City Council/Planning Commission Joint Study Session on Sea Level Rise

March 28, 2023

Sea Level Rise Panel



Gwen Shaughnessy
Senior Climate Adaptation Specialist
Lynker, LLC supporting NOAA's Office for Coastal Management

Kelsey Ducklow
Statewide Coastal Resilience Coordinator
California Coastal Commission





Jeffrey K. Anderson
Principal Engineer
Northern Hydrology & Engineering

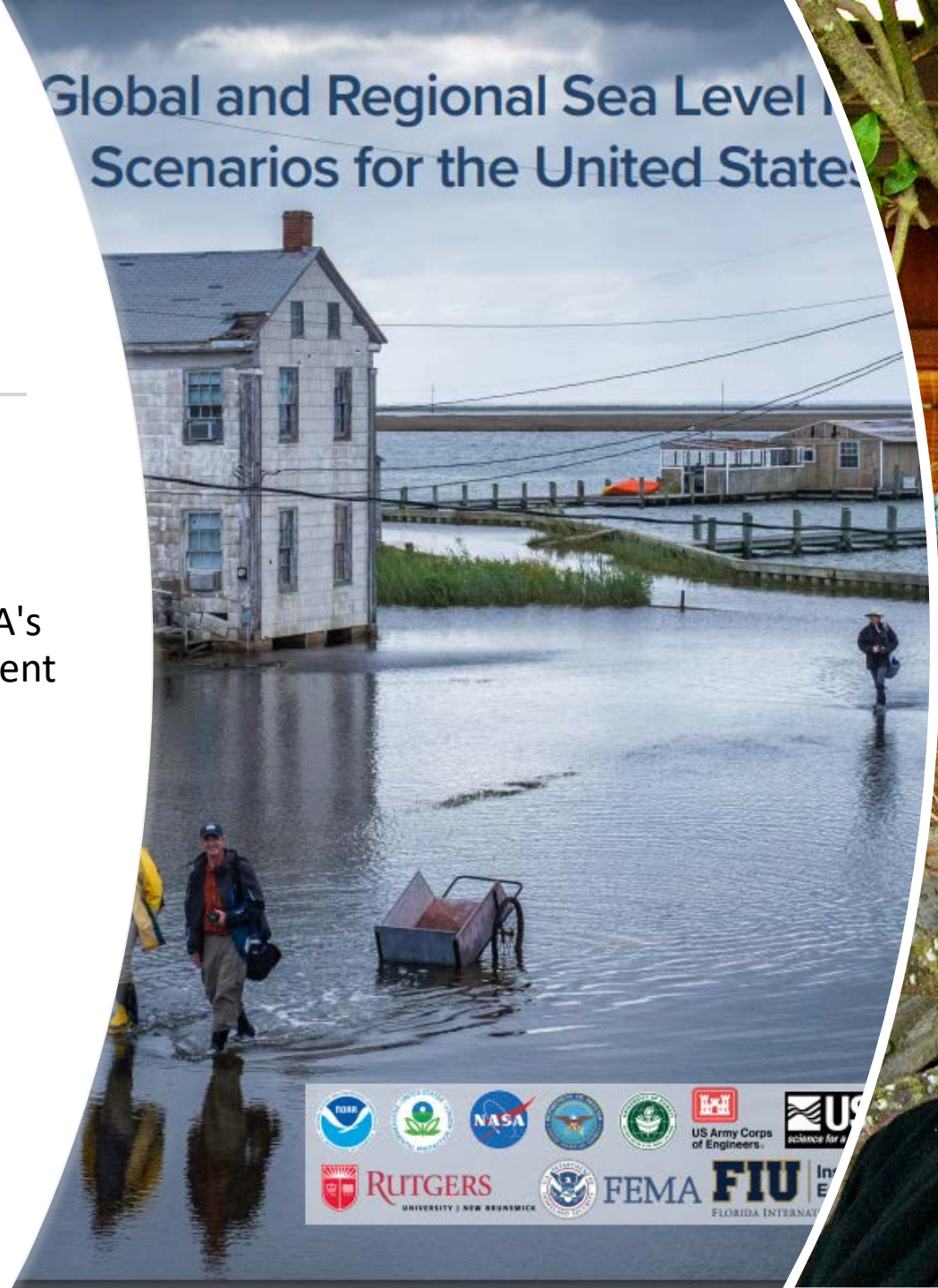
Adaron Laird
Sr. Environmental Planner
Greenway Partners



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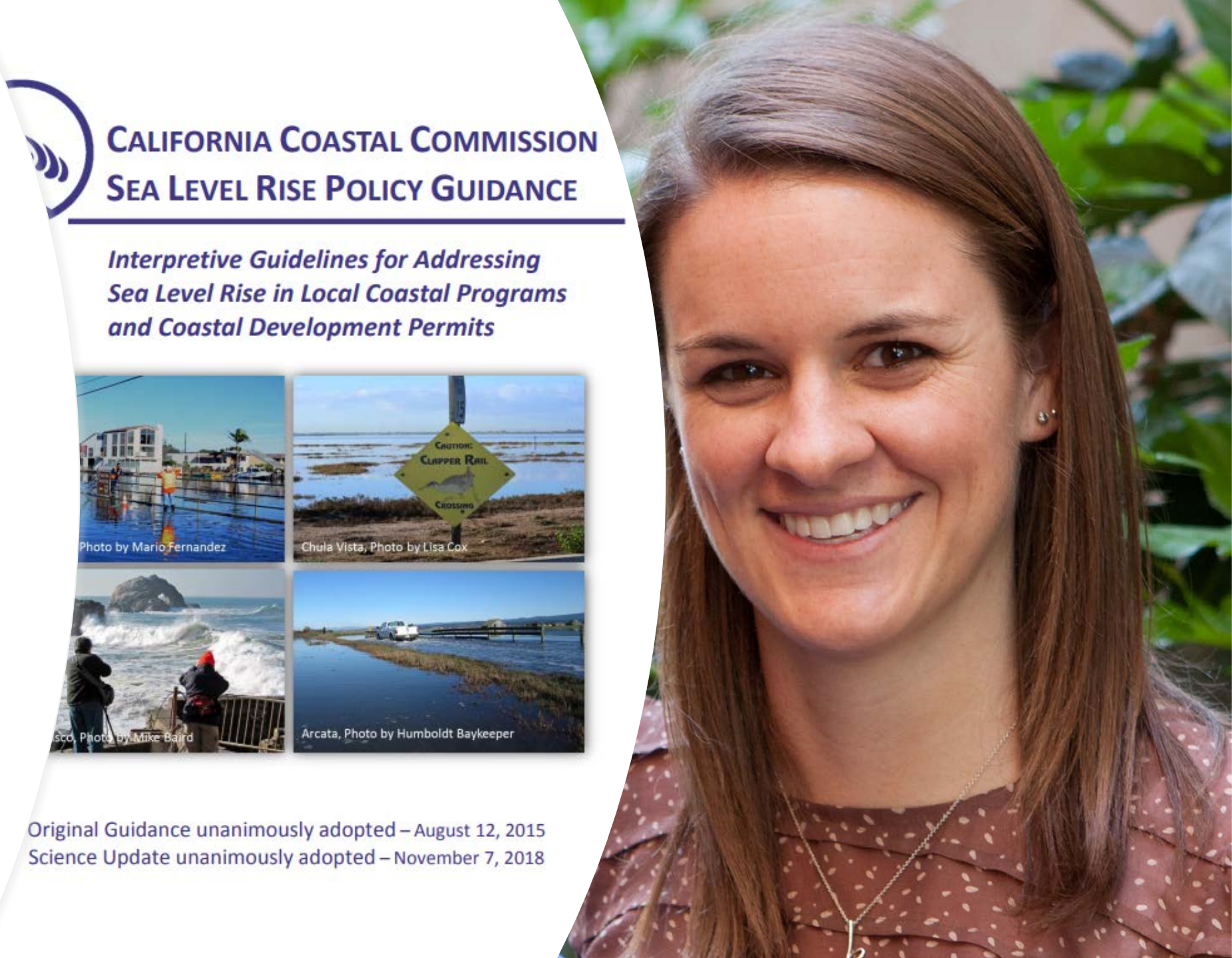




Kelsey Ducklow

Statewide Coastal Resilience Coordinator

California Coastal Commission



California Coastal Commission

Sea Level Rise Adaptation Planning

IMPLEMENTING STATEWIDE SLR GUIDANCE

Arcata Planning Commission

3/29/2023



Kelsey Ducklow
Coastal Resilience Coordinator

CALIFORNIA COASTAL COMMISSION

CALIFORNIA COASTAL ACT

Section 30253: **New development shall…**

- Minimize risks to life and property
- Assure stability & structural integrity
- Neither create nor contribute to erosion
- Assure no protective devices needed for life of structure
- Minimize energy consumption and vehicle miles traveled



CALIFORNIA COASTAL ACT



Section 30235: **Shoreline Protection allowed for…**

- Coastal dependent uses
- Public beaches
- Existing (pre-Coastal Act) structures
- **IN DANGER FROM EROSION**

With **MITIGATION** to offset:

- Loss of beach and sand
- Other unavoidable impacts

CALIFORNIA COASTAL ACT

Section 30270:

The **commission shall take into account the effects of sea level rise** in coastal resources planning and management policies and activities in order to identify, assess, and, to the extent feasible, avoid and mitigate the adverse effects of sea level rise.

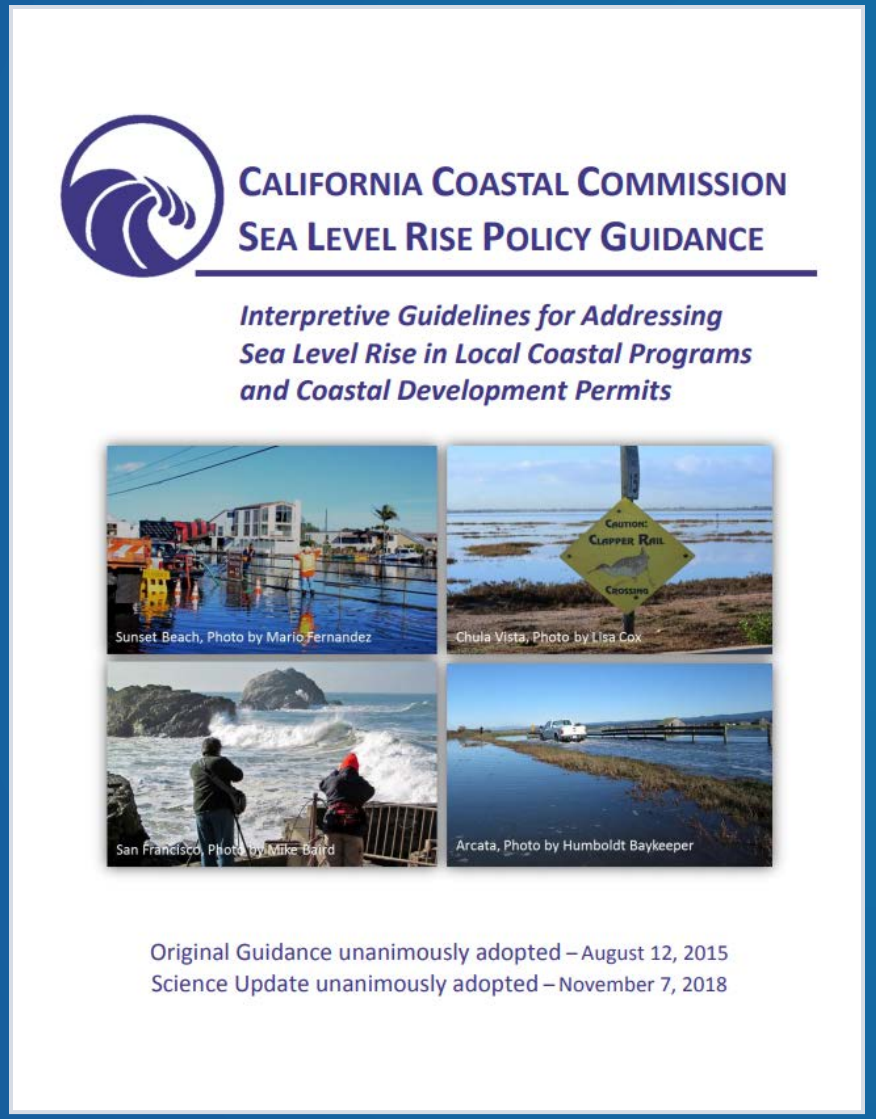


Capistrano State Beach, Jan. 2019 | CKTI

CCC BACKGROUND



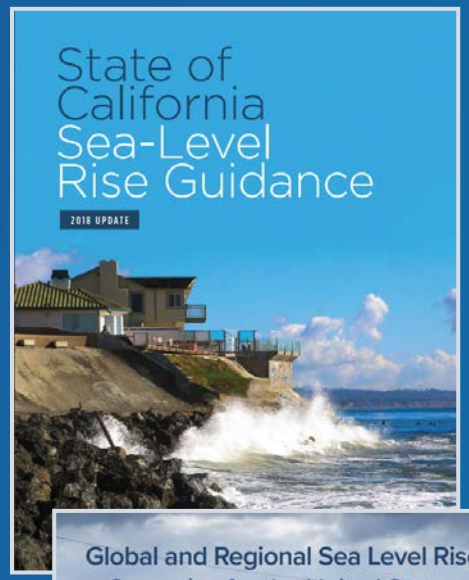
SEA LEVEL RISE GUIDANCE

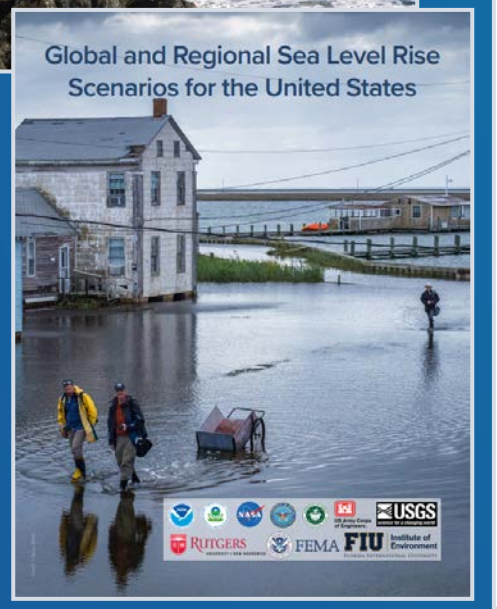


Overarching guidance from the OPC State SLR Guidance, information specific to CCC context

