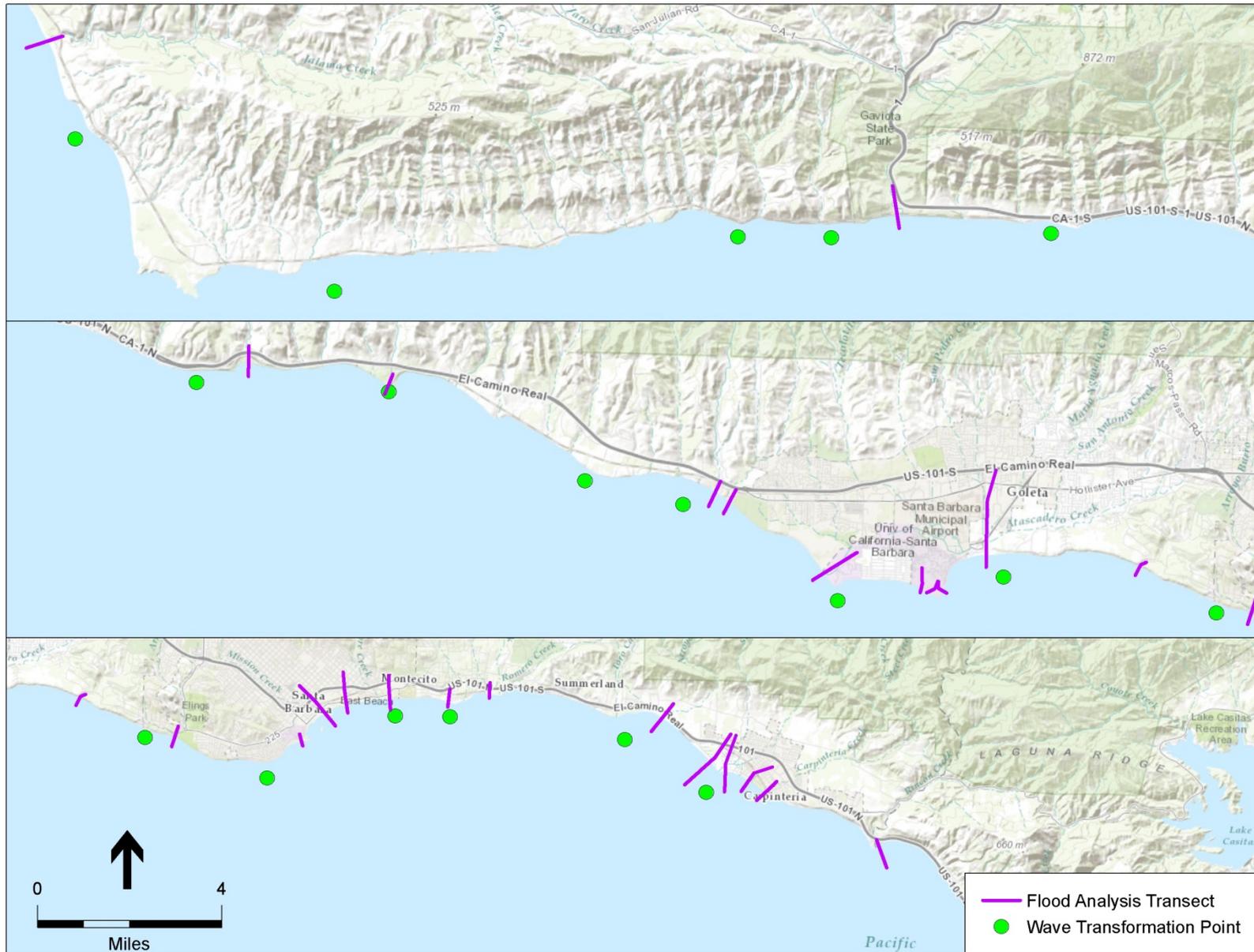
# Wave Transformation Models



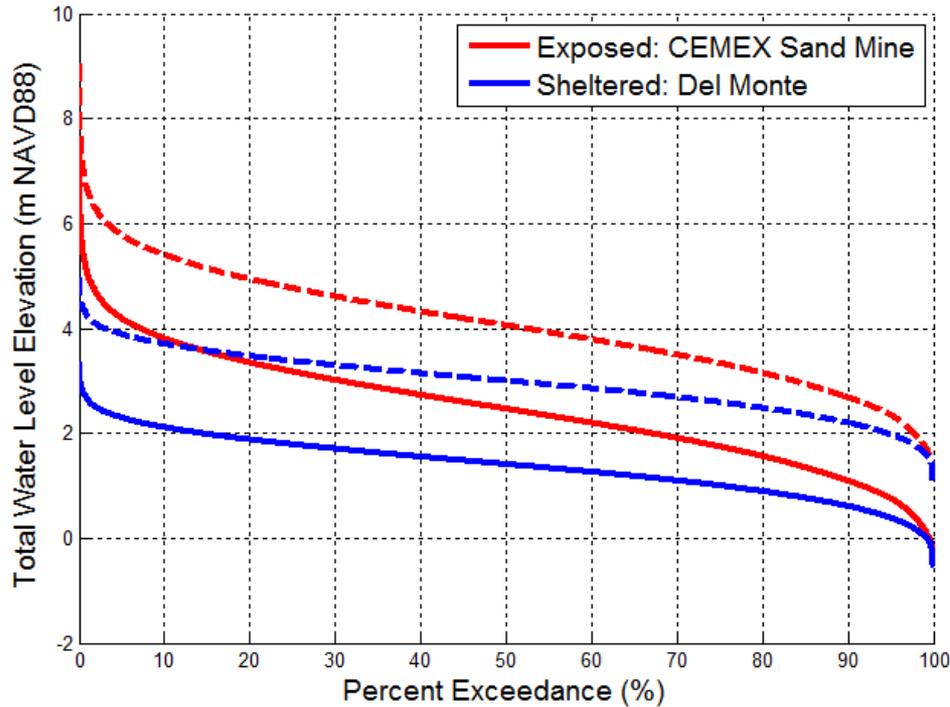
Transformations using Grids from USGS from COSMOS 3.0

