

# Potential Impacts of sea-level rise on Transportation and Fuel Infrastructure

Modeling Climate Impacts in the California Delta, San Francisco Bay, California Coast

John Radke<sup>1,2,4</sup> & Greg Biging<sup>3</sup>

<sup>1</sup> Landscape Architecture and Environmental Planning

<sup>2</sup> City and Regional Planning

<sup>3</sup> Environmental Science Policy & Management

<sup>4</sup> Center for Catastrophic Risk Management

<sup>5</sup> Geography

Howard Foster<sup>4</sup>, Emery Roe<sup>4</sup>, Martine Schmidt-Poolman<sup>4</sup>,  
Yang Ju<sup>1</sup>, William Fourt<sup>1</sup>, Wei-Chen Hsu<sup>1</sup>, Amna Alruheil<sup>1</sup>, Rosanna Neuhausler<sup>5</sup>



University of California, Berkeley



# Sea Level Rise effects

- Science says: SLR up to 1.41m by 2100
- People generally worried about areas that fall within SLR “borders”

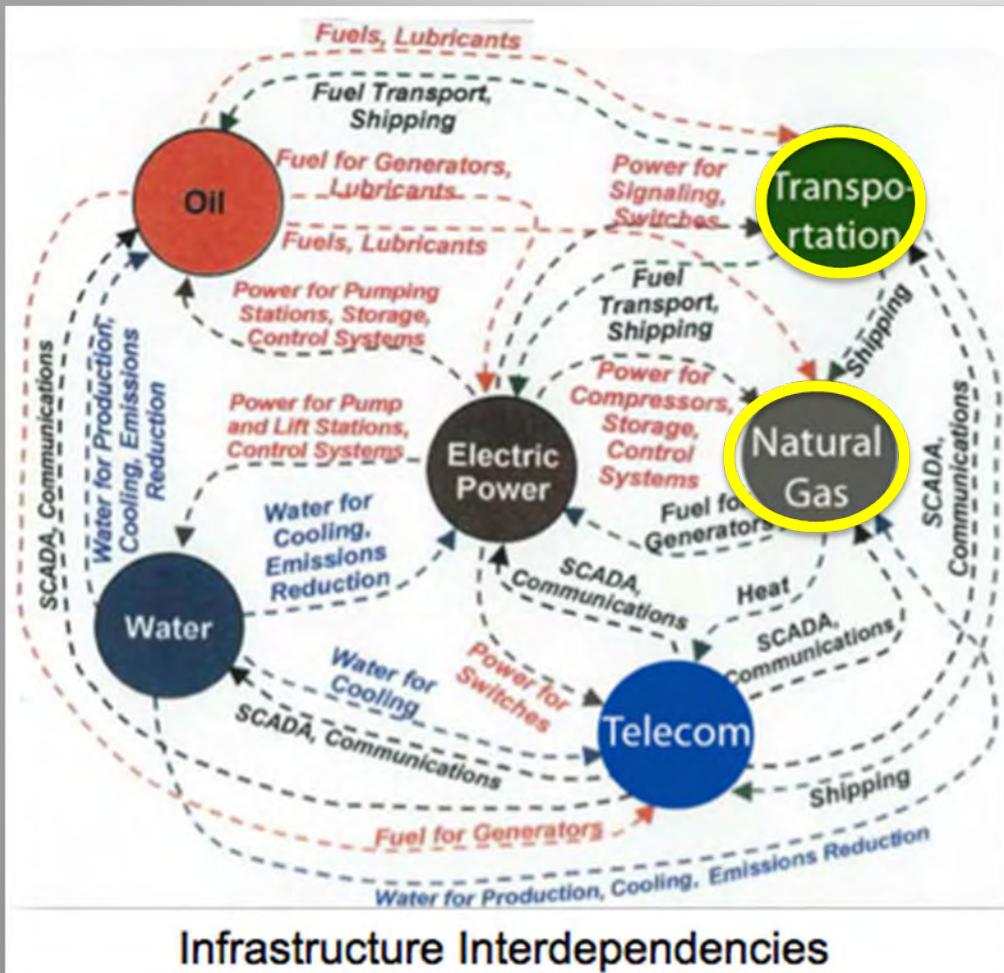
D. Cayan, UC Santa Cruz Climate Change Looking Glass Meeting 2/28-3/1 /2014



... but, even if you live outside of that area, you will be affected

# Assess vulnerability due to Sea Level Rise

## The Domino Effect: Interconnected, Interdependent Infrastructure



1. COMPLETED: Transportation study (CEC-500-2012-040)
2. PRESENT: Gas Pipeline Vulnerability (CEC-500-11-016)

# Both projects look at inundation

## Transportation study:

- We model four sea-level rise (SLR<sub>x</sub>) increments {x: 0m, 0.5m, 1.0m or 1.40m}
- to which we add a 100-year extreme storm event (ESE<sub>100</sub>)
- we use a pathway (rather than bathtub) model

Over estimation of inundation with a 2.0 m (water Level) using a bathtub model



Improvement of inundation estimation with a 2.0 m (water level) with water pathway model

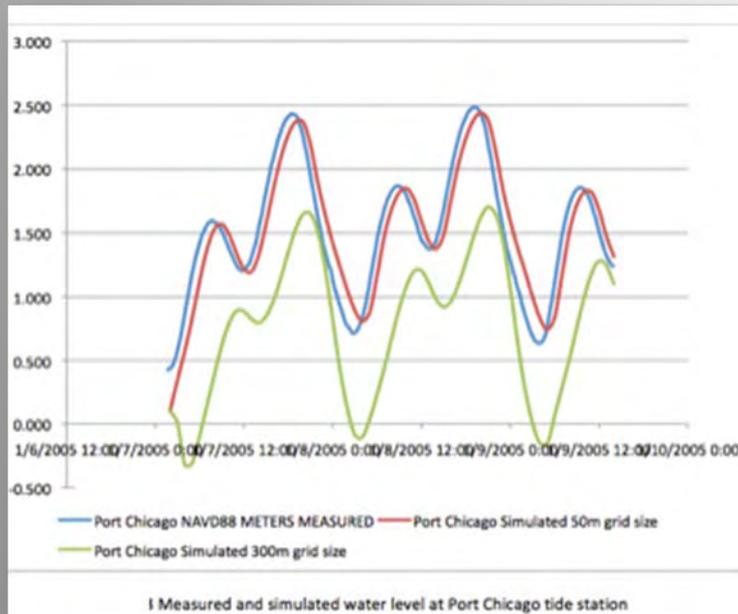


# Both projects look at inundation

## Gas Pipeline Vulnerability study:

- We model four sea-level rise (SLR<sub>x</sub>) increments {x: 0m, 0.5m, 1.0m or 1.40m}
- to which we add a near 100-year extreme storm event (ESE<sub>100</sub>)
- we use a dynamic process model that incorporates *Diurnal tides* and *Peak water levels* during storm even