- Use best available science
- Precautionary approach
- Prioritize natural adaptation options
- Phased adaptation approaches
- Address climate and environmental justice concerns

SEA LEVEL RISE GUIDANCE





Projected Sea Level Rise (in feet): *North Spit*

	Probabilistic Projections (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	**Medium-High Risk Aversion**	**Extreme Risk Aversion**
	Upper limit of "likely range" (~17% probability SLR exceeds...)	*1-in-200 chance (0.5% probability SLR exceeds...)*	*Single scenario (no associated probability)*
2030	0.7	1.0	1.2
2040	1.1	1.6	2.0
2050	1.5	2.3	3.1
2060	1.9	3.1	4.3
2070	2.4	4.0	5.6
2080	2.9	5.1	7.2
2090	3.5	6.2	8.9
2100	4.1	7.6	10.9
2110*	4.3	8.0	12.7
2120	4.9	9.4	15.0
2130	5.5	10.9	17.4
2140	6.2	12.5	20.1
2150	6.8	14.1	23.0

SEA LEVEL RISE GUIDANCE

Low Risk Aversion Scenario

Use for projects that would have limited consequences or a higher ability to adapt



Medium-High Risk Aversion Scenario

Use for projects with greater consequences and/or a lower ability to adapt



Extreme Risk Aversion Scenario (H++)

Use for projects with little to no adaptive capacity that would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts should that level of sea level rise occur



SEA LEVEL RISE GUIDANCE

Low Risk Aversion Scenario

Use for p
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Mediu

Use for
and/or

Extrem

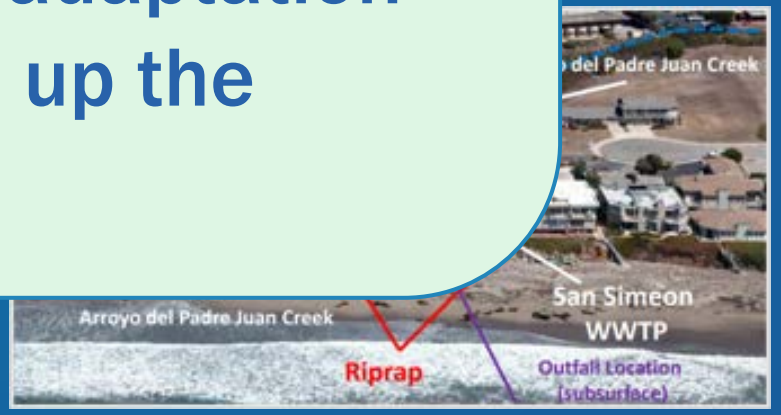
Use for
capacity
or signif
have cons
safety, or environmental impacts should that level of sea level rise occur

Remember:

- Difference between *planning* and *designing* for a specific amount of sea level rise
- **Phased approaches/adaptation pathways help make up the difference**







ONGOING SLR WORK

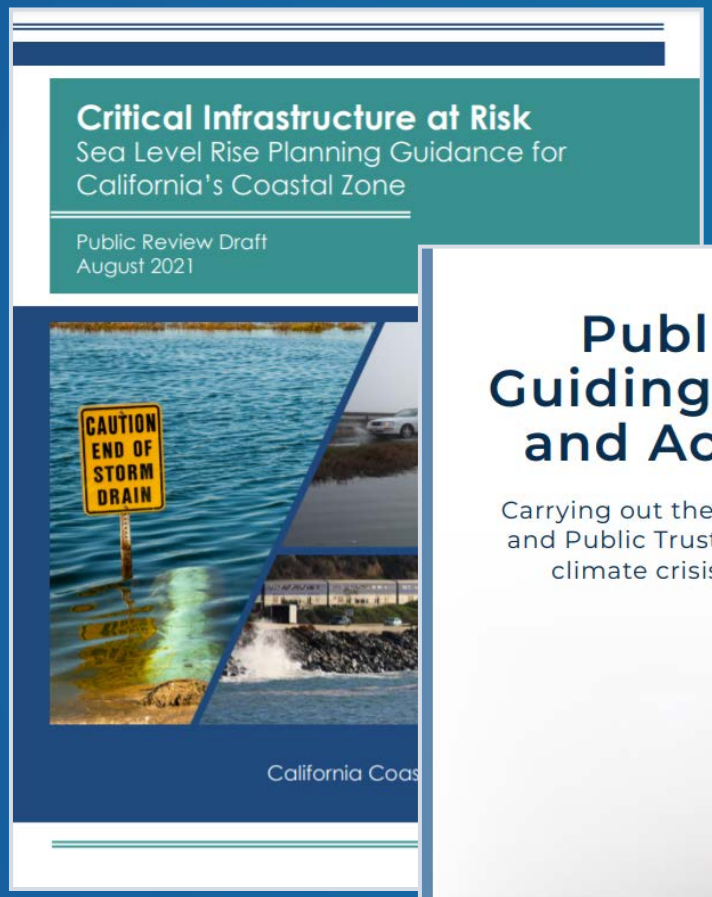


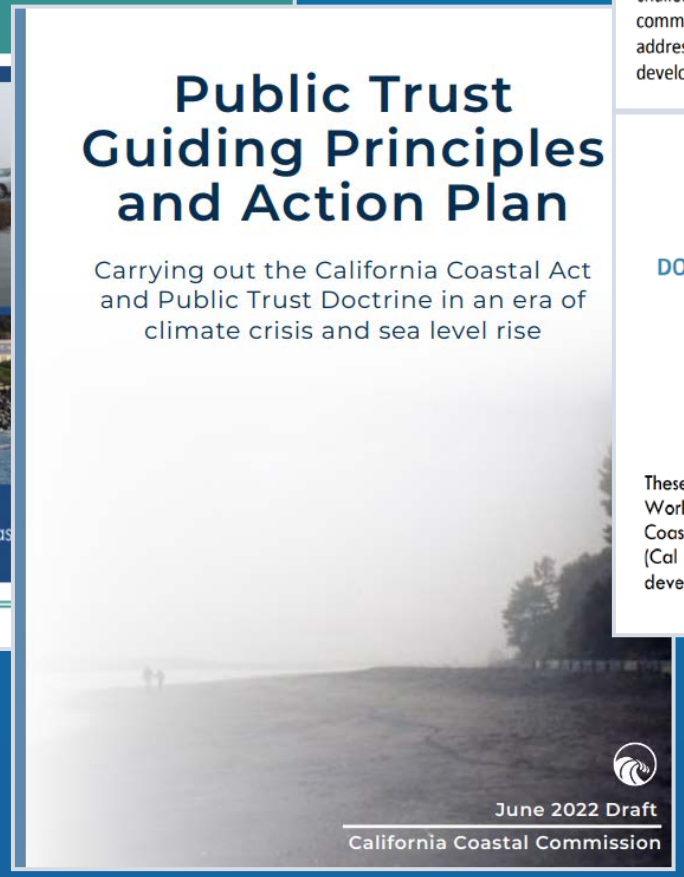
LCP Grant Program

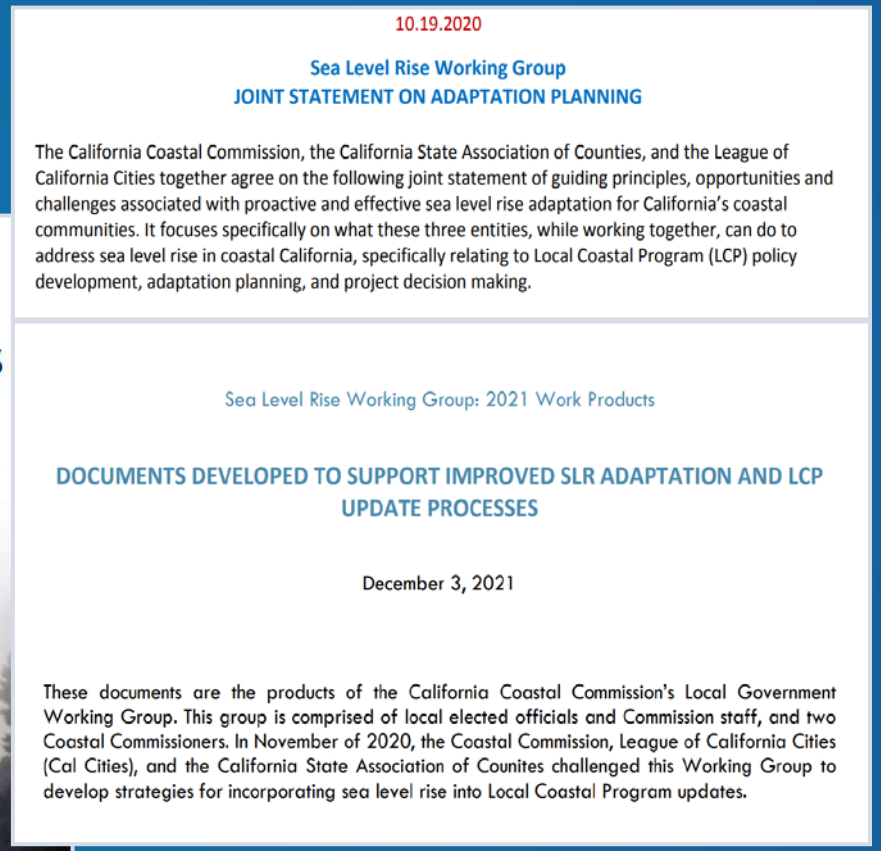
- ~$16.5 million to date
- LCP updates with a focus on climate change, SLR, and coastal resiliency planning
- $31 million in new funding (~$14M remaining for grants)

www.coastal.ca.gov/lcp/grants/

ONGOING SLR WORK







10.19.2020

Sea Level Rise Working Group
JOINT STATEMENT ON ADAPTATION PLANNING

The California Coastal Commission, the California State Association of Counties, and the League of California Cities together agree on the following joint statement of guiding principles, opportunities and challenges associated with proactive and effective sea level rise adaptation for California's coastal communities. It focuses specifically on what these three entities, while working together, can do to address sea level rise in coastal California, specifically relating to Local Coastal Program (LCP) policy development, adaptation planning, and project decision making.

Sea Level Rise Working Group: 2021 Work Products

DOCUMENTS DEVELOPED TO SUPPORT IMPROVED SLR ADAPTATION AND LCP UPDATE PROCESSES

December 3, 2021

These documents are the products of the California Coastal Commission's Local Government Working Group. This group is comprised of local elected officials and Commission staff, and two Coastal Commissioners. In November of 2020, the Coastal Commission, League of California Cities (Cal Cities), and the California State Association of Counites challenged this Working Group to develop strategies for incorporating sea level rise into Local Coastal Program updates.

THANK YOU!