- Southern California Grid
- Santa Barbara Grid (extended)

# Wave Transformation Points & Flood Profiles



# Total Water Levels



- Combined SLR and Wave Run-up
- Generate exceedance curves for each block using individual slopes and toe elevations

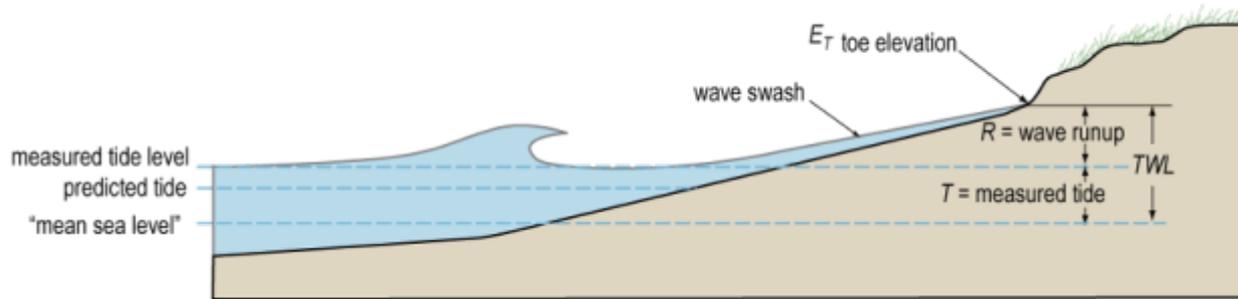
# Total Water Level

- Wave Data:

- Coincident hourly wave and water level time series, 1996-2013
- Deepwater Waves from Harvest Platform buoy, with gaps filled from Diablo Canyon buoy (located near Point Conception)
- Waves transformed to shore using refraction modeling

- Tides:

Water levels from tide gage at Santa Barbara (Station 9411340)



- Runup methods

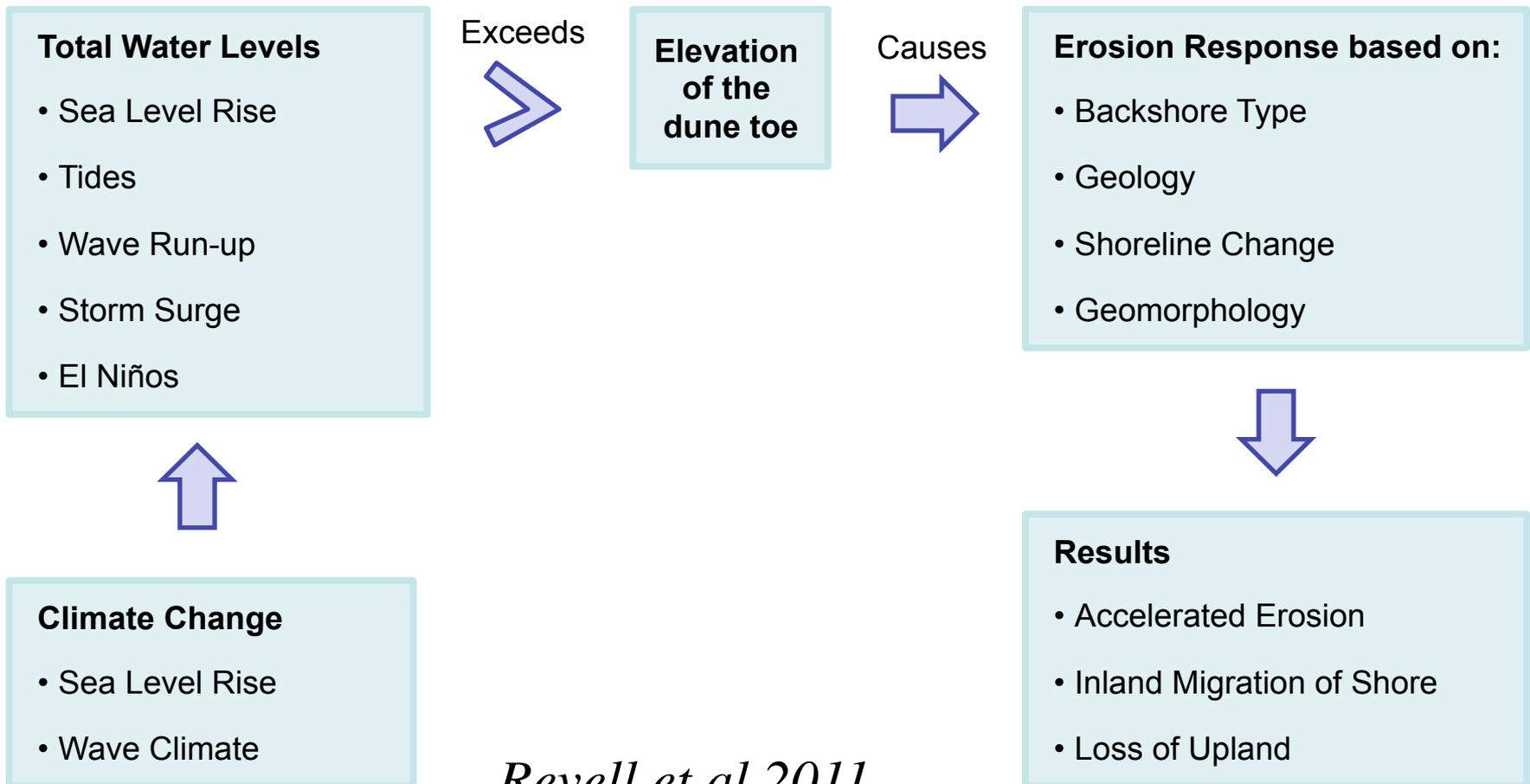
- Stockdon for all profiles – drives erosion
- Composite slope for low backshores – drives flooding