Improvement of inundation estimation with a dynamic process model

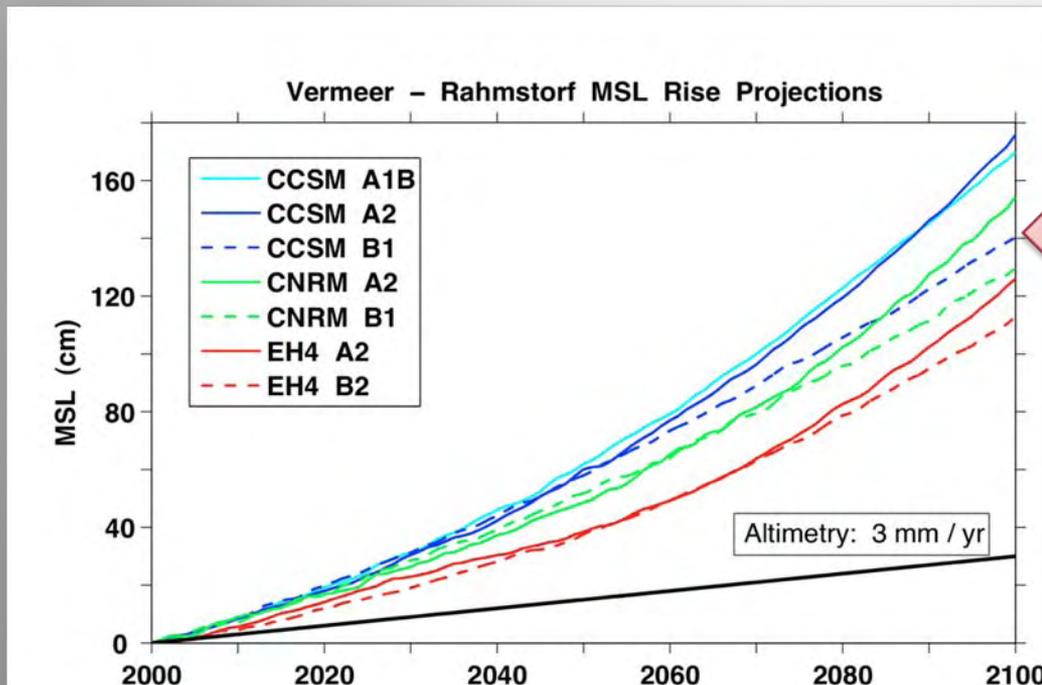


# Components to estimate potential inundation areas

## Inundation study:

- we model four sea-level rise (SLR<sub>x</sub>) increments {x: 0m, 0.5m, 1.0m or 1.40m}
- to which we add a 100-year extreme storm event (ESE<sub>100</sub>)
- we inundate a land surface model comprised of: bathymetry, dem & dsm

## Global circulation models:



1.4

(Source) Bromirski, P. D., D. R. Cayan, N. Graham, R. E. Flick and M. Tyree (Scripps Institution of Oceanography). 2012. Coastal Flooding Potential-Projections 2000–2100. California Energy Commission. CEC-500-2012-011

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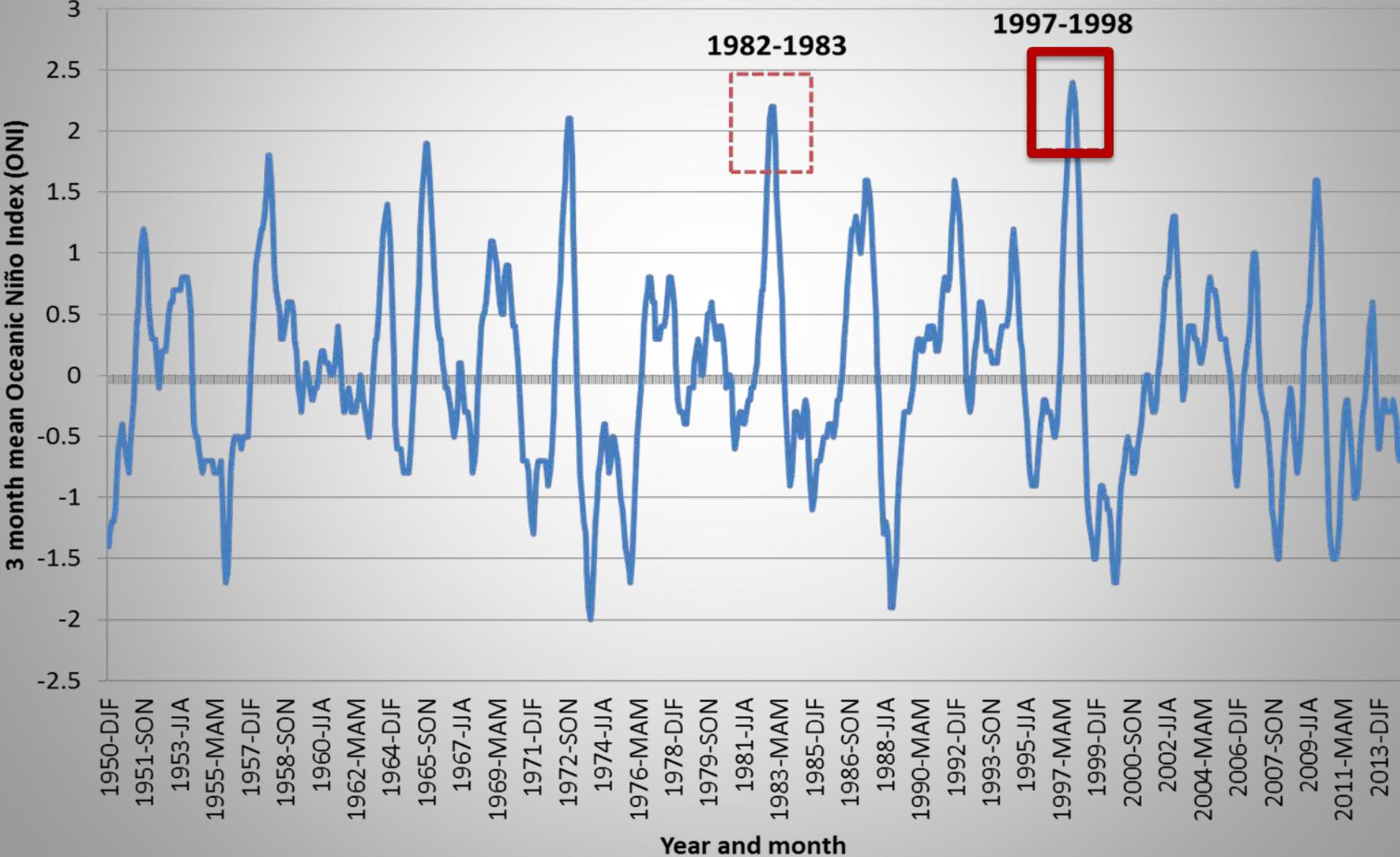
Extreme water level calculation from NOAA at San Francisco based on NAVD 88

Probability	Recurrence Interval	High water level
1.00%	100	2.60
10.00%	10	2.45
50.00%	2	2.29
99.00%	1	2.10

High and low water events which exceeded or was close to the 1% Annual Exceedance Probability Level

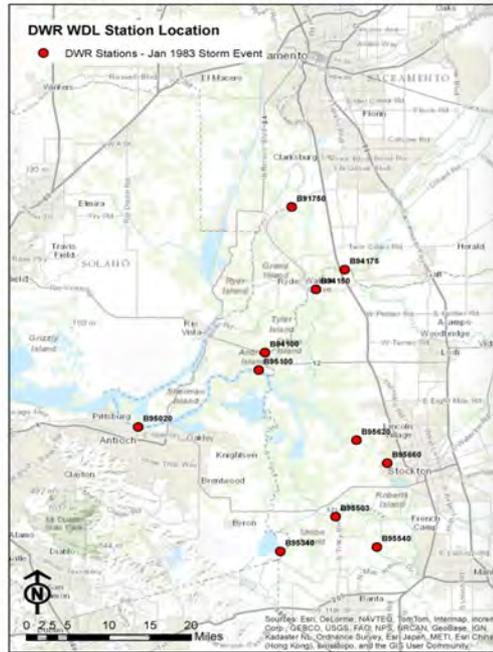
Station Number	Station Name	Date of High Water Event	Compare to 100-year storm
9414290	San Francisco	1/27/1983 – 2.707m	Exceeded
		12/3/1983 – 2.674m	Exceeded
		2/6/1998 – 2.587m	Not exceeded, but was close to it