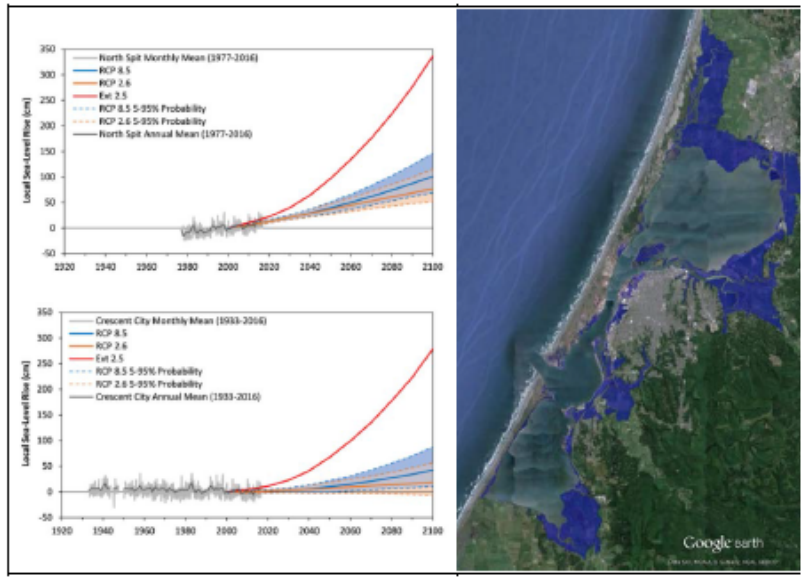


coastal.ca.gov/climate/slr

kelsey.ducklow@coastal.ca.gov

Jeffrey K. Anderson
Principal Engineer
Northern Hydrology & Engineering

Sea-Level Rise in the Humboldt Bay Regi



March 2018

Prepared for

City of Arcata
736 F Street
Arcata, CA 95521

Prepared by

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McKinleyville, CA 95519

Northern Hydrology & Engineering



Humboldt Bay Sea-Level Change

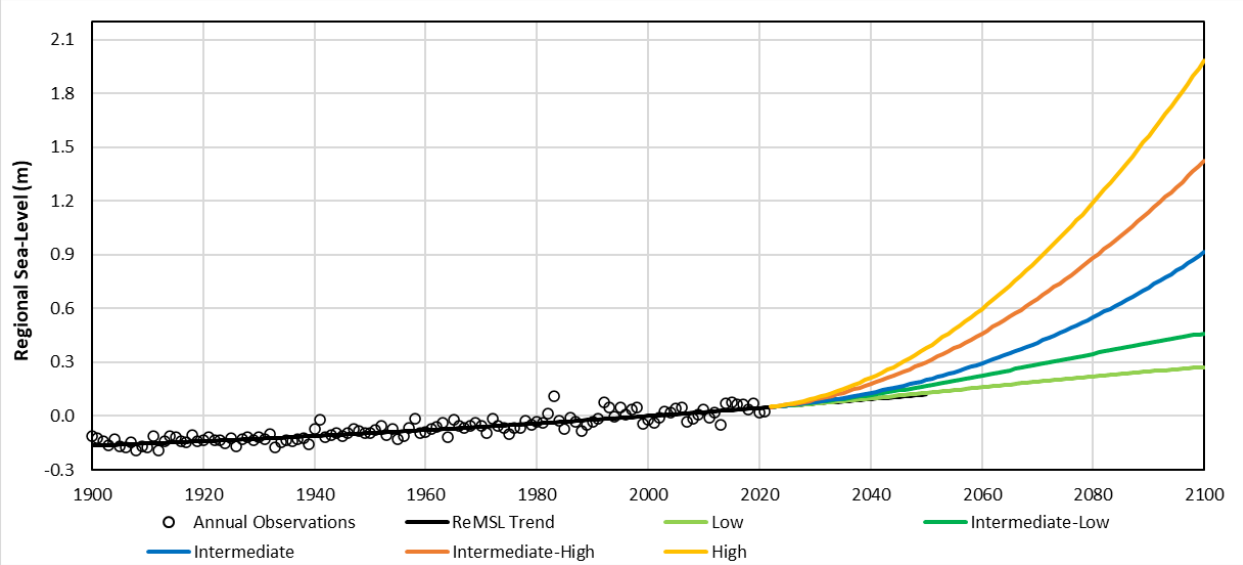
Jeff Anderson

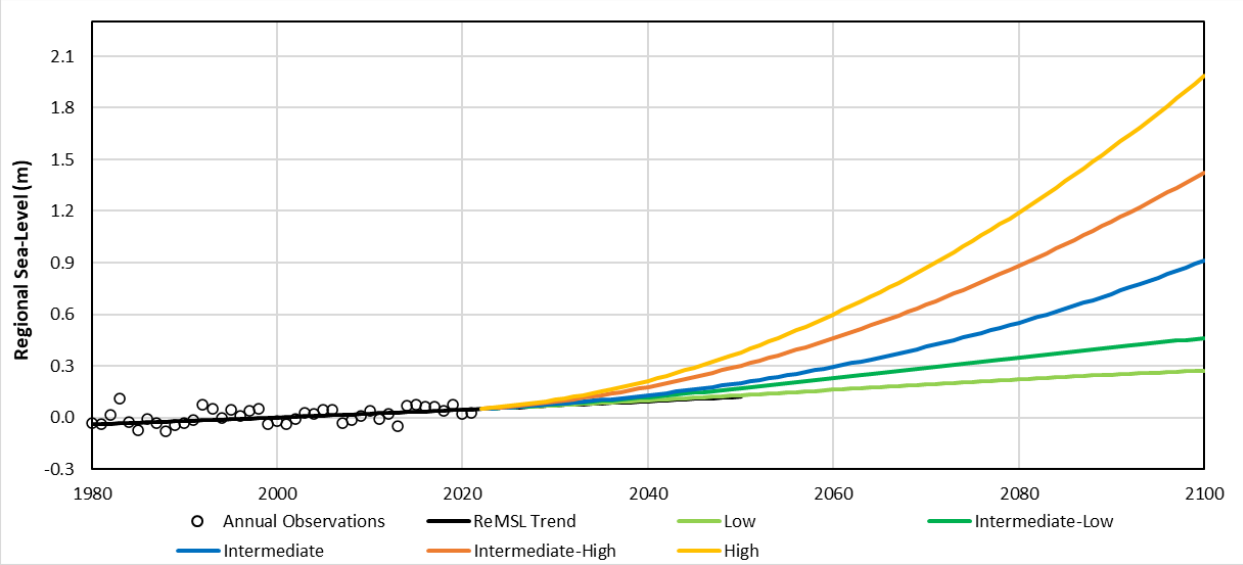
Northern Hydrology & Engineering

28 March 2023

Humboldt Bay Sea-Level Change

Regional Mean Sea Level (ReMSL) Rise

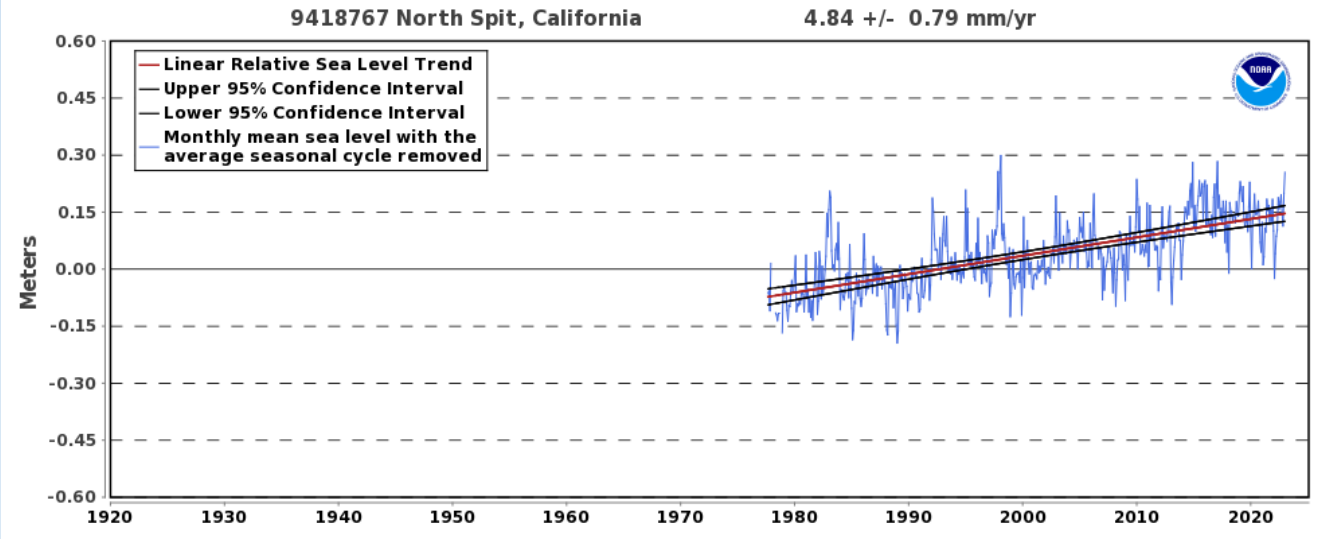


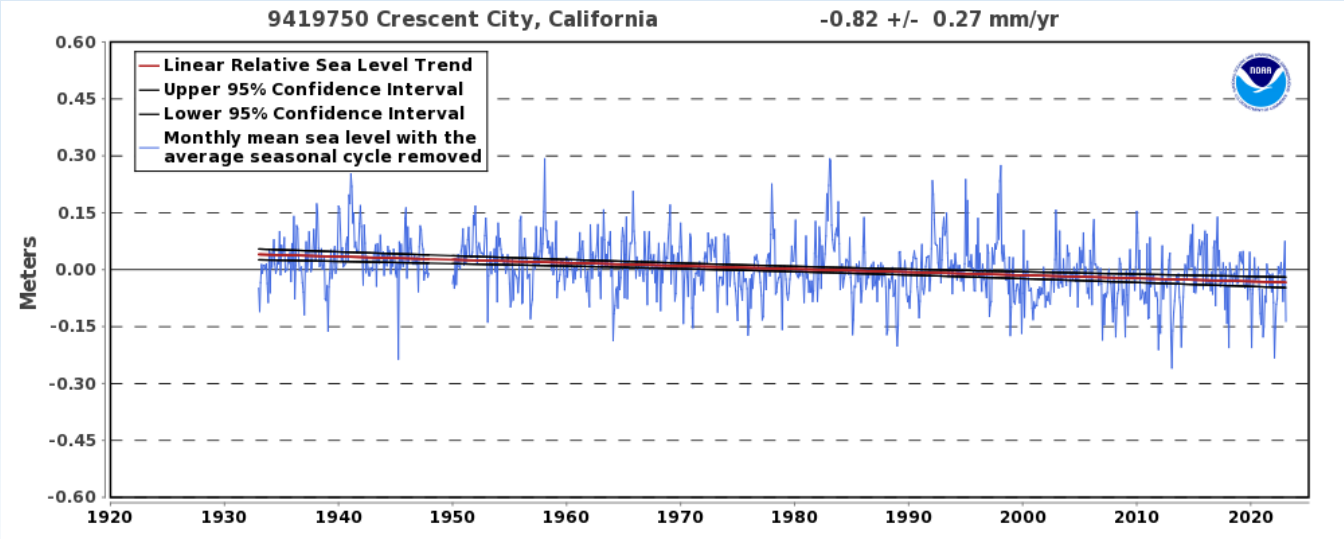


- ReMSL is the change to global mean sea level (GMSL) caused by regional and local factors
- ReMSL (1930s-2022) for the Pacific Northwest = ~ 2.0 mm/yr
- Higher than GMSL rise (1930s-2022) = ~ 1.7 mm/yr
- Figures show ReMSL trend (1900-2022) attached to the NOAA (2022) sea-level rise scenarios

Humboldt Bay Sea-Level Change

Relative Sea-Level (RSL) Change





- RSL is the change in ReMSL relative to the land
- Includes the affects of vertical land motion (VLM)
- RSL = ReMSL - VLM
- Tide stations measure RSL
- Depending on the direction and rate of VLM, RSL change can be positive (+) or negative (-)

Humboldt Bay Sea-Level Change

tektonika

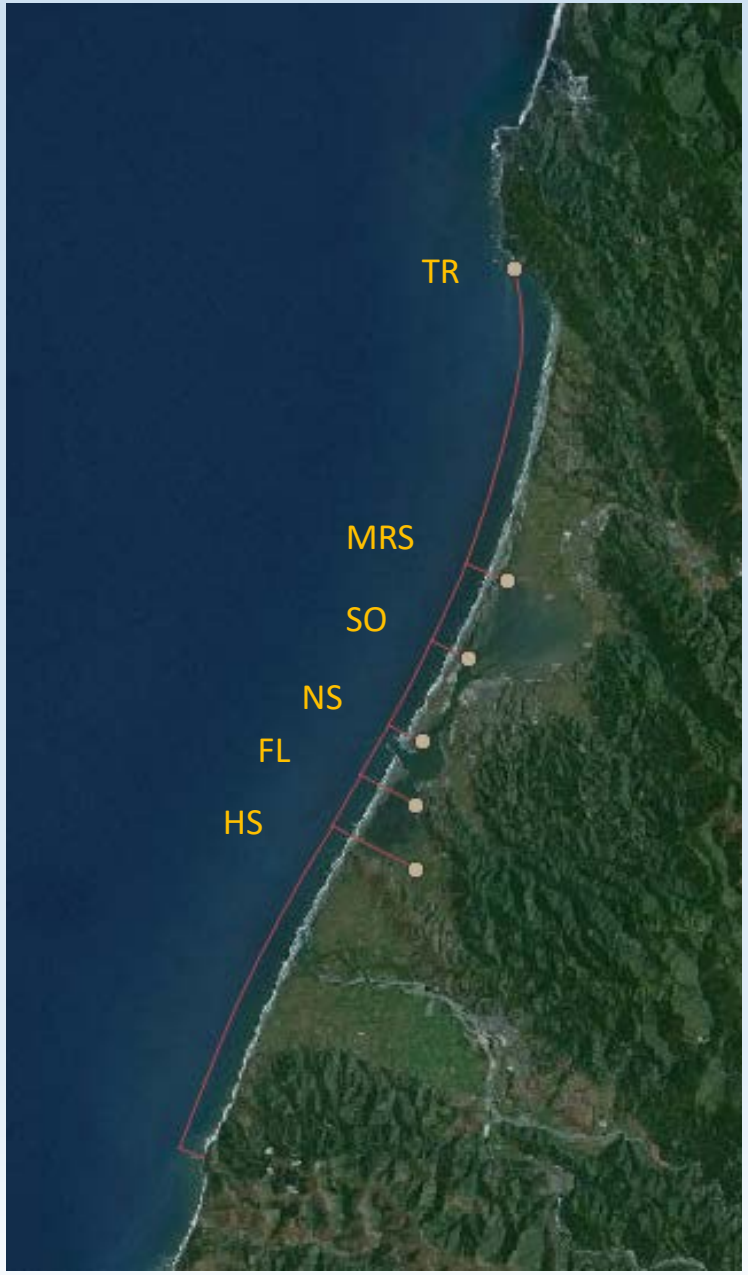
https://doi.org/10.55575/tektonika2023.1.1.6

20th to 21st Century Relative Sea and Land Level Changes in Northern California: Tectonic Land Level Changes and their Contribution to Sea-Level Rise, Humboldt Bay Region, Northern California