# Coastal Erosion Hazards Analysis



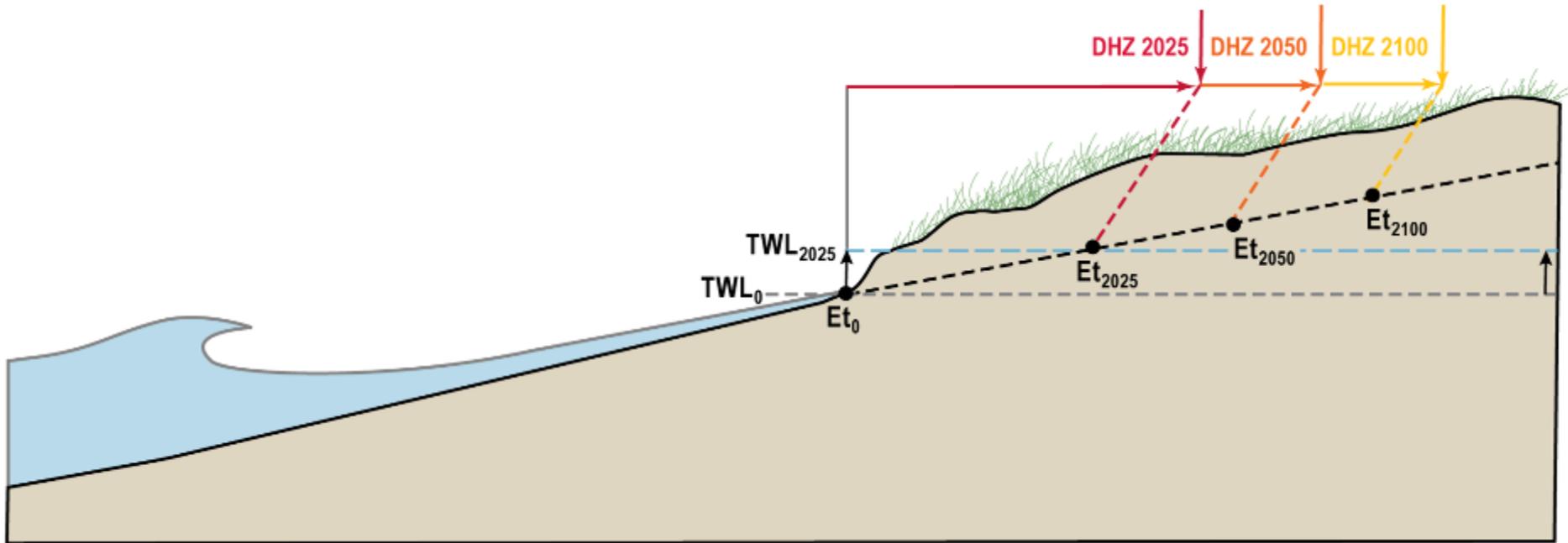
Goleta Beach February 1998  
Photo courtesy of Dr. Mark Morey

# Coastal Erosion Hazards Concepts



*Revell et al 2011*

# Dune Erosion Components



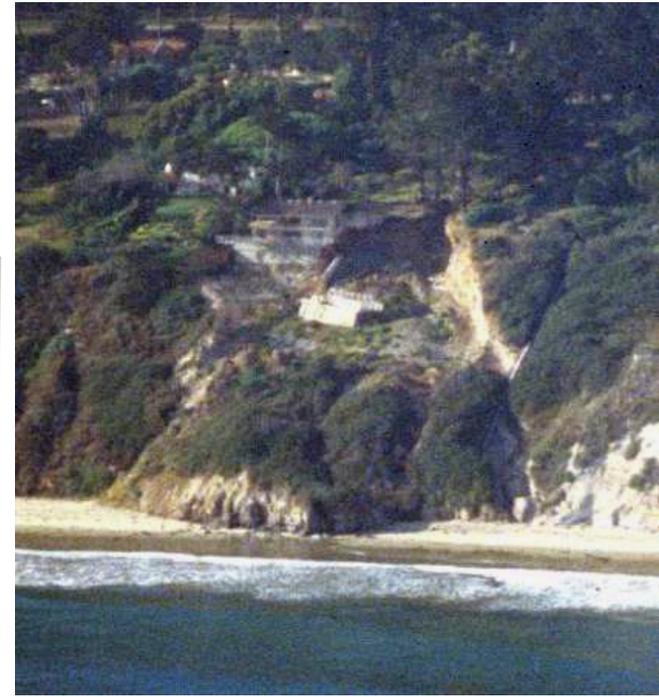
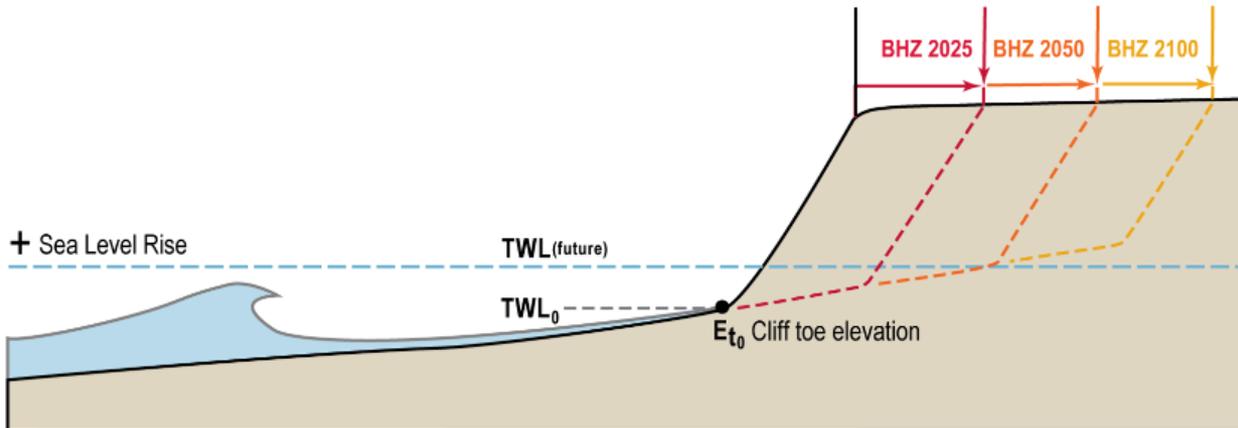
- 3 components –