# a near 100-year extreme storm event ( $ESE_{100}$ )



# Gauging station data availability for model calibration

DWR Station with 1/27/1983 Storm Data



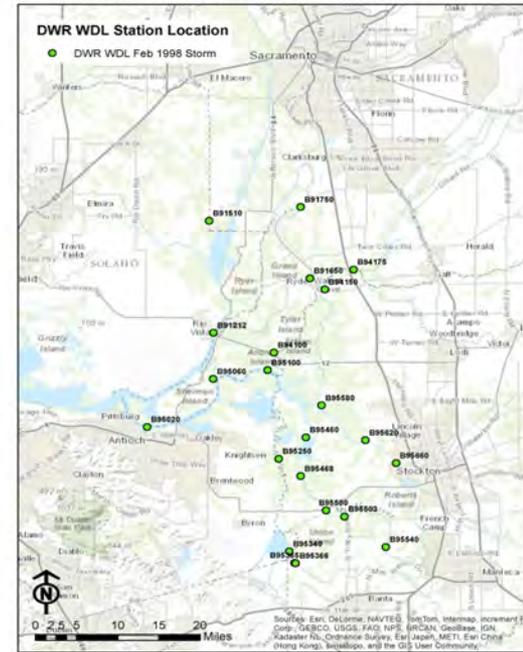
11 stations reporting

DWR Station with 12/3/1983 Storm Data



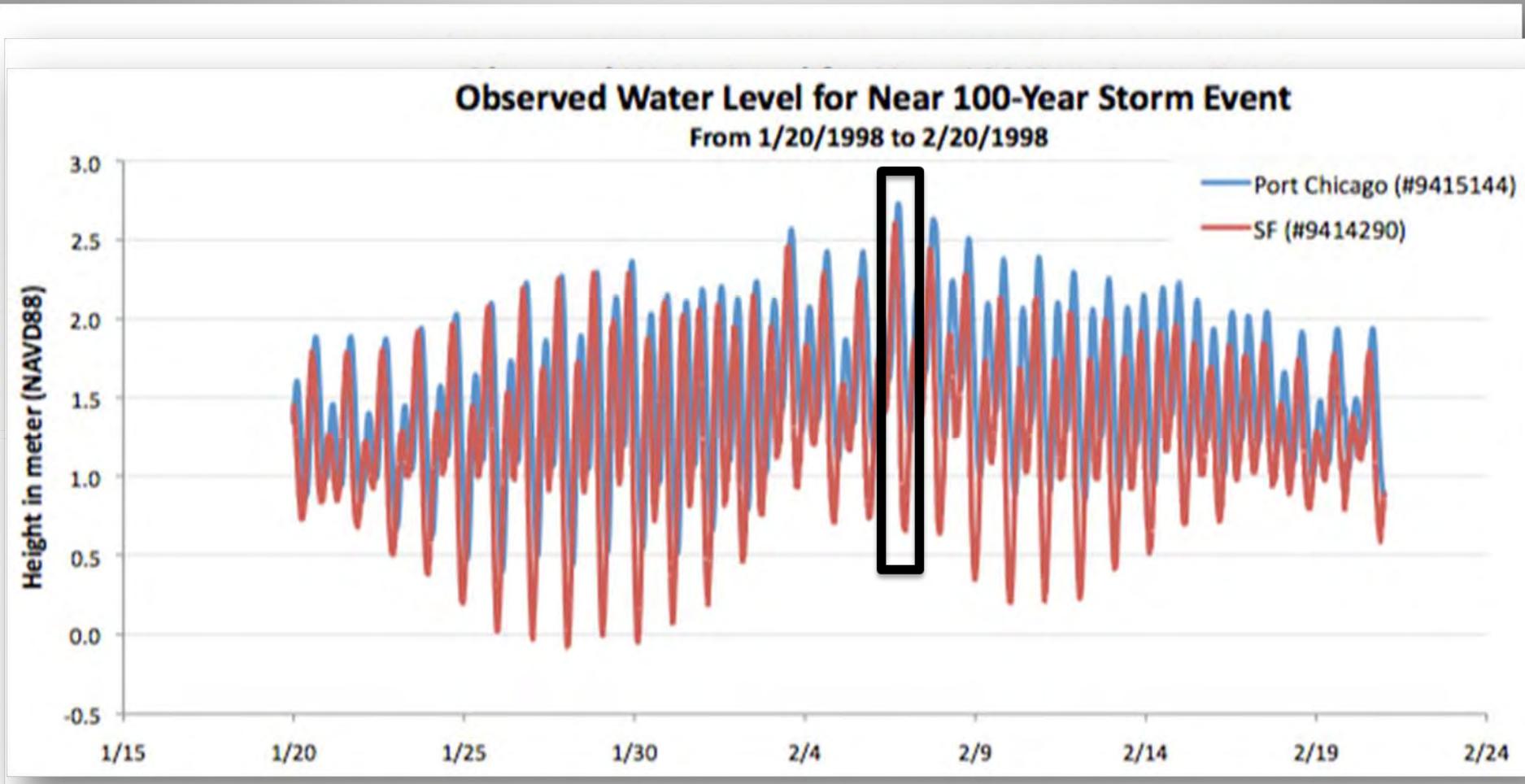
14 stations reporting

DWR Station with 2/6/1998 Storm Data



21 stations reporting

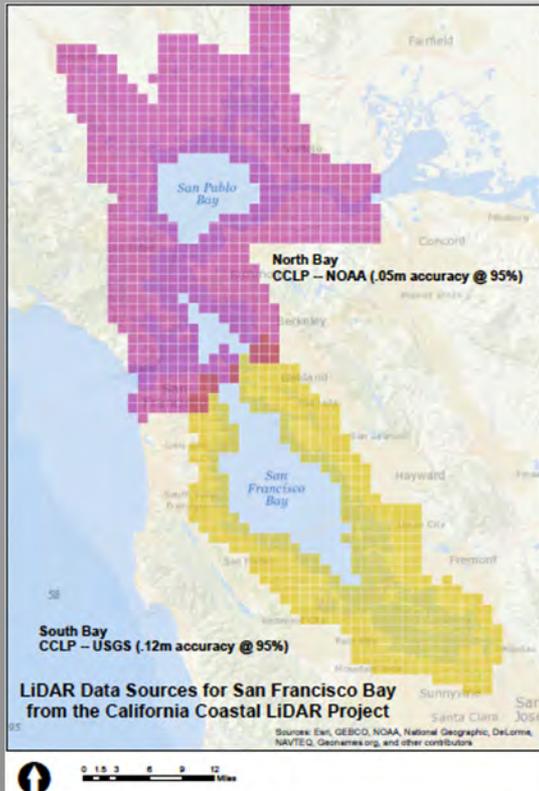
# Observed water level for near 100 year storm event



# Components to estimate potential inundation areas

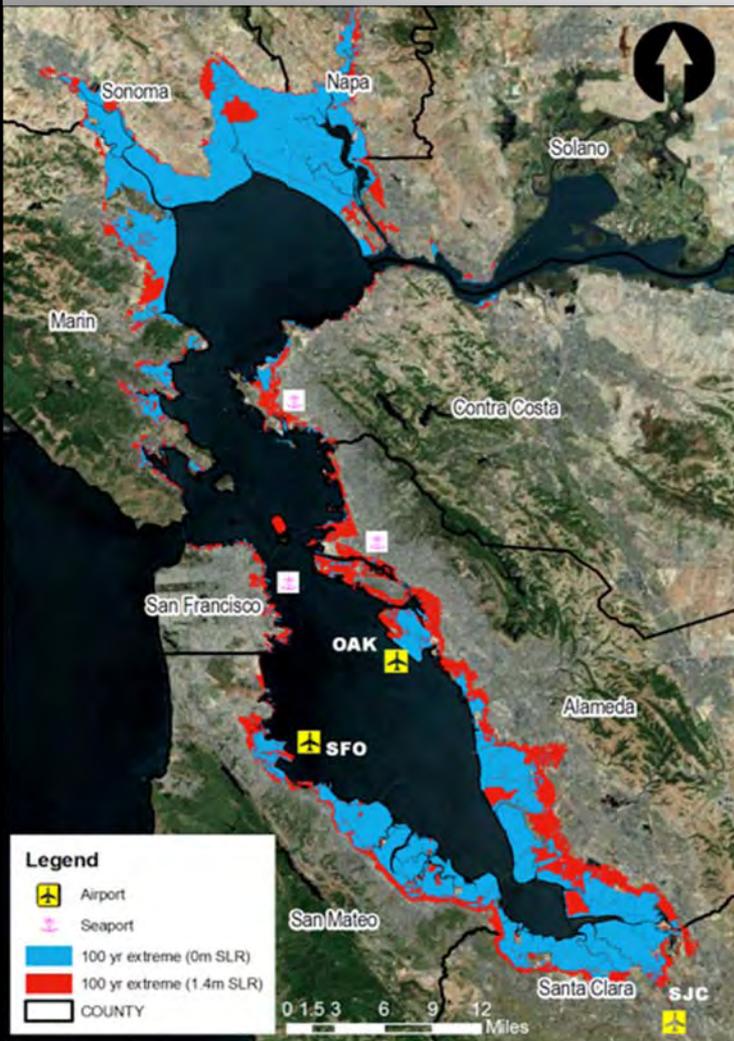
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Insert 3d image of SF Bay surface model