Jason R. Patton [1,2], Todd B. Williams[2], Jeffrey K. Anderson[3], Mark Hemphill-Haley [1], Reed J. Burgette [4], Ray Weldon II [5], Robert C. McPherson[1], Thomas H. Leroy[2,6]

[1]Cal Poly Humboldt, Department of Geology, 1 Harpst St., Arcata, CA 95521, USA | [2]Cascadia GeoSciences, 380 Beach Dr., Arcata, CA 95521, USA | [3]Northern Hydrology and Engineering, P.O. Box 2515, McKinleyville, CA 95519, USA | [4]Oregon Department of Geology and Mineral Industries, 800 NE Oregon Street, Suite 965, Portland, OR 97232, USA | [5]University of Oregon, Department of Earth Sciences, 1272 University of Oregon, Eugene, OR 97403 | [6]Pacific Watershed Associates, 1652 Holly Dr, McKinleyville, CA 95519, USA

Humboldt Bay Region

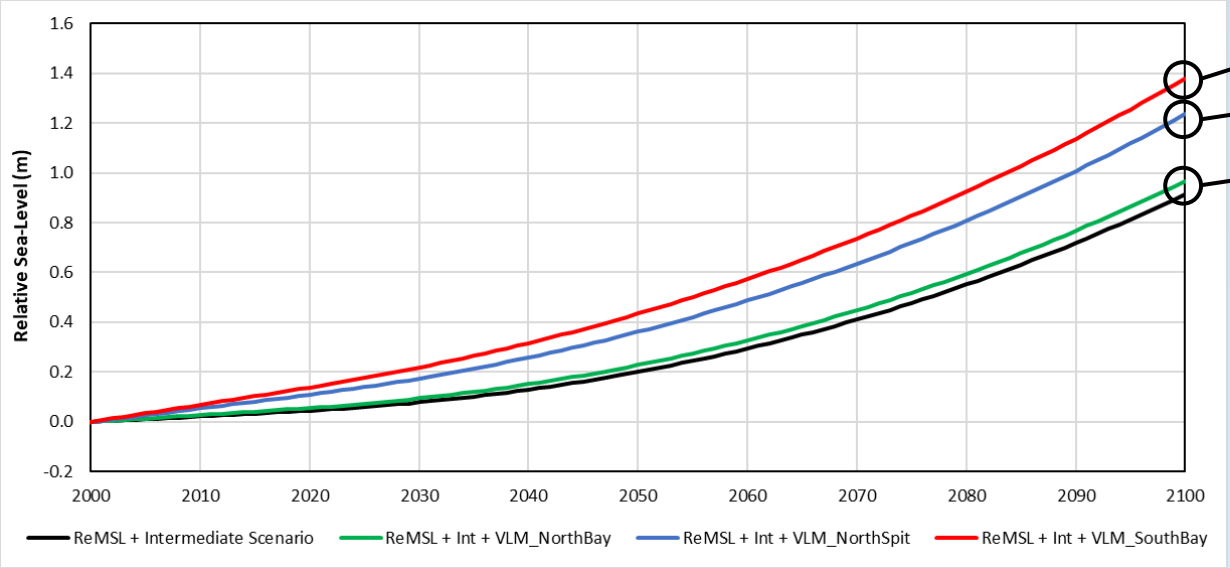


Relative Sea Level (RSL) and Vertical Land Motion (VLM) Rates

Station	RSL (mm/yr)	VLM (mm/yr)
Crescent City (CC)	-0.84	2.83
Trinidad (TR)	2.86	-0.87
Mad River Slough (MRS)	2.53	-0.54
Samoa (SO)	3.92	-1.93
North Spit (NS)	5.20	-3.21
Fields Landing (FL)	4.65	-2.66
Hookton Slough (HS)	6.64	-4.65

Humboldt Bay Sea-Level Change

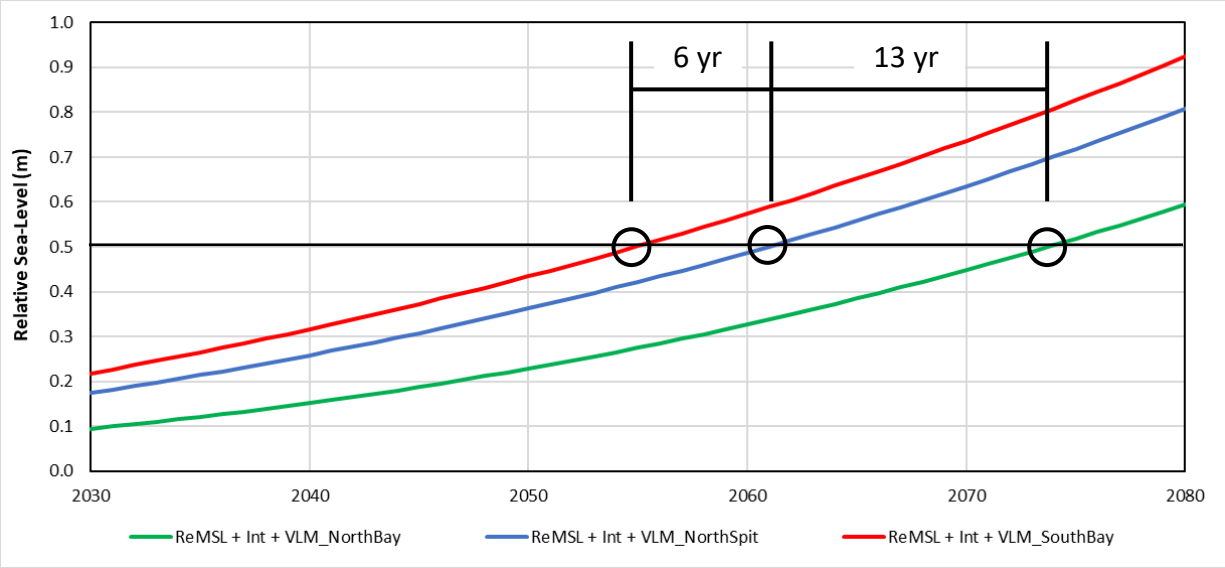
Relative Sea-Level (RSL) Change



1.38 m (4.5 ft)

1.24 m (4.1 ft)

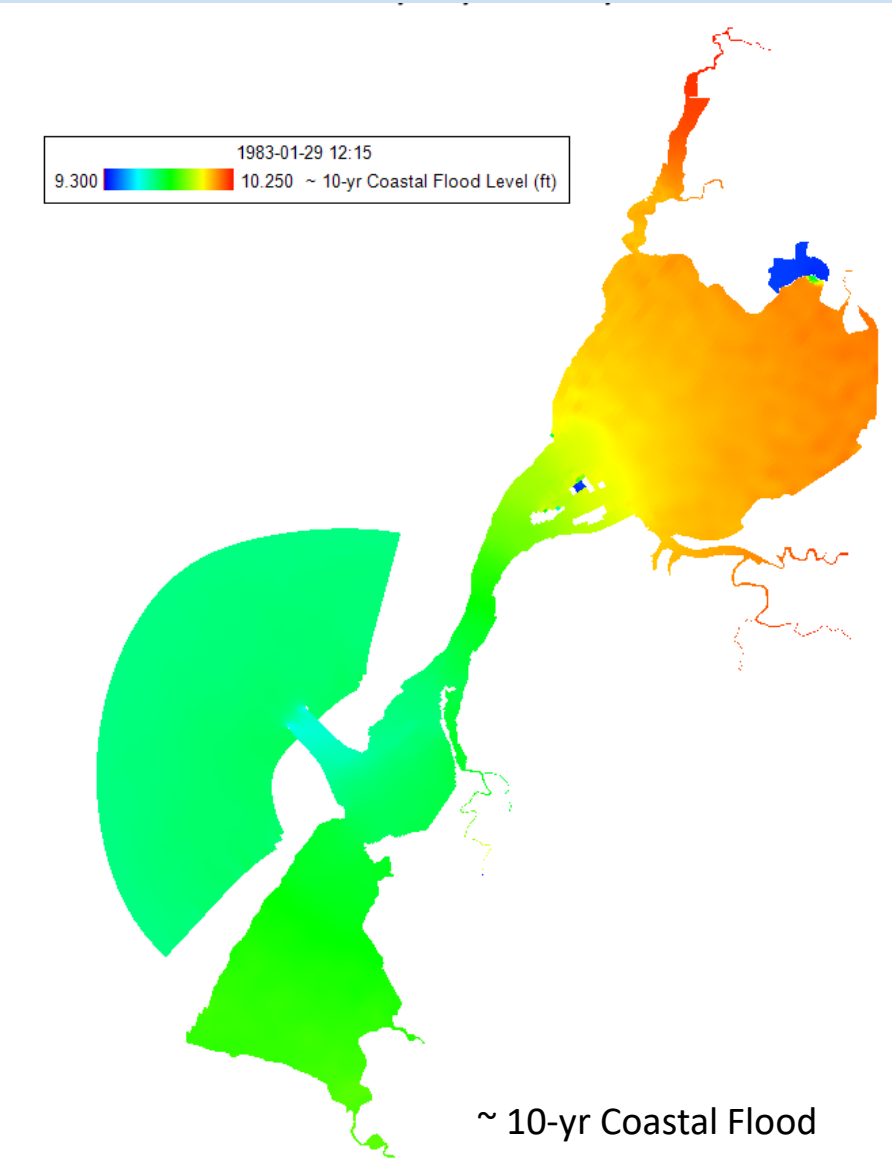
0.97 m (3.2 ft)



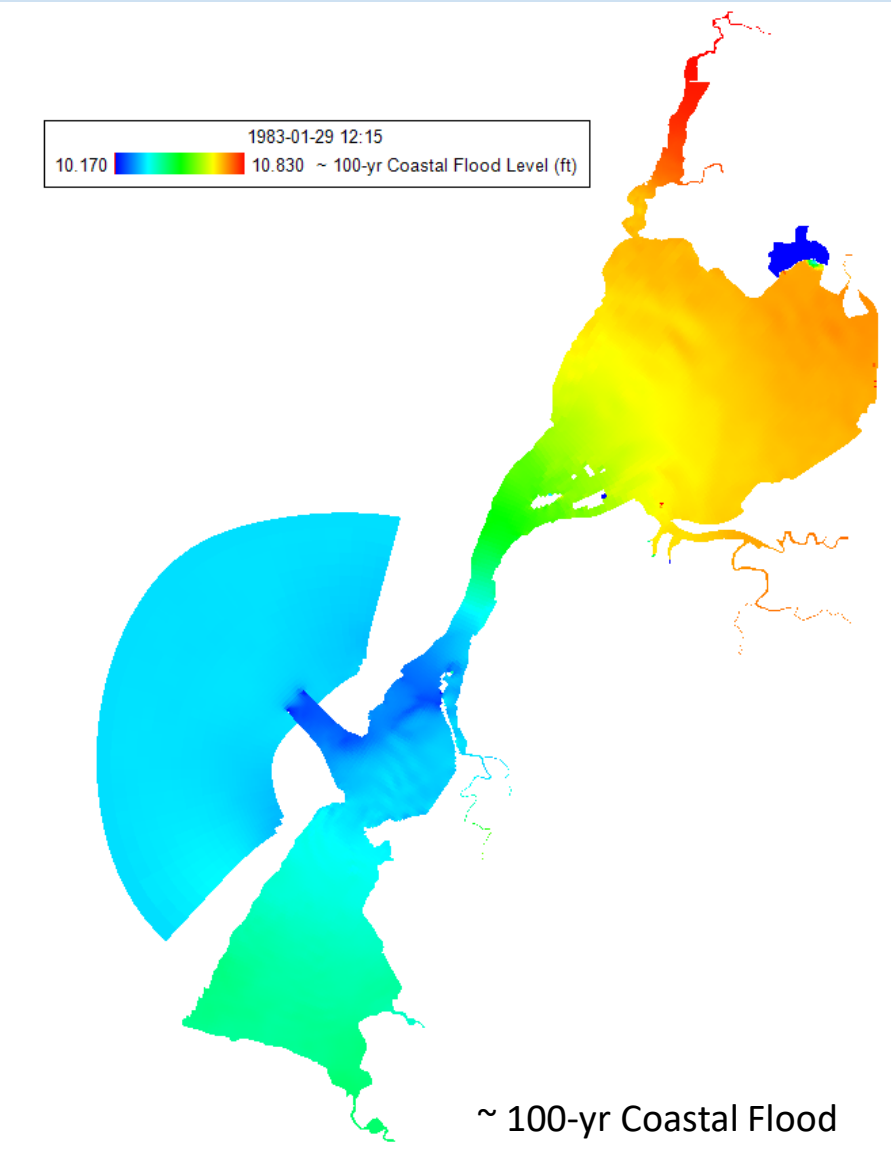
- RSL = ReMSL - VLM
- Subtracted VLM rates for MRS, North Spit and Hookton Slough
- This could represent RSL rates for North Bay, Middle Bay, and South Bay