1. Changes in TWL from SLR combined with shoreface slope
2. Historic shoreline trends (USGS, updated with 2005, 2009, 2010)
3. Impact of a “100 year storm event”

# Goleta Beach

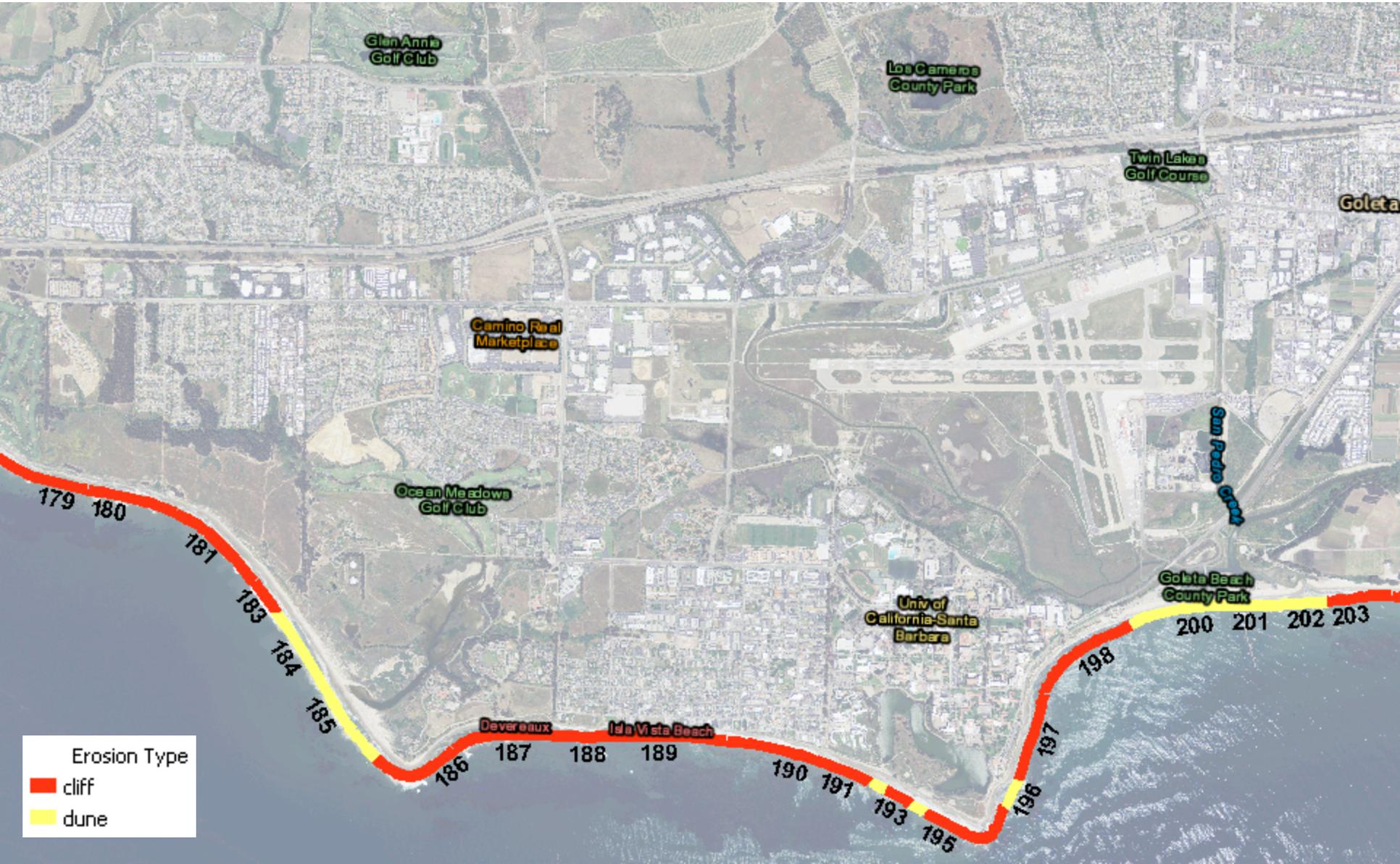


# Cliff Erosion Model



- Prorated acceleration of historic erosion rates based on increases in the duration of wave attack at various elevations
- Include geologic unit standard deviation x planning horizon or geomorphic failure widths to account for uncertainties in alongshore variability

# Erosion Mapping



# Flood Mapping Approach

## Downtown Santa Barbara



- Divide coast into regions based on geomorphology
- Identify dominant process driving coastal flooding:
  1. 100-year tide
  2. Wave run-up on cliffs
  3. Overtopping by waves into low-lying areas
  4. Closed lagoon water levels
  5. Other