# Transportation study results (CEC-500-2012-040)



## Assessing vulnerability of road network

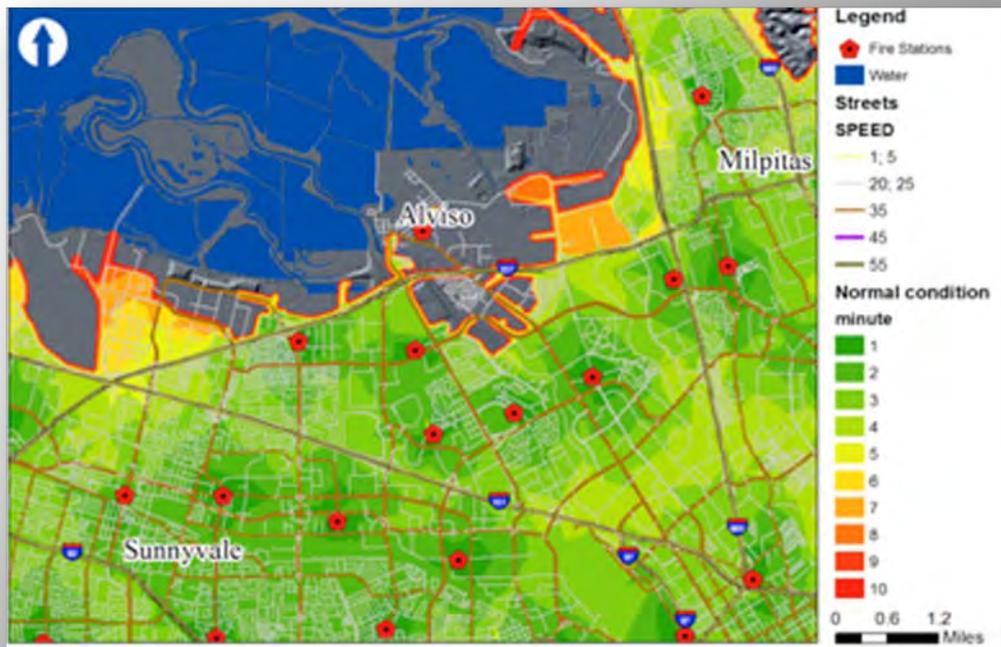
- First responder accessibility
- Node-to-node accessibility impacts on the major traffic corridors
- Hinterland accessibility to major traffic corridor intersections



North Bay - Richmond

- First responder accessibility

South Bay Region



Under normal conditions



North Bay - Richmond

- First responder accessibility

South Bay Region

under a 100-year extreme storm event with 1.4 meter sea-level rise



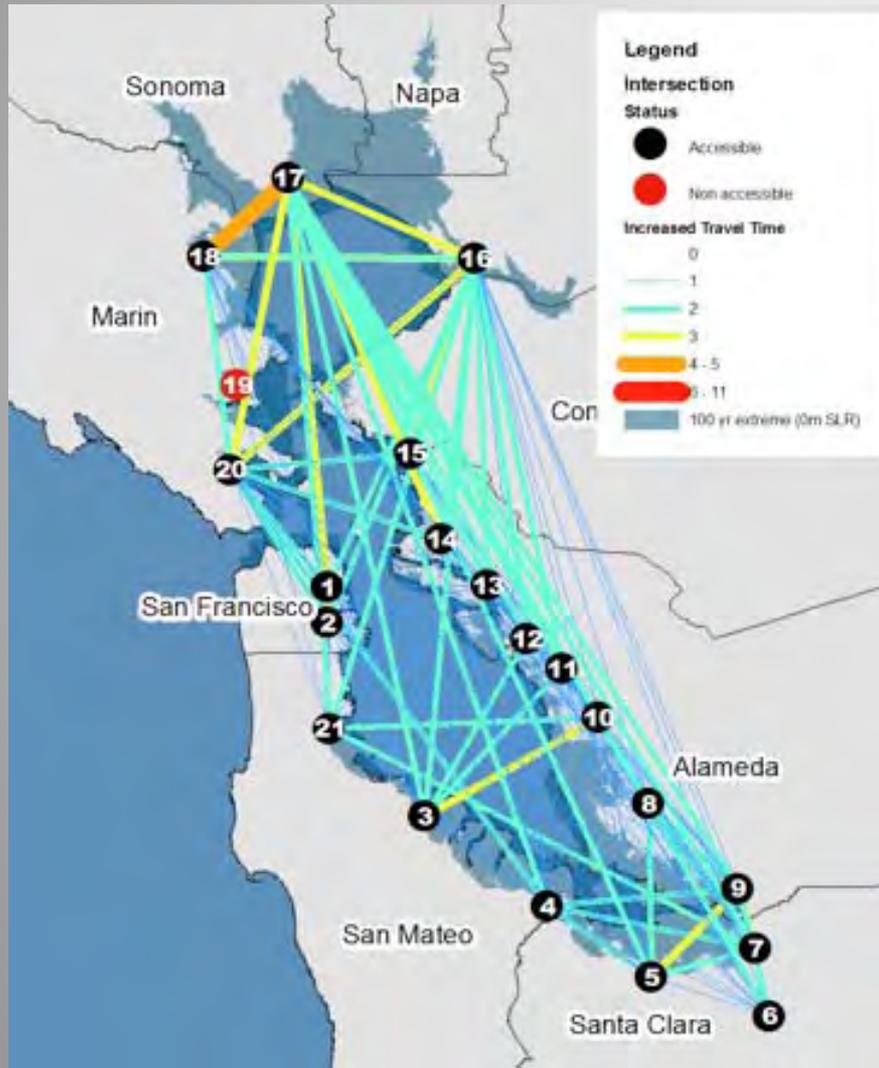
# Assessing vulnerability of road network