Humboldt Bay Sea-Level Change

Humboldt Bay is not a Bathtub



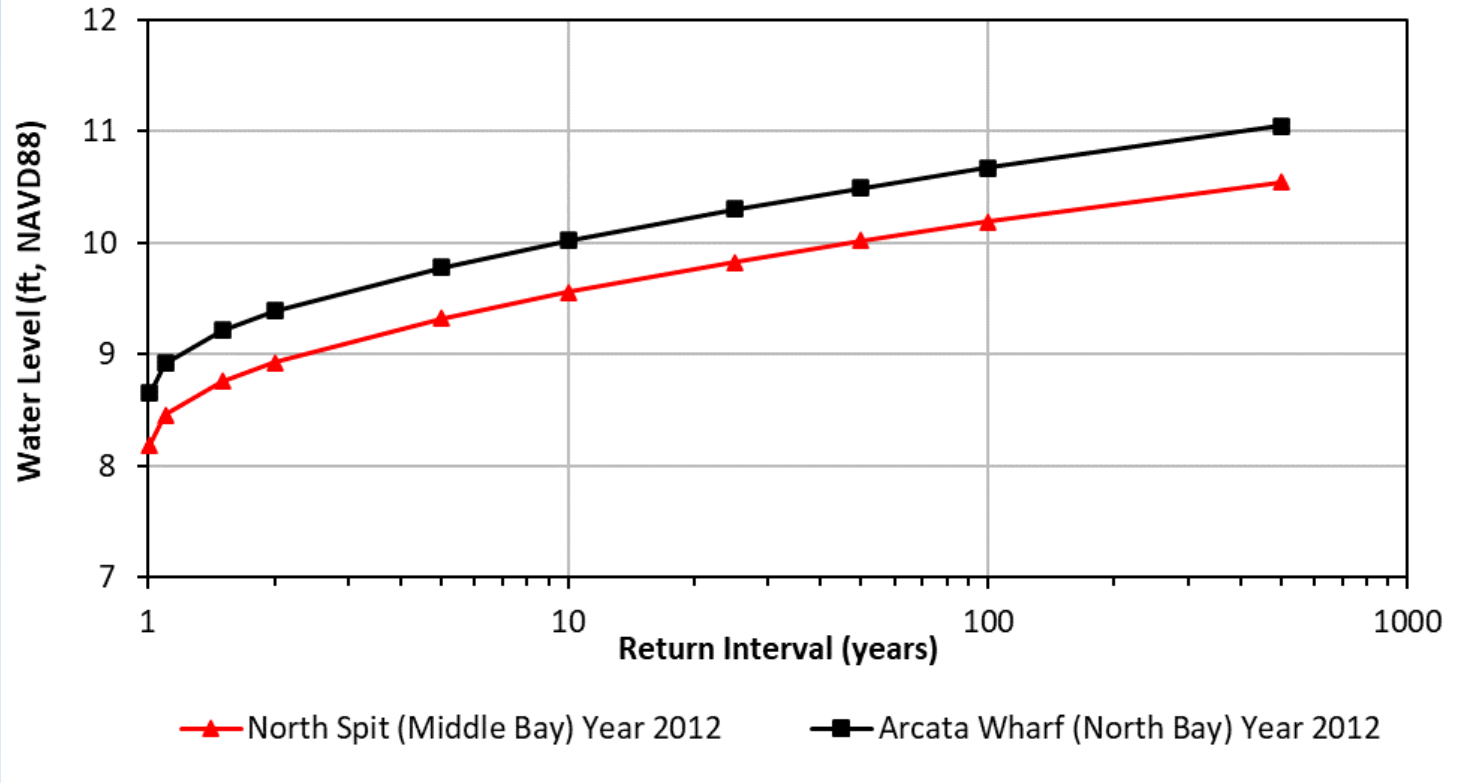
~ 10-yr Coastal Flood



~ 100-yr Coastal Flood

Humboldt Bay Sea-Level Change

Humboldt Bay is not a Bathtub



Return Interval (yr)	Annual Exceedance (%)	North Spit (ft, NAVD88)	Arcata Wharf (ft, NAVD88)
1	~100	8.2	8.7
2	50	8.9	9.4
5	20	9.3	9.8
10	10	9.6	10.0
25	4	9.8	10.3
100	1	10.2	10.7
500	0.2	10.5	11.1

Adaron Laird

Sr. Environmental Planner

Greenway Partners

City of Arcata



Current Tidal Inundation Areas versus Potential Tidal Inundation Areas (Stillwater) with 4.6 feet (1.5 meters) of Sea Level Rise

Sea Level Rise Vulnerability Assessment

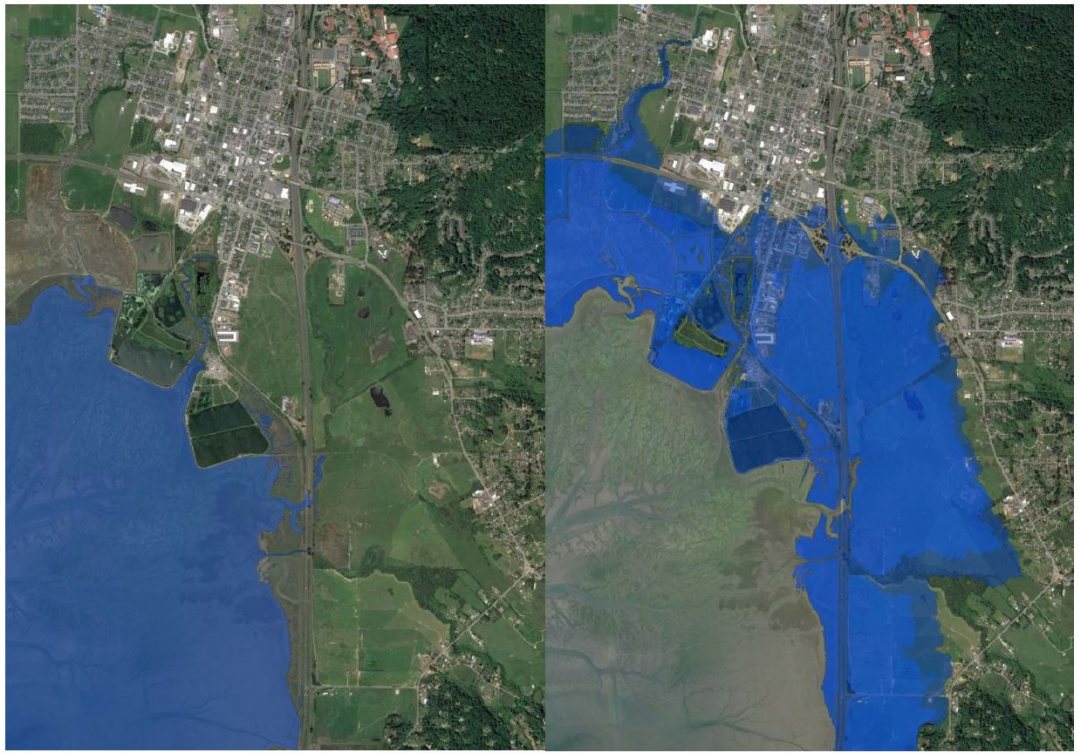


City of Arcata

Joint City Council & Planning Commission
Sea Level Rise Workshop
Tuesday, March 28, 2023

Aldaron Laird
Environmental Planner

City of Arcata



Current Tidal Inundation Areas versus Potential Tidal Inundation Areas (Stillwater)
with 4.6 feet (1.5 meters) of Sea Level Rise

Sea Level Rise
Vulnerability Assessment

Aldaron Laird

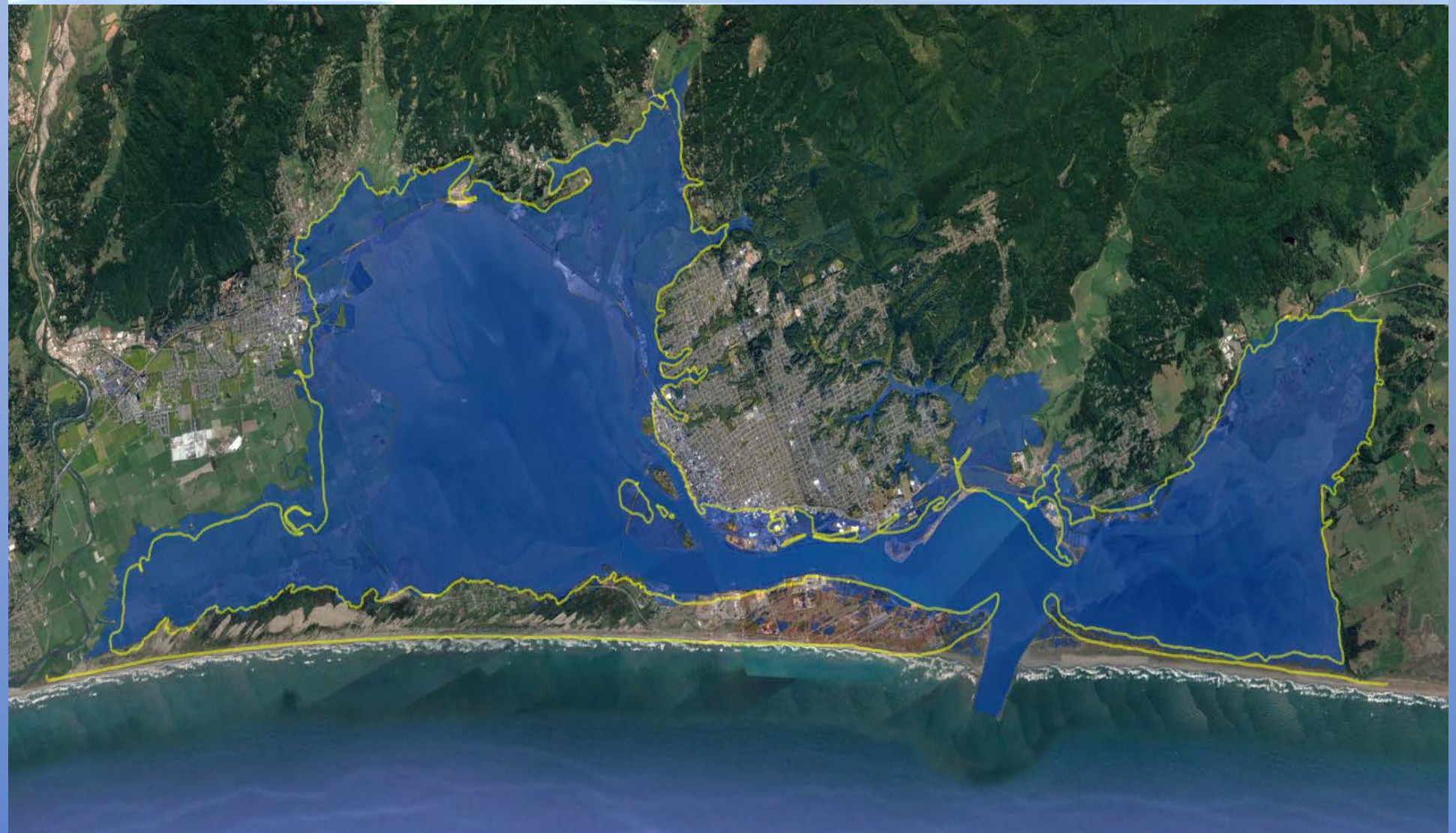
Historical Humboldt Bay - 1870
~ 25,800 acres



Present Day Humboldt Bay
~ 20,400 acres



Humboldt Bay ~ 2060
~ 31,100 acres



New Years Eve 2005 - State of Disaster

Record Extreme Water Elevation, Humboldt Bay 9.6’



Humboldt Bay
Sea Level Rise Projections

- 2005 State of Disaster 9.6 ft
- 2020 MAMW 8.8 ft MMMW 7.7 ft
  MHHW 6.5 ft
- 2030 1 ft MAMW 9.8 ft MMMW 8.7 ft
  MHHW 7.5 ft
- 2045 2 ft MAMW 10.8 ft MMMW 9.7 ft
  MHHW 8.5 ft
- 2060 3 ft MAMW 11.8 ft MMMW 10.7 ft
  MHHW 9.5 ft