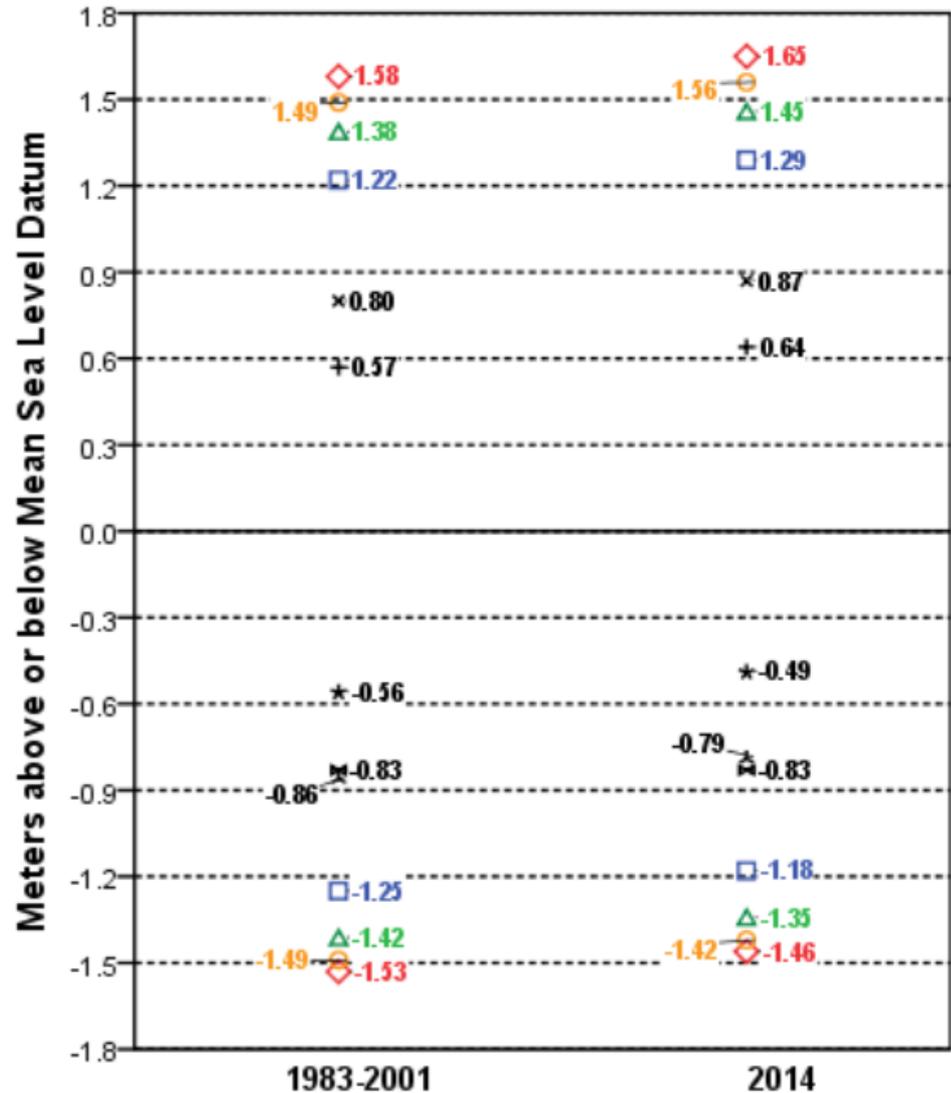
# 1. 100-yr Tide

- 100-yr water level from Rincon tide gage (NOAA 2013)
  - 2.99 m NAVD88
- Assume rises with SLR
- Adding EMHW as requested

Annual Exceedance Probability Levels and Tidal Datums

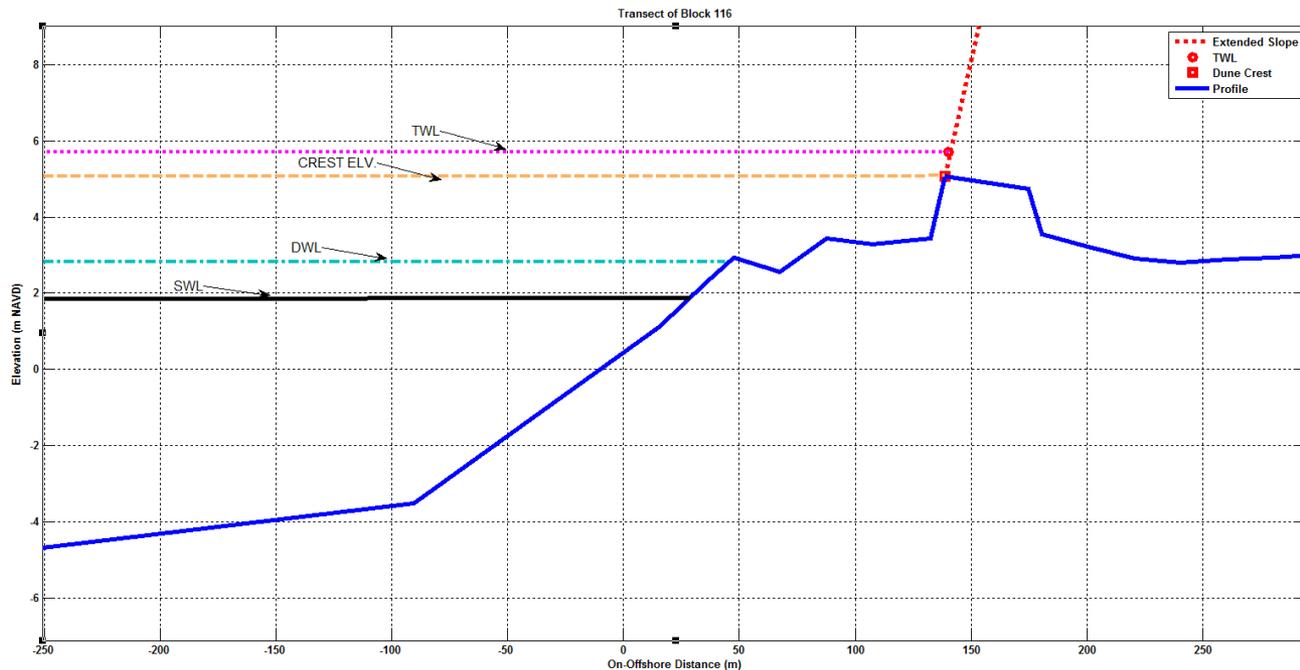
- ◊ 1%
- 10%
- △ 50%
- 99%
- × MHHW
- + MHW
- \* MLW
- △ MLLW
- ⊠ NAVD88