## The Domino Effect: Interconnected, Interdependent Infrastructure



- Node-to-node accessibility impacts on the major traffic corridors

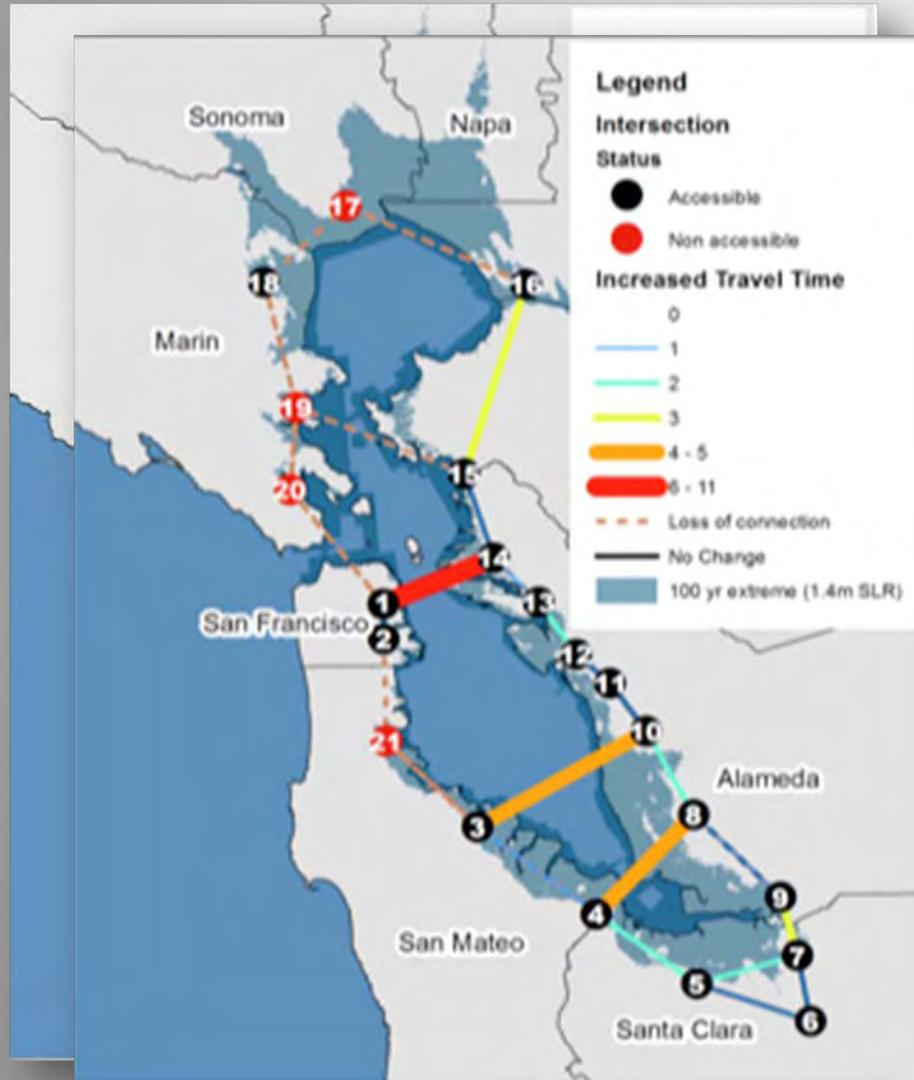
- Node-to-node accessibility impacts on the major traffic corridors



Increased Travel Time (as Multiples of Normal Travel Time) between Intersections after a 100-Year Extreme Event with Different Sea-Level Rise Scenarios

0 meter rise

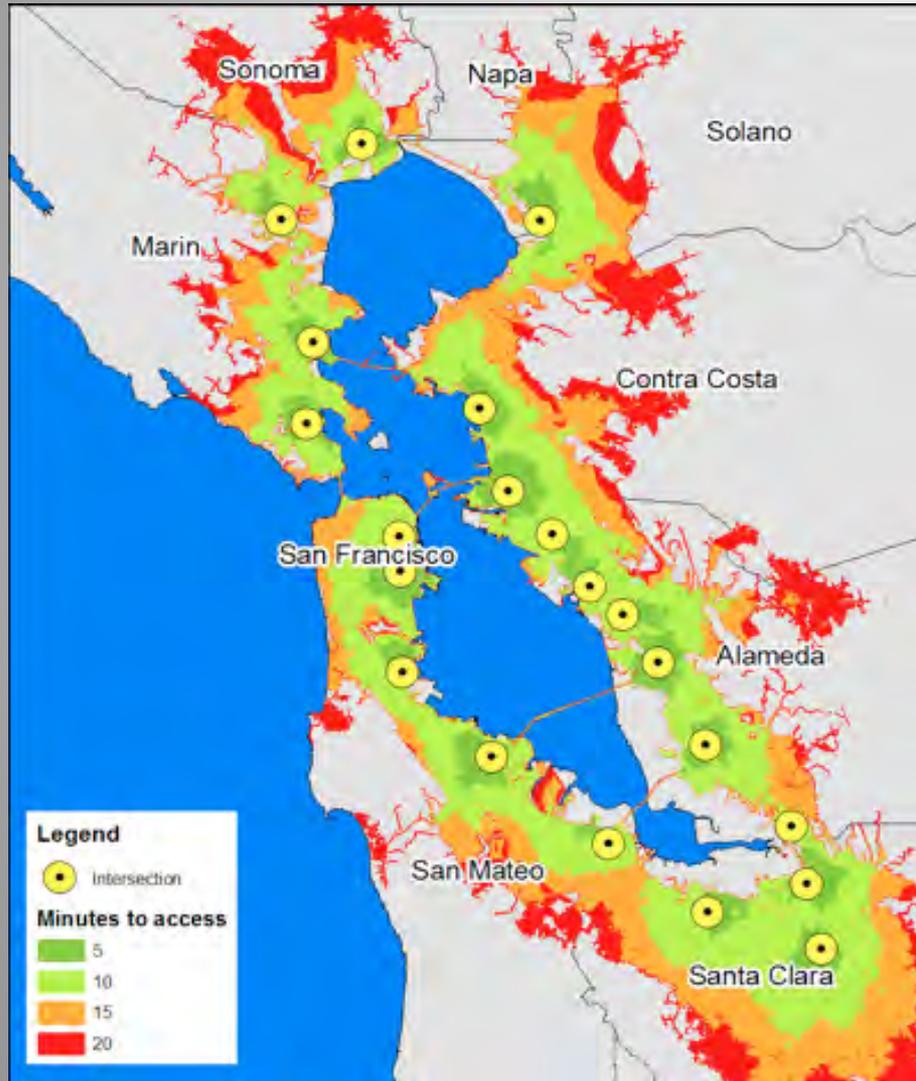
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Increased Travel Time (as Multiples of Normal Travel Time) between Intersections after a 100-Year Extreme Event with Different Sea-Level Rise Scenarios