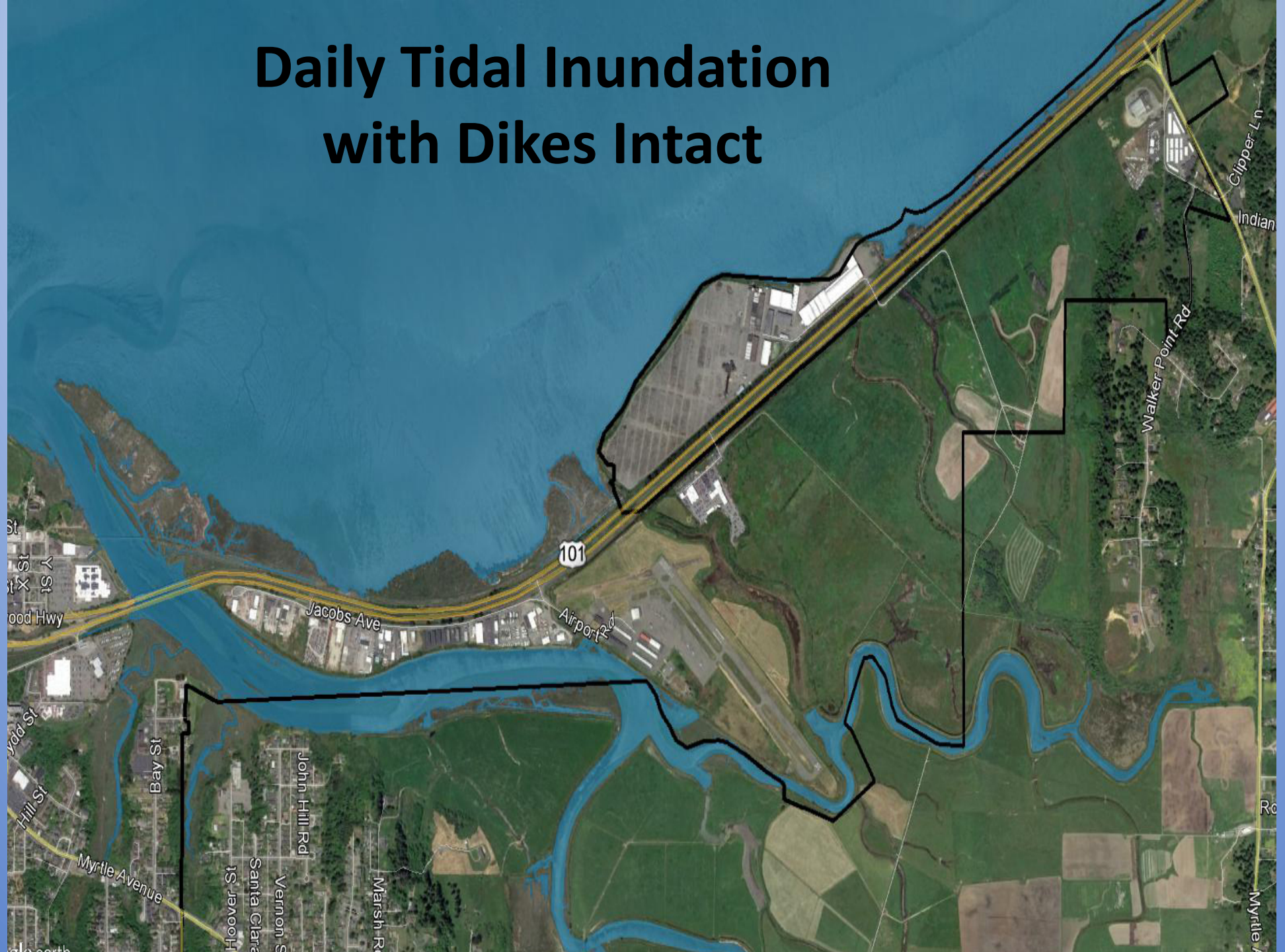
Historical Legacy Diking-Off Salt Marsh



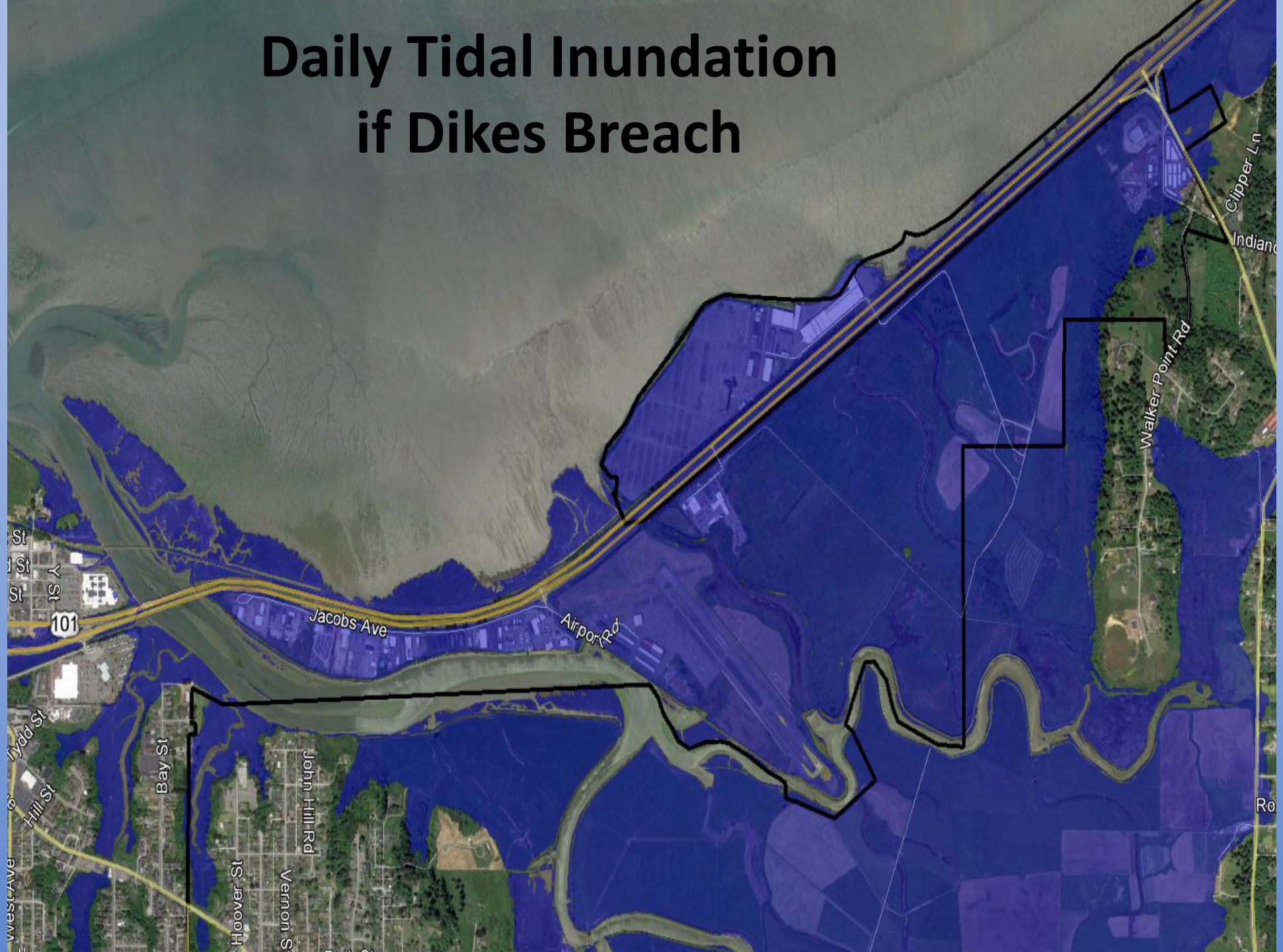
41 miles of dikes

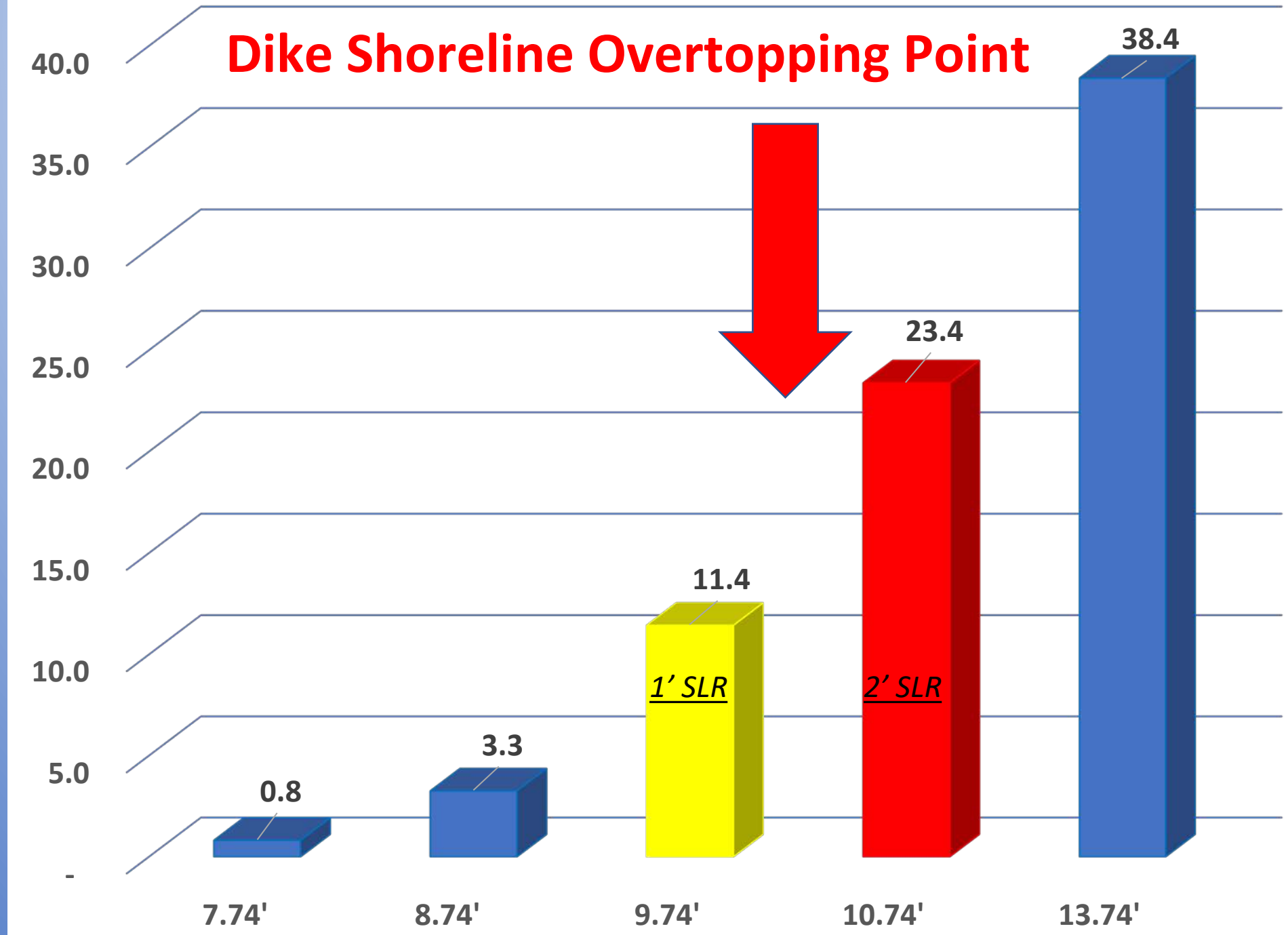


Daily Tidal Inundation with Dikes Intact



Daily Tidal Inundation if Dikes Breach




Dike Shoreline Overtopping Point
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
-
0.8
3.3
11.4
23.4
38.4
1' SLR
2' SLR
7.74'
8.74'
9.74'
10.74'
13.74'

Humboldt Bay
Shoreline Vulnerability

Dominate Shoreline Structures have an Overtopping Threshold at 10 feet

Water Elevation Reaches ~ 10 feet Elevation

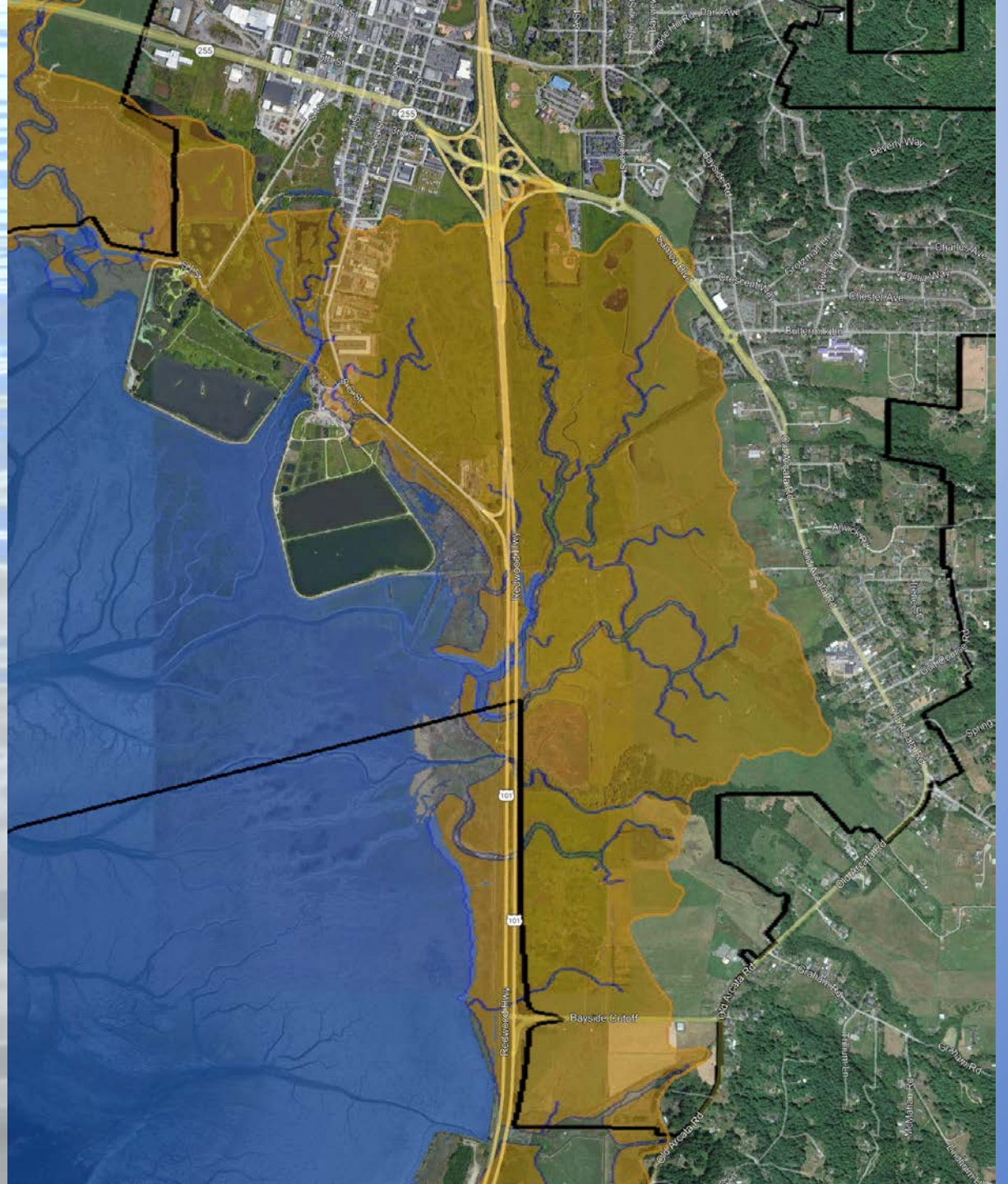
- **2030 with 1 foot of SLR = King Tide**
- **2045 with 2 feet of SLR = Monthly High Tide**
- **2060 with 3 feet of SLR = Daily High Tide**