Rincon Island, CA



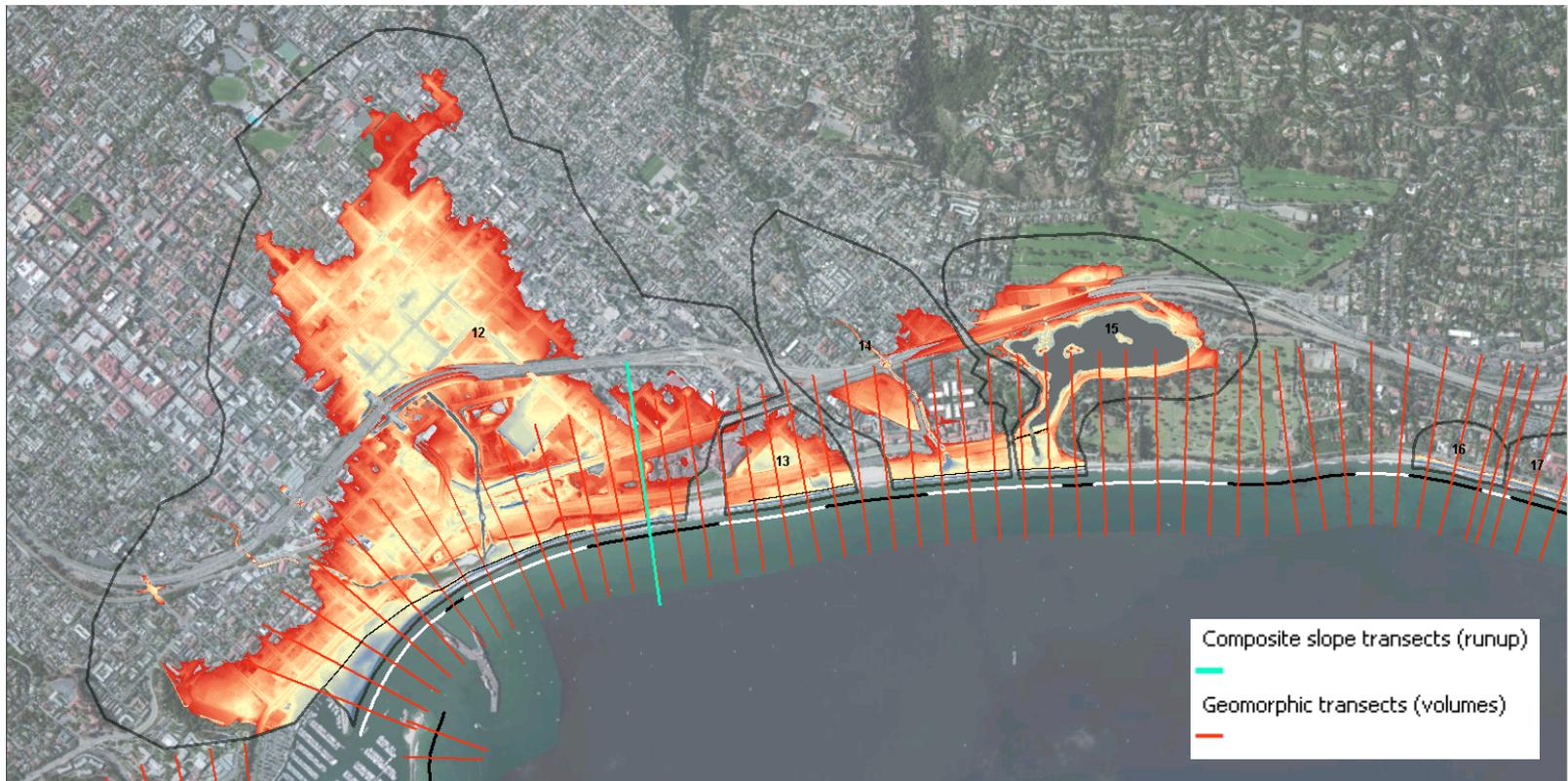
## 2. Wave Run-up

- Wave run-up analysis using full-length representative profiles
- Identified the event in a 17-year (1996 – 2013) wave time series that caused the highest run-up on each profile.
- Runup represented by
  1. Potential elevation at backshore
  2. Potential inland extent of wave action



### 3. Overtopping

- Delineate flood basins based on topography
- Estimate overtopping **volume** at 100 m spacing alongshore
- Map flood elevation over existing topography