1.4 meter rise

- Hinterland accessibility to major traffic corridor intersections

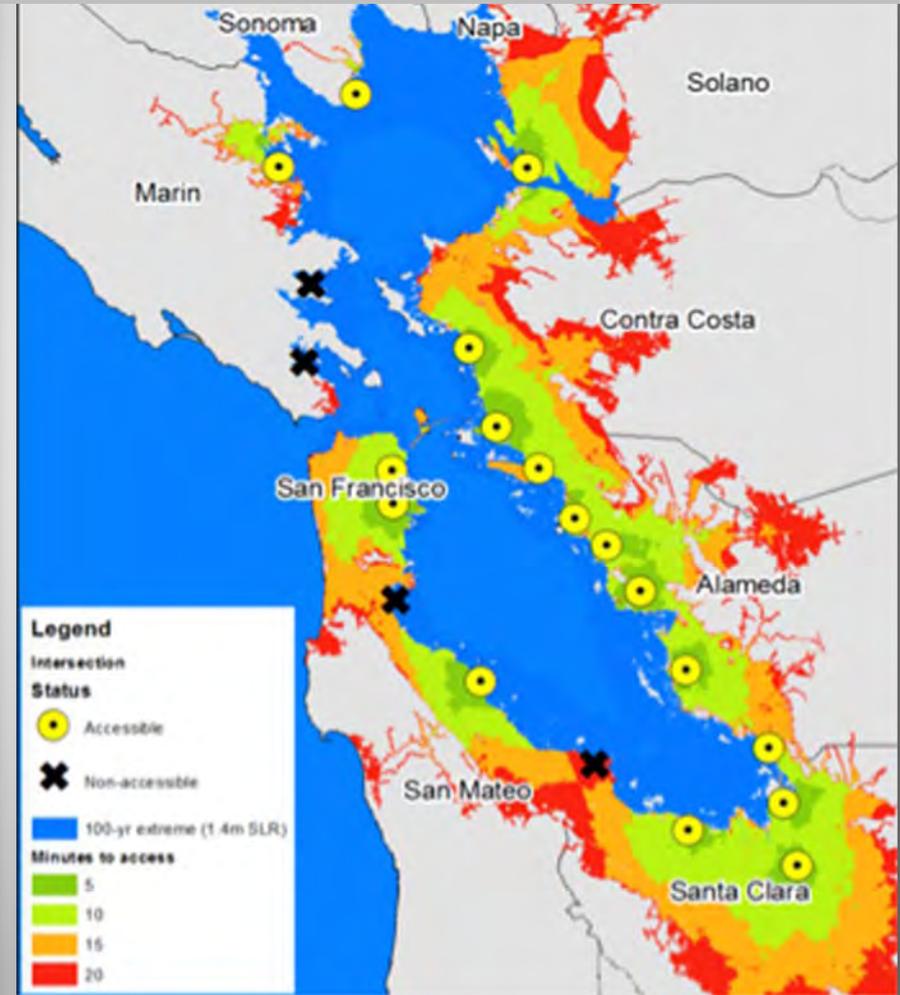
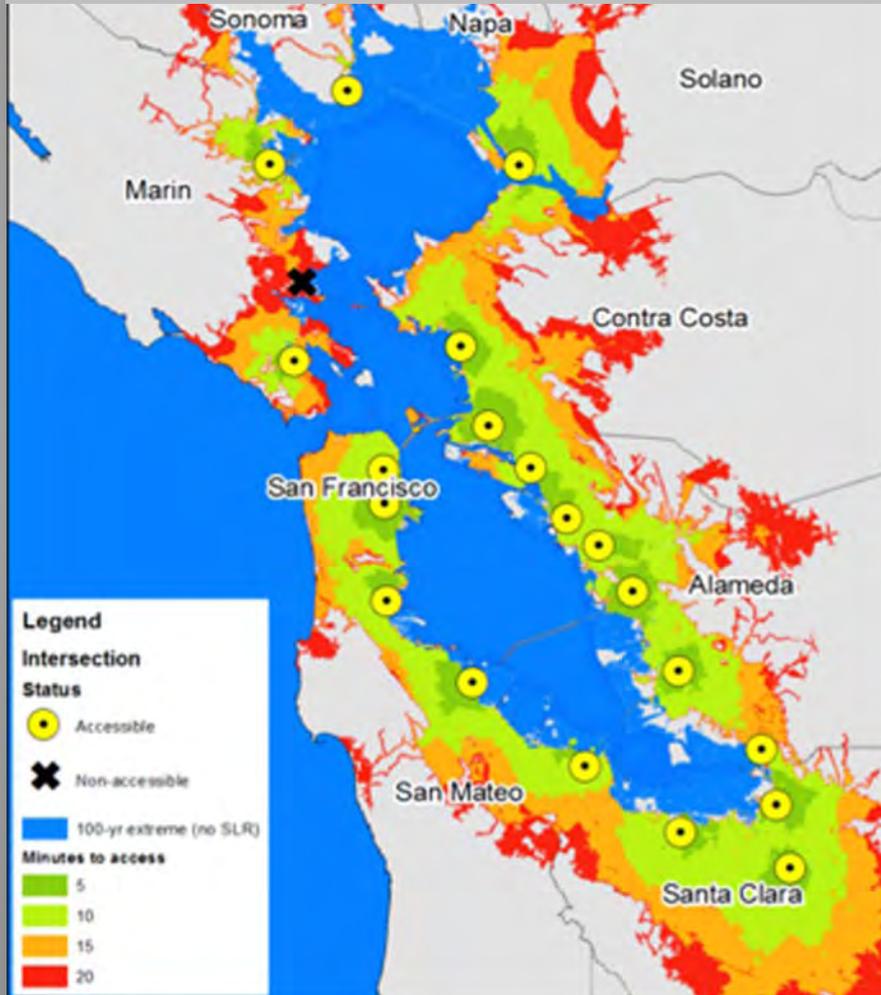


- Hinterland accessibility to major traffic corridor intersections

0 meter

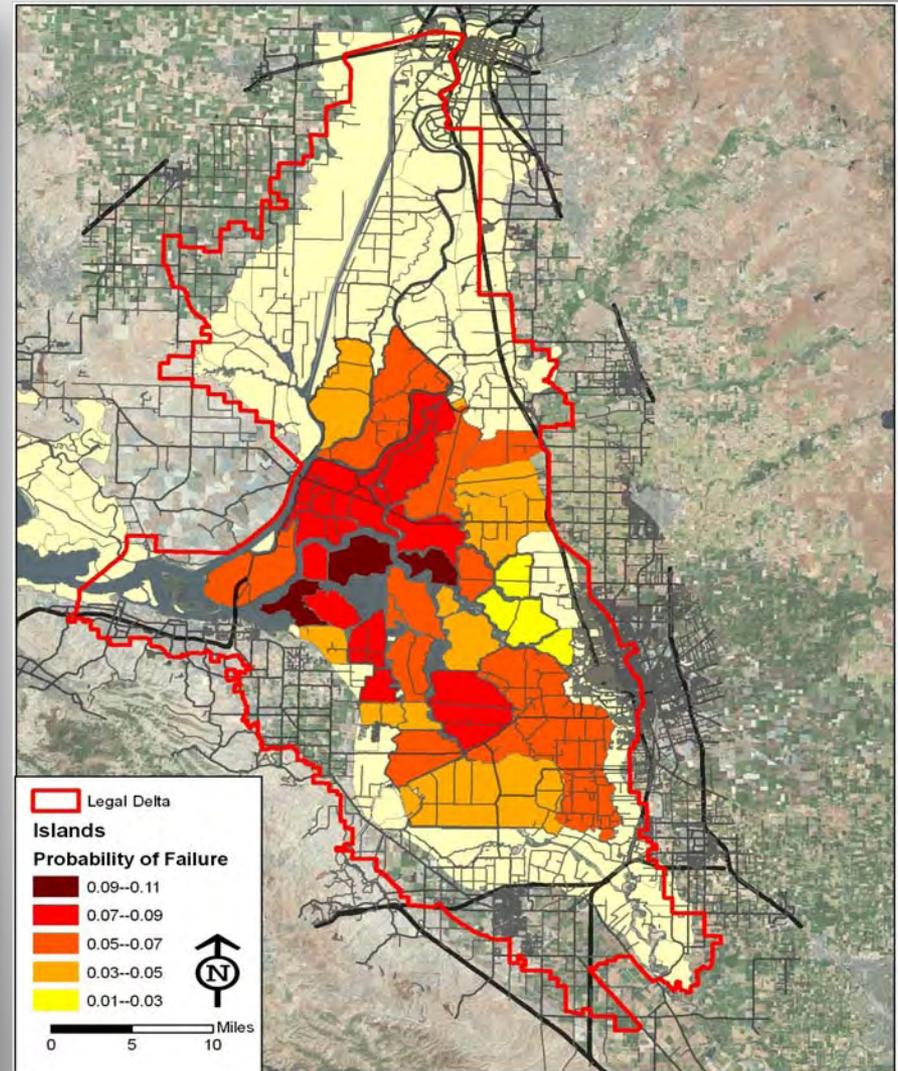
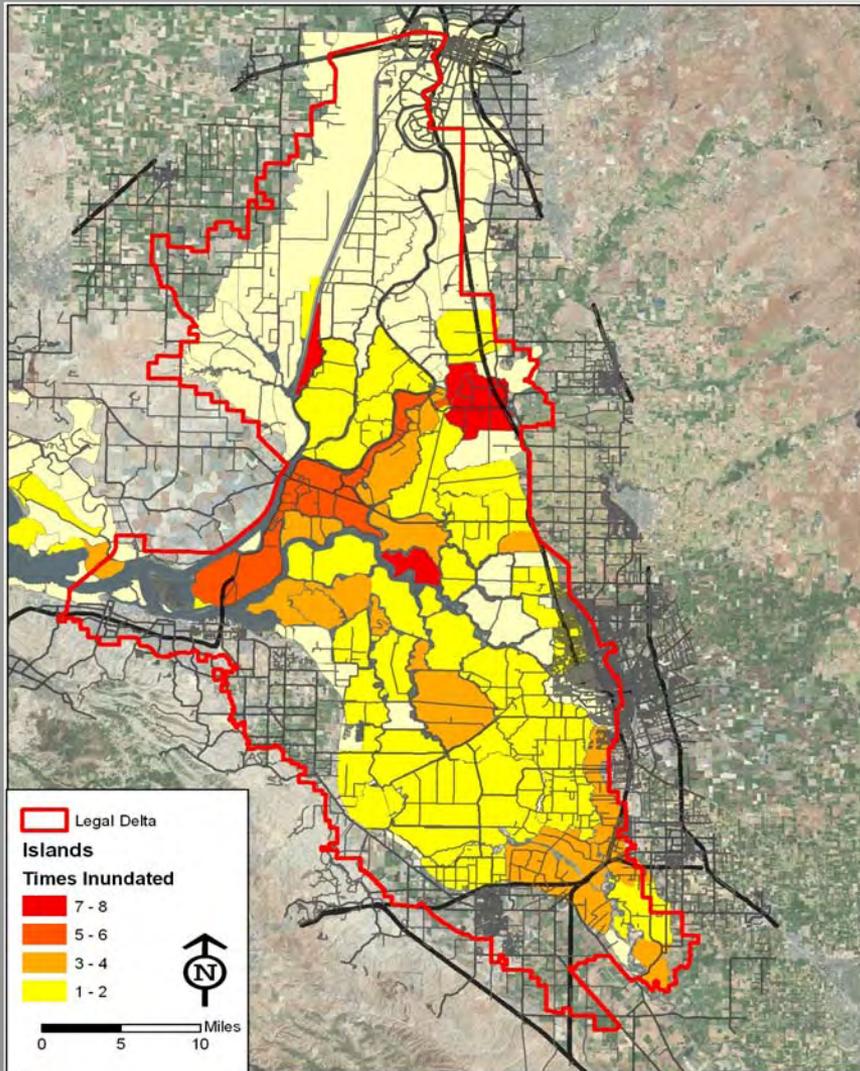
Inundation Scenarios