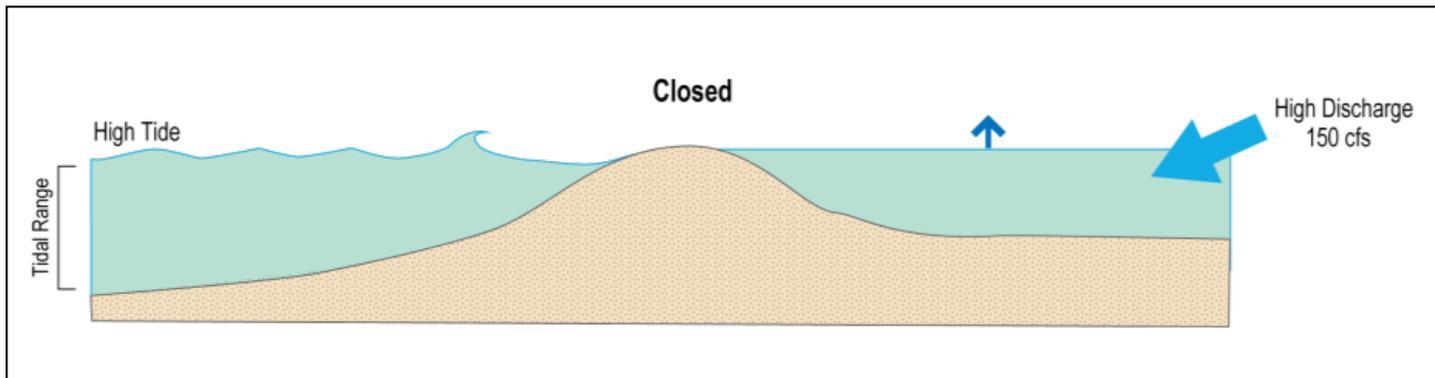
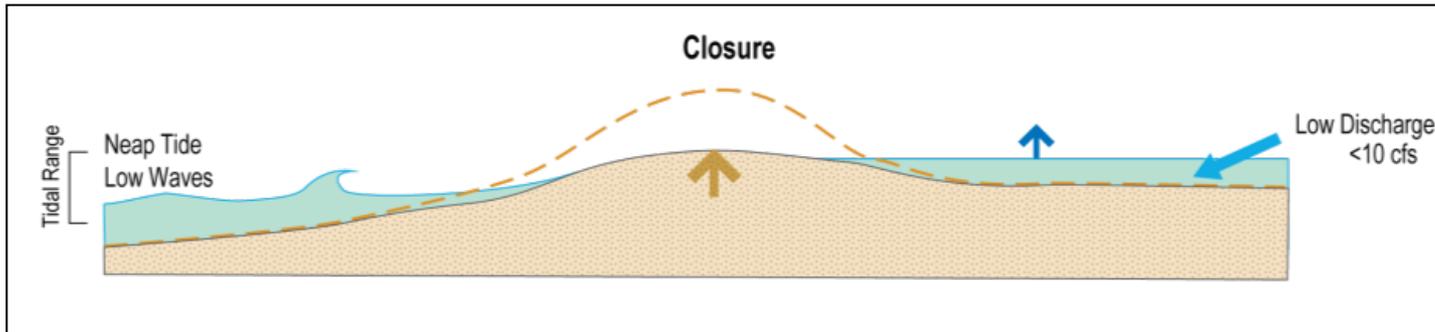
# Cabrillo Blvd

**Figure 10. Palm Park, on Cabrillo Boulevard, was strewn with debris, including a picnic table that was carried in by waves that had overtopped East Beach in March 1983 (*Santa Barbara News-Press*).**



## 4. Closed Lagoon Water Levels

- Highest water levels observed during lagoon closures
- Water levels related to beach berm elevation
- Geomorphic interpretation of maximum beach berm crest
- Assume beach berm elevation grows with SLR