1.4 meter



# First responder accessibility: The Delta

## Probability of Island (levee) failure

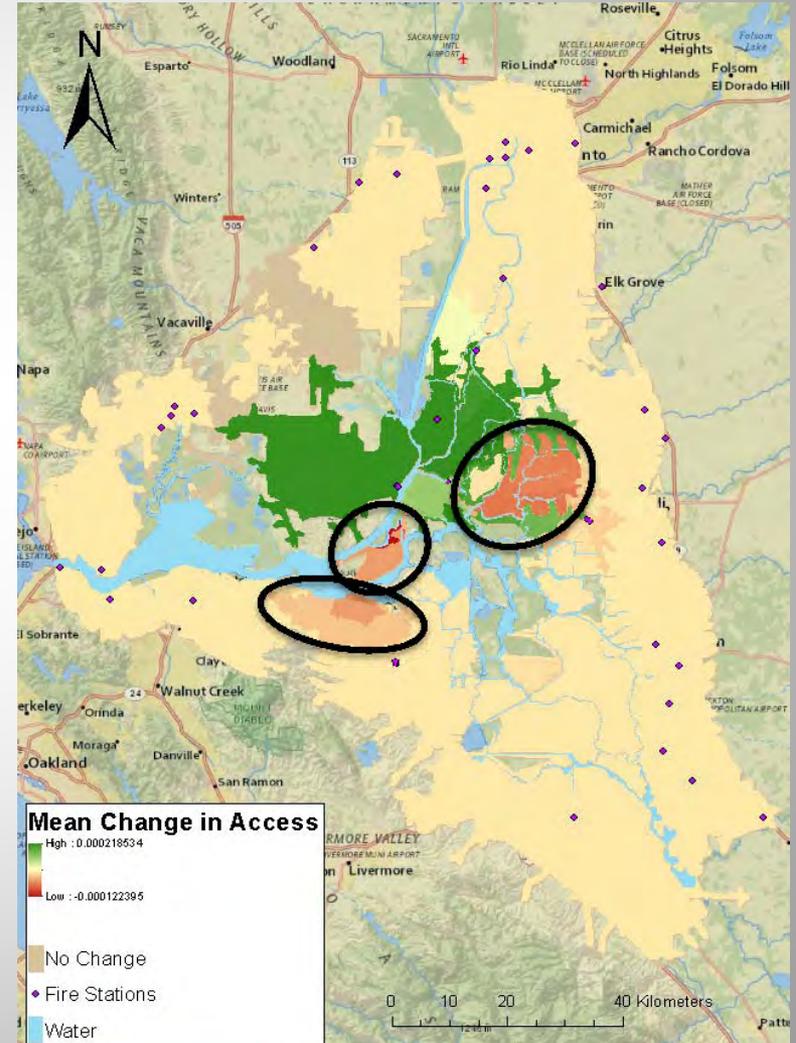
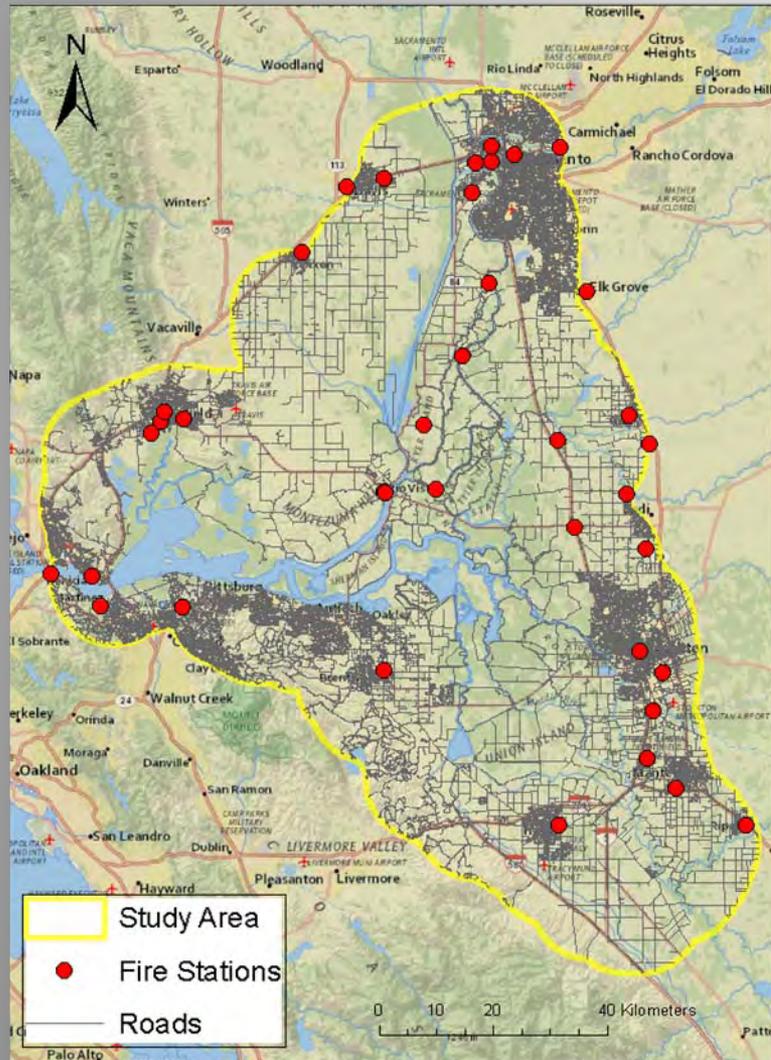