# Lagoons Closed (except for Carpinteria Salt Marsh)

Pre Breach 7am April 1, 2014

*Photo: A. Bermond*



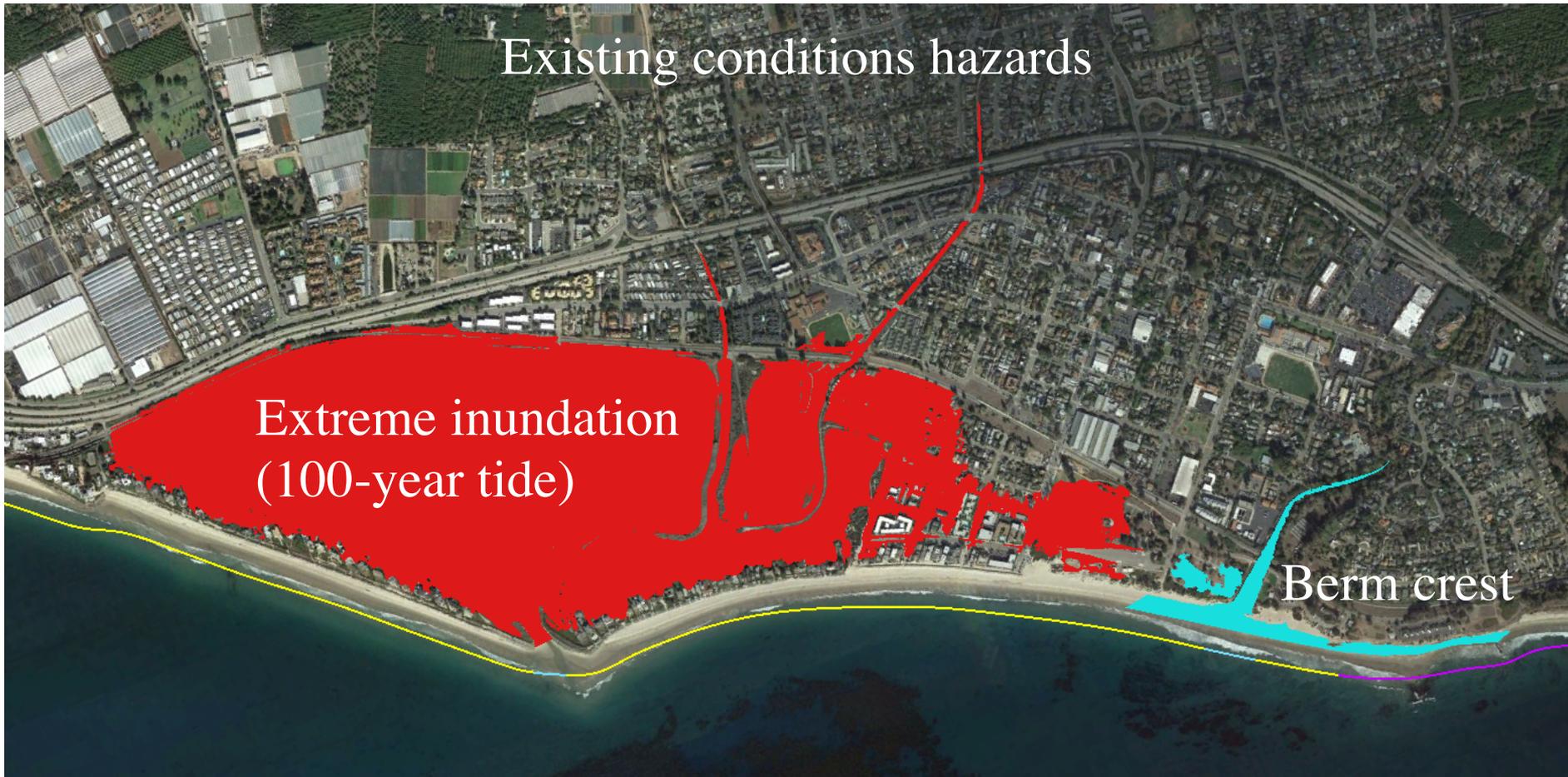
# Lagoons Open

Post Breach 5:45pm – April 1, 2014



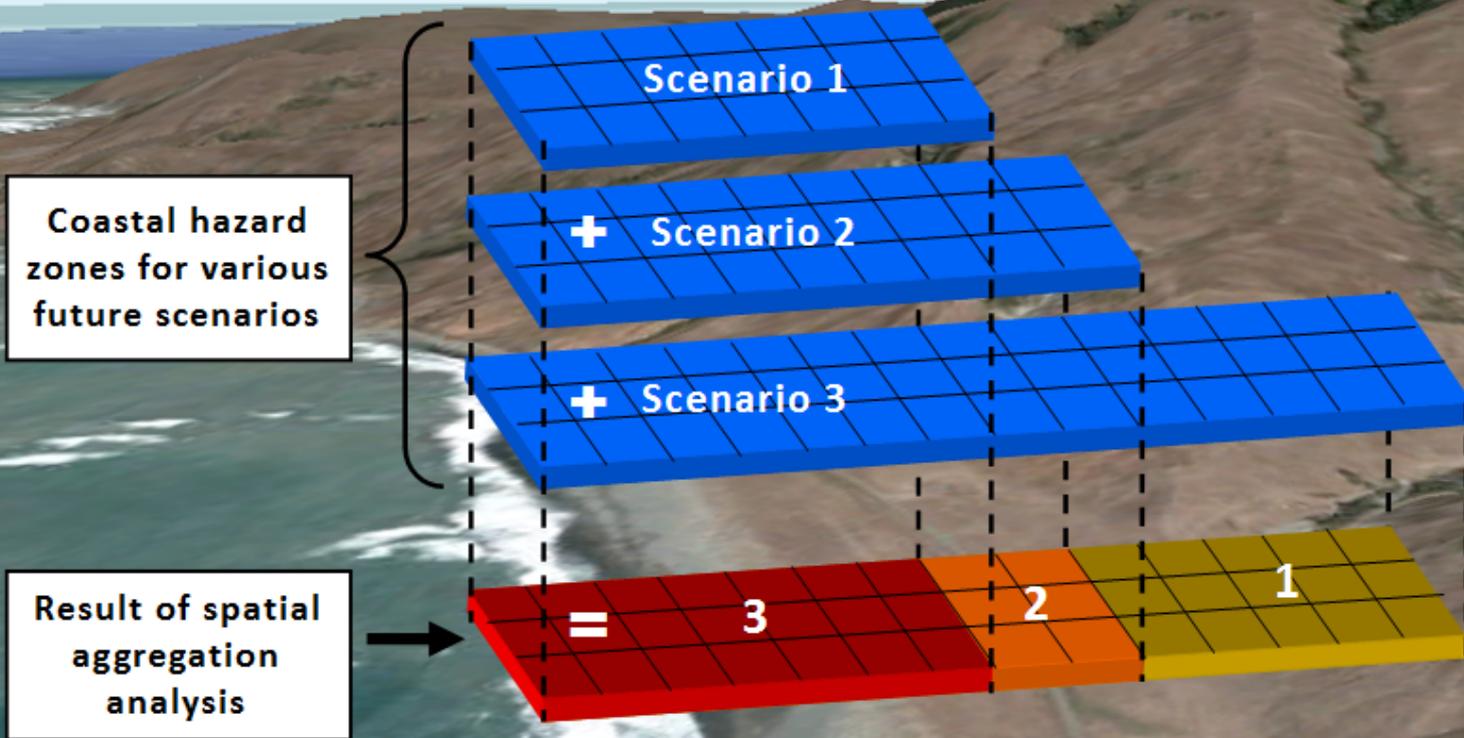
*Photo: A. Bermond*

# Mapping Flood Hazard Zones



# Evaluating Uncertainty: *Spatial Aggregation*

Spatial Aggregation Schematic



*Spatial Aggregation* =  
 Adding together overlapping hazard zones, pixel by pixel, to show relative probability.



# Proposed Next Steps

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- ▶ **South Coast Vulnerability Assessment**
  - ▶ Summer 2015 through Fall 2015
  
- ▶ **North County Modeling & Mapping**
  - ▶ Proposed Fall 2015 through Winter 2017
  
- ▶ **LCP Amendment**
  - ▶ Proposed Fall 2015 through Winter 2017
  
- ▶ **Adaptation Plan (unfunded)**