# Sherman Island 3Di simulation





# First responder accessibility: The Delta



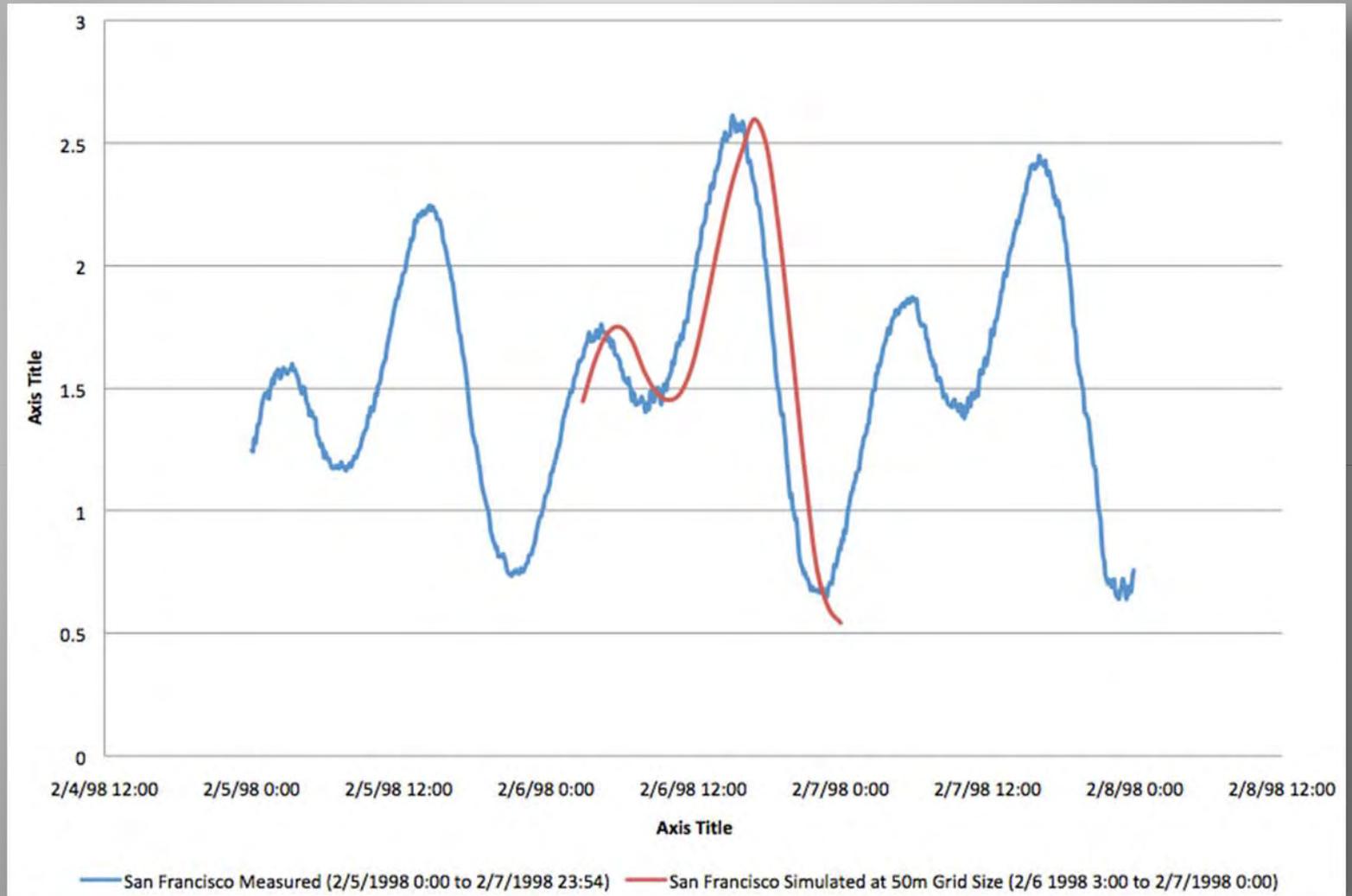
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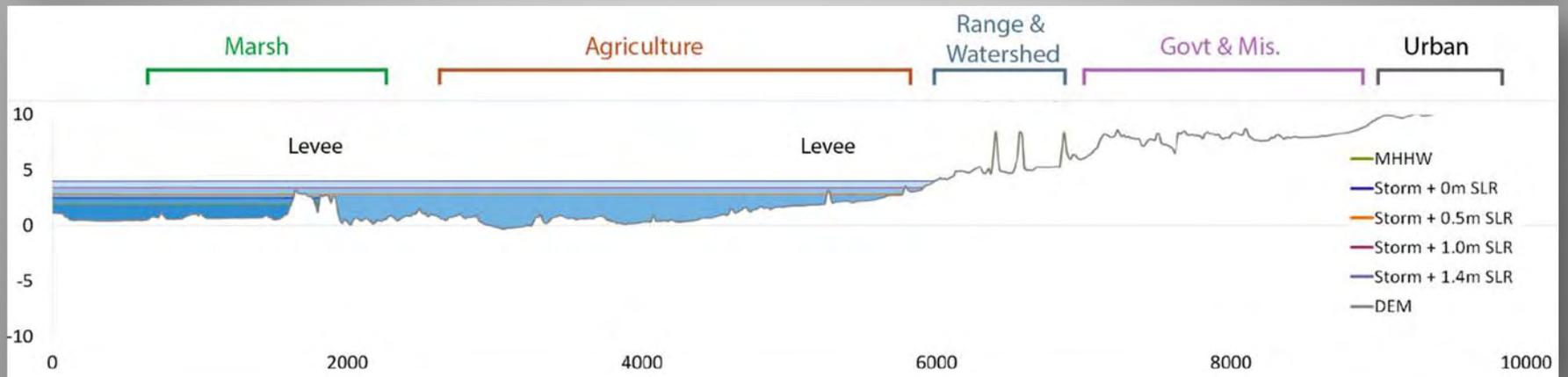
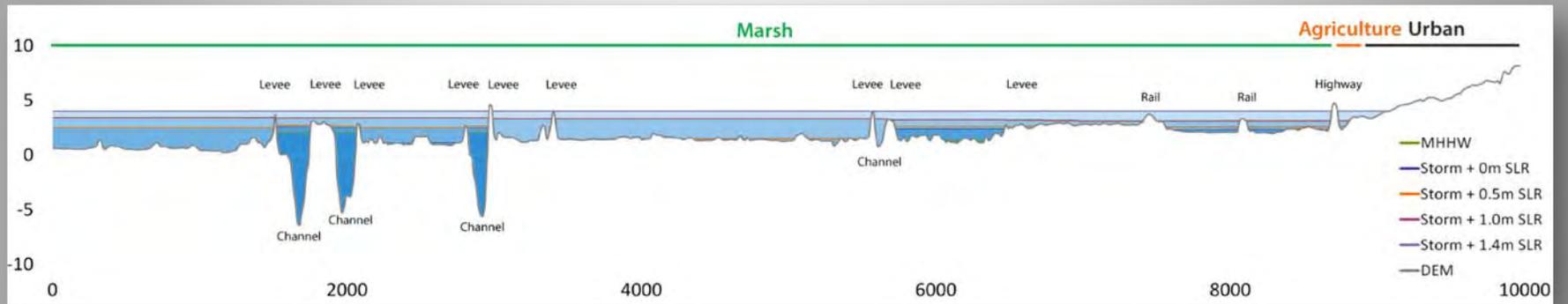
Fort Hamilton region



# 3Di model calibrated with 1998 storm event



# Cross-section of inundation



# Bay-Delta inundation simulations

**Preliminary results: Mission Bay 3Di Simulation**  
**Fort Hamilton region**  
**Sherman Island**

# Inundated Pipeline in SF Bay Region

$$PWL_{1.4} = SLR_{1.4} + ESE_{100}$$



Total Length of inundated pipeline = 275 kilometers (171 miles)

Total number of inundated pipe segments = 498