STATE AGENCY SEA-LEVEL RISE ACTION PLAN FOR CALIFORNIA
FEBRUARY 2022
SLR adaptation planning should include pathways to resiliency to 3.5’ by 2050 and 6.0’ by 2100
PREPARED BY
OCEAN PROTECTION COUNCIL

Back

City of Arcata

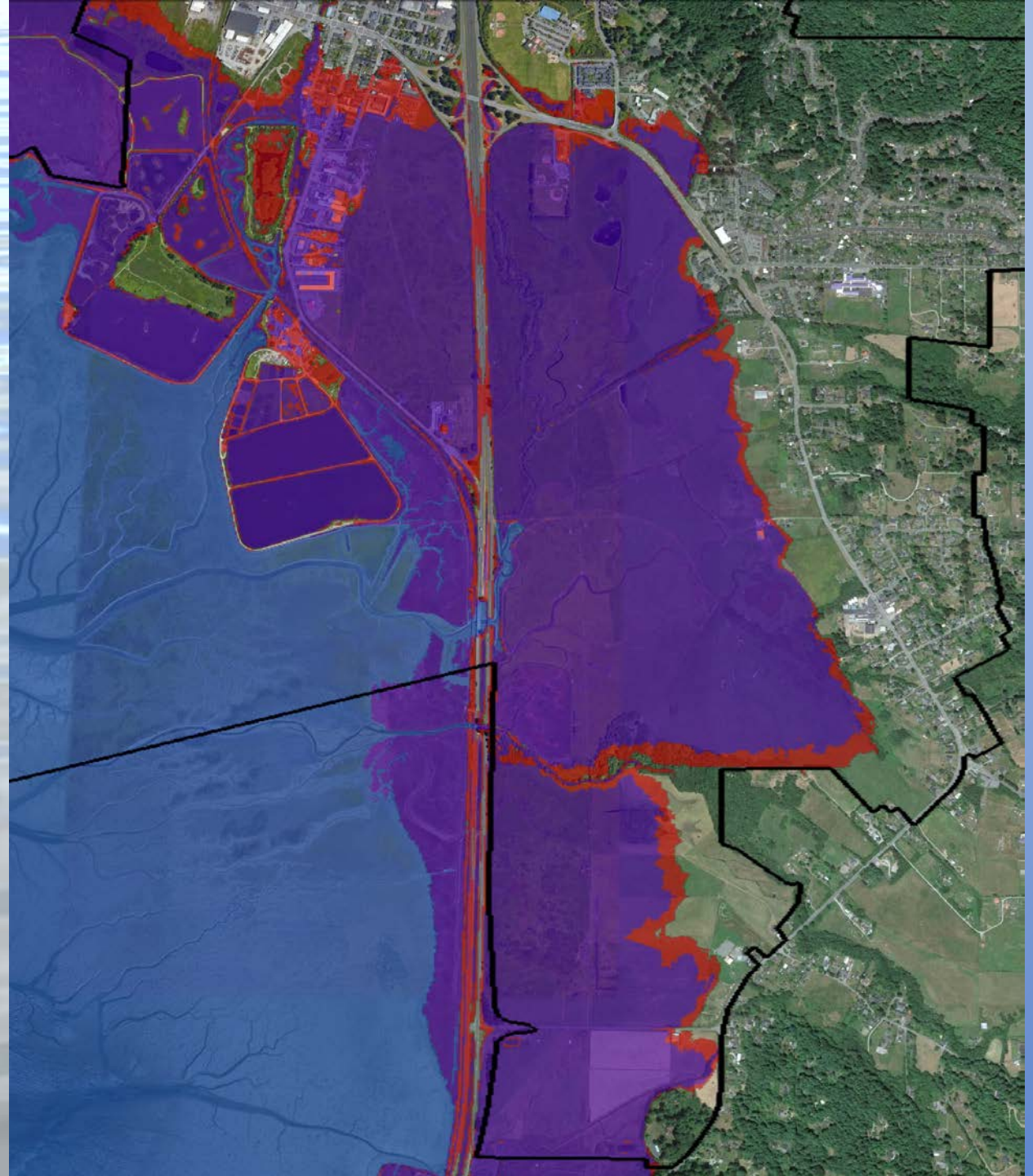
Former Salt Marsh Areas Vulnerable Tidewater Inundation


Redwood Hwy
Bayside Cutoff
Old Arcata Rd
Giuntoli Ln
Janes Rd
Aldergrove Ave
Chester Ave
Beverly Way
Arlington Dr
Arlington Ct
Arlington Way
Arlington Ln
Arlington Cir
Arlington Rd
Arlington Ave
Arlington Pl
Arlington Ter
Arlington Blvd
Arlington Trl
Arlington Pkwy
Arlington Sq
Arlington Loop
Arlington Path
Arlington Crossing
Arlington Heights
Arlington Hills
Arlington Meadows
Arlington Woods
Arlington Valley
Arlington Ridge
Arlington Park
Arlington Gardens
Arlington Estates
Arlington Manor
Arlington Village
Arlington Square
Arlington Plaza
Arlington Center
Arlington Commons
Arlington Terrace
Arlington Boulevard
Arlington Parkway
Arlington Circle
Arlington Court
Arlington Drive
Arlington Lane
Arlington Road
Arlington Street
Arlington Avenue
Arlington Place
Arlington Trail

City of Arcata

Areas Vulnerable to Sea Level Rise:

- 0.5 meter
- 1.0 meters



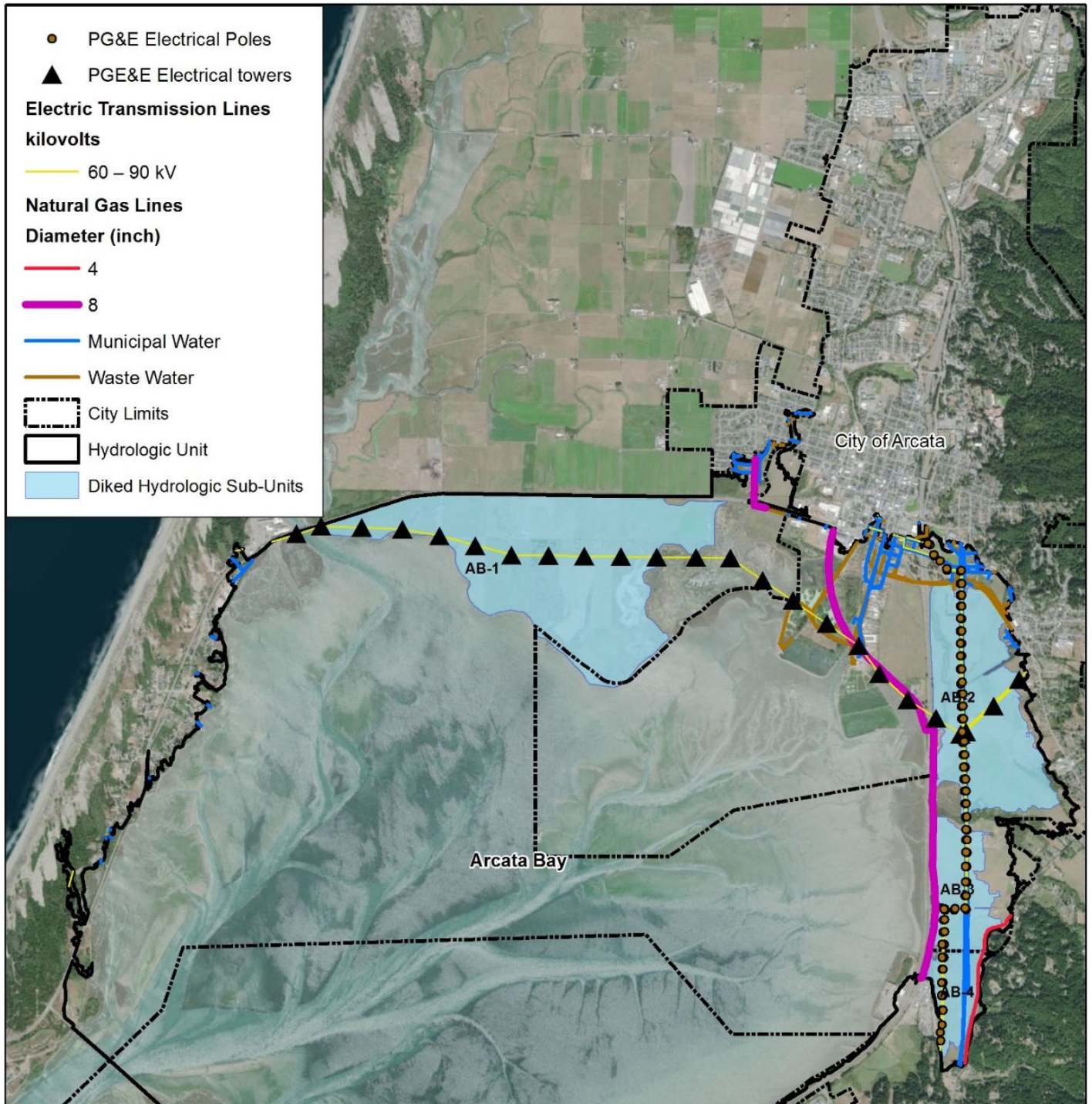
City of Arcata

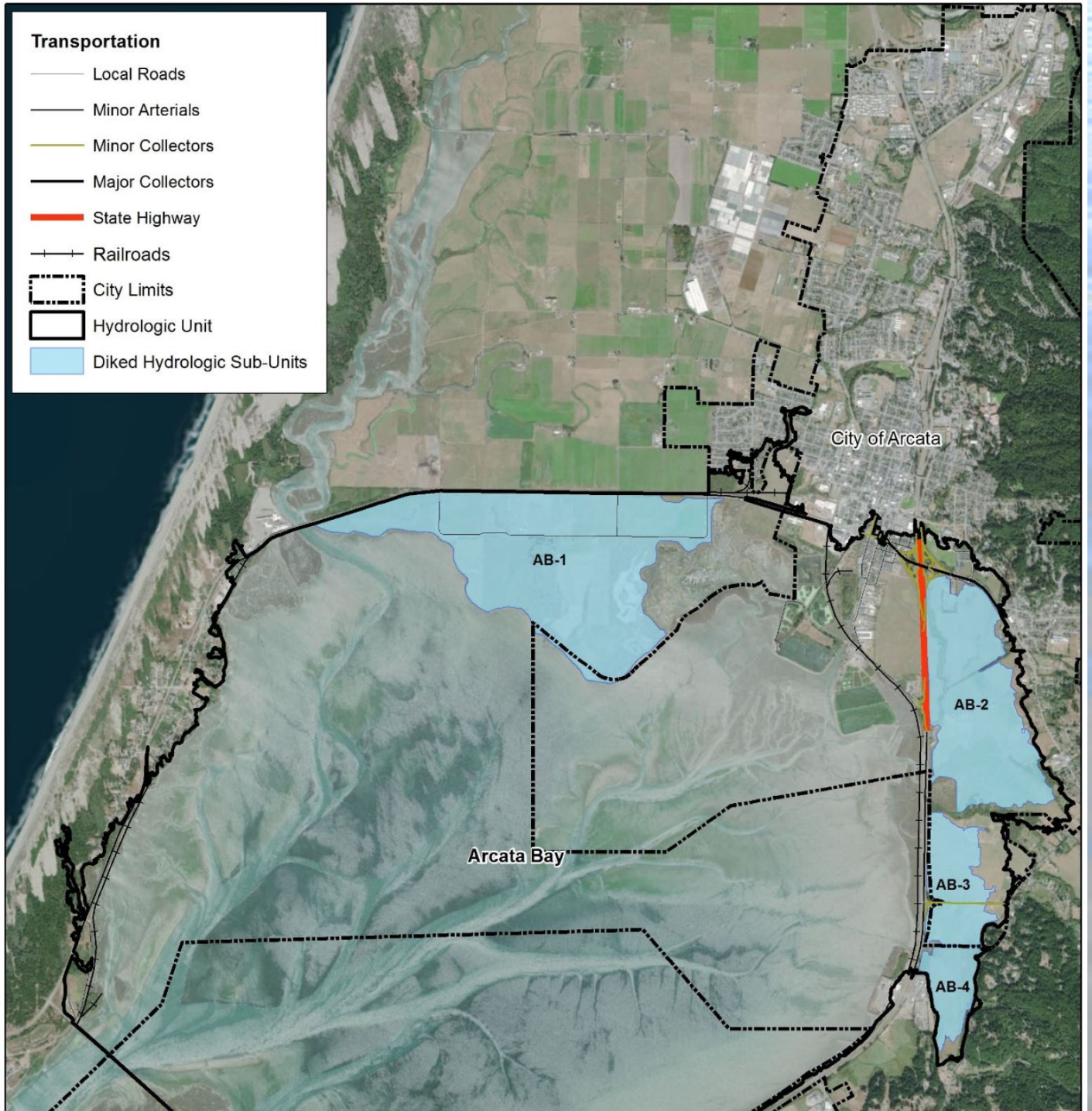
Assets at Risk

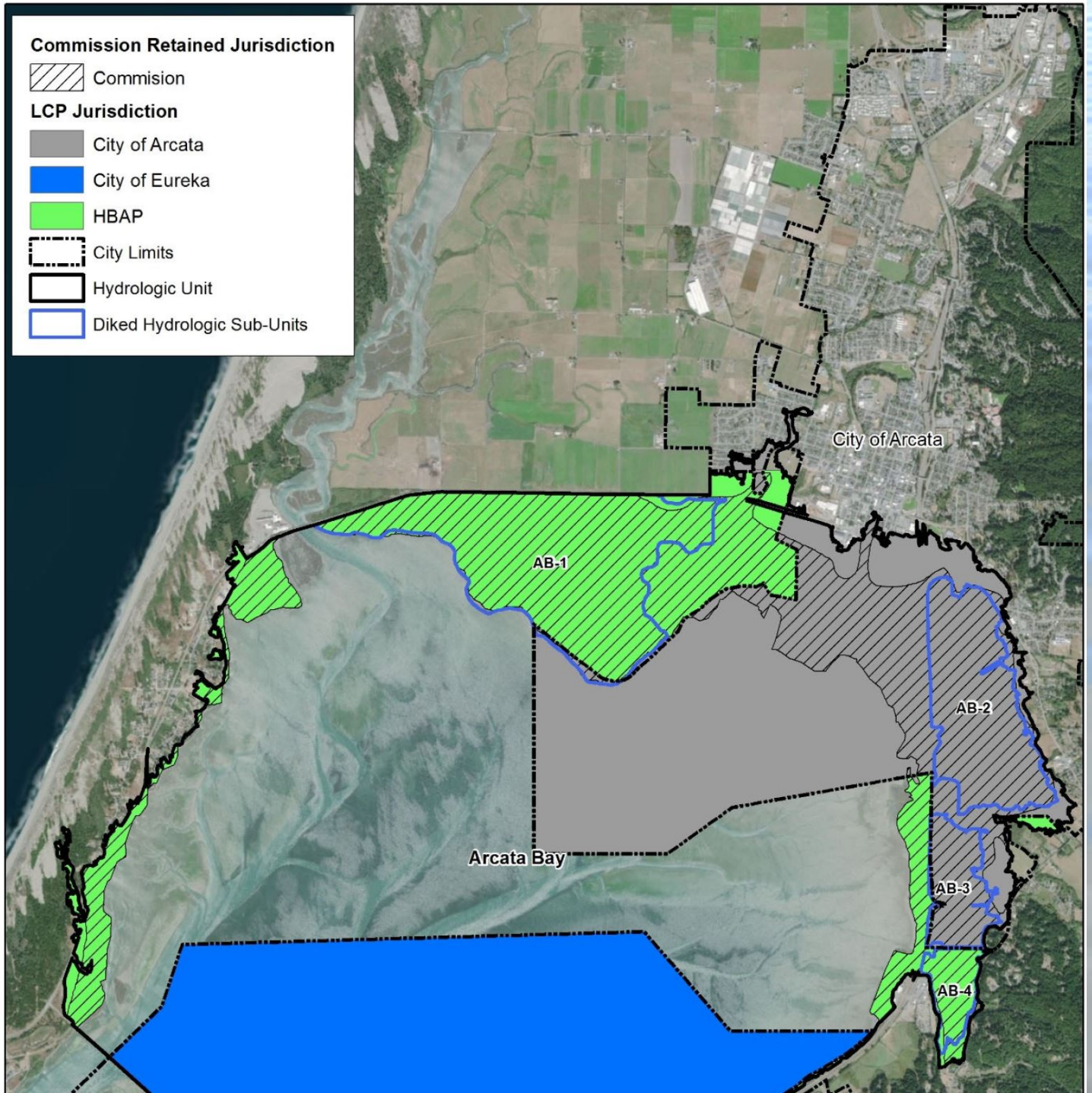
from 1.0 meter of Sea Level Rise:

HYDROLOGIC UNIT	AREA			WATER LINES	SEWER LINES	GAS LINES	ELECTRICAL TRANSMISSION		
	1.0 meter	1.5 meters	2.0 meters				LINES	TOWERS	POLES
ARCATA BAY	**2501**	**2675**	**2808**	**21.5**	**10.7**	**4.02**	**11.9**	**24**	**85**
AB-1	726						1.95	10	0
AB-2	383			5.2	0.34		3.47	4	38
AB-3	139			2.7		0.82	1.53		22
AB-4	79.3			1.8		0.47			10

HYDROLOGIC UNIT	AREA			TRANSPORTATION				BULK CARGO	BOAT LAUNCH
	1.0 meter	1.5 meters	2.0 meters	Local	State	Air	Rail		
ARCATA BAY	**2501**	**2675**	**2808**	**13**	**5.2**	**0**	**6.17**	**0**	**1**
AB-1	726			2.2					
AB-2	383			0.0					
AB-3	139			0.2					
AB-4	79.3								


PG&E Electrical Poles
PGE&E Electrical towers
Electric Transmission Lines
kilovolts
60 – 90 kV
Natural Gas Lines
Diameter (inch)
4
8
Municipal Water
Waste Water
City Limits
Hydrologic Unit
Diked Hydrologic Sub-Units
City of Arcata
AB-1
AB-2
AB-3
AB-4
Arcata Bay


Transportation
Local Roads
Minor Arterials
Minor Collectors
Major Collectors
State Highway
Railroads
City Limits
Hydrologic Unit
Diked Hydrologic Sub-Units
City of Arcata
AB-1
AB-2
AB-3
AB-4
Arcata Bay

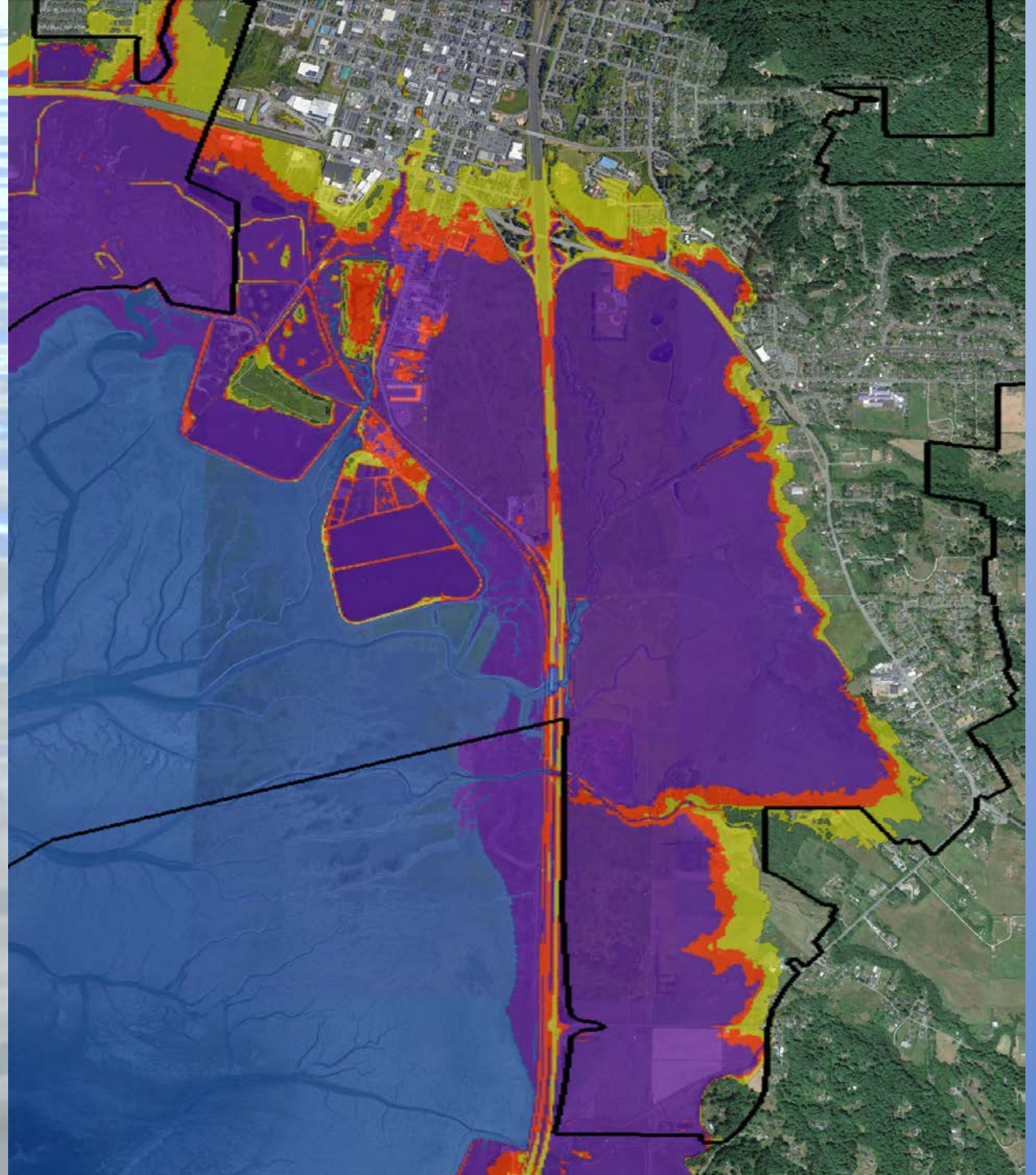

Commission Retained Jurisdiction
Commision
LCP Jurisdiction
City of Arcata
City of Eureka
HBAP
City Limits
Hydrologic Unit
Diked Hydrologic Sub-Units
City of Arcata
AB-1
AB-2
AB-3
AB-4
Arcata Bay

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City of Arcata

Areas Vulnerable to Sea Level Rise:

- 0.5 meters
- 1.0 meters
- 2.0 meters

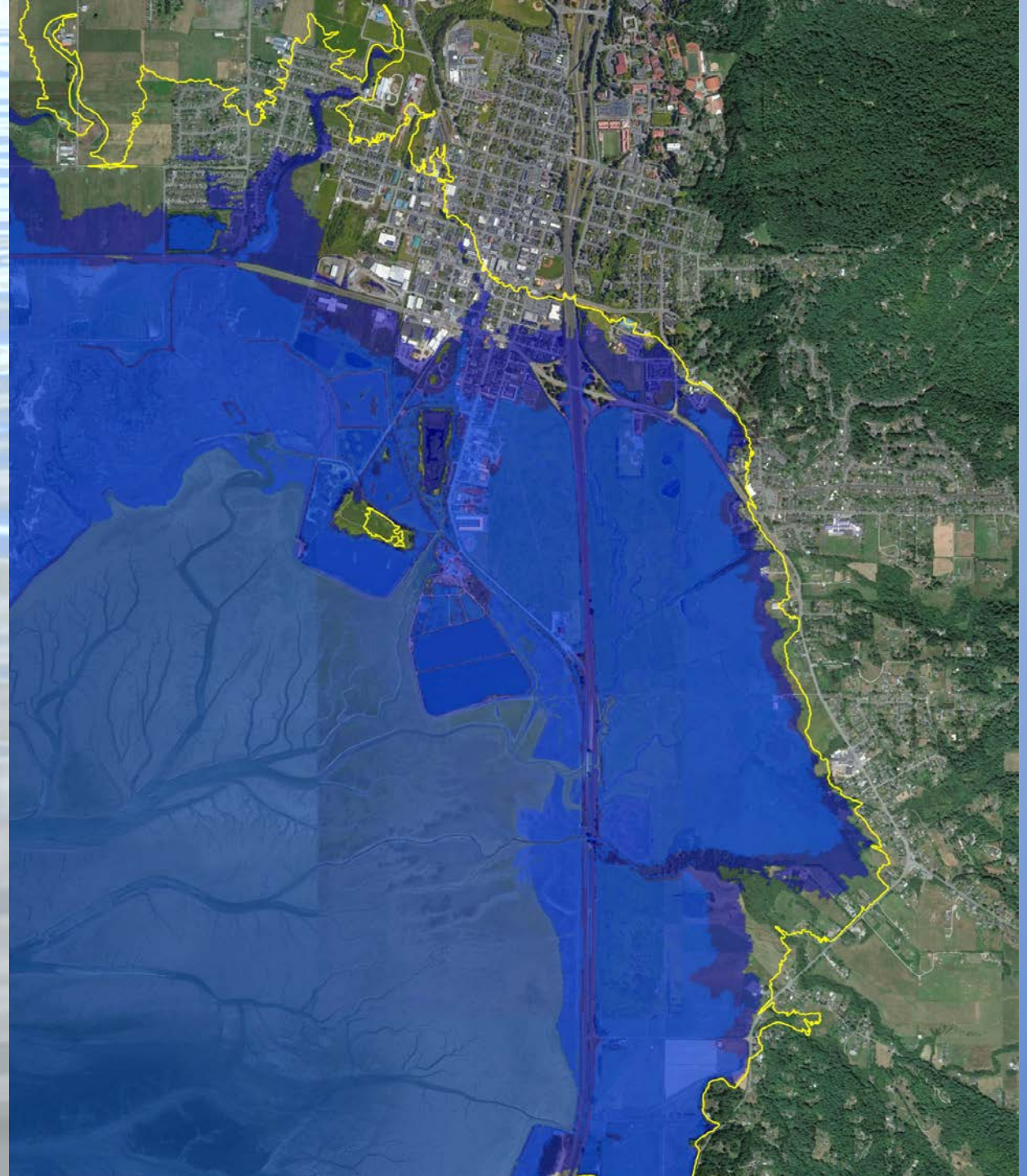


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City of Arcata

Areas Vulnerable to Sea Level Rise:

- 0.5 meters
- 2.0 meters
- 3.0 meters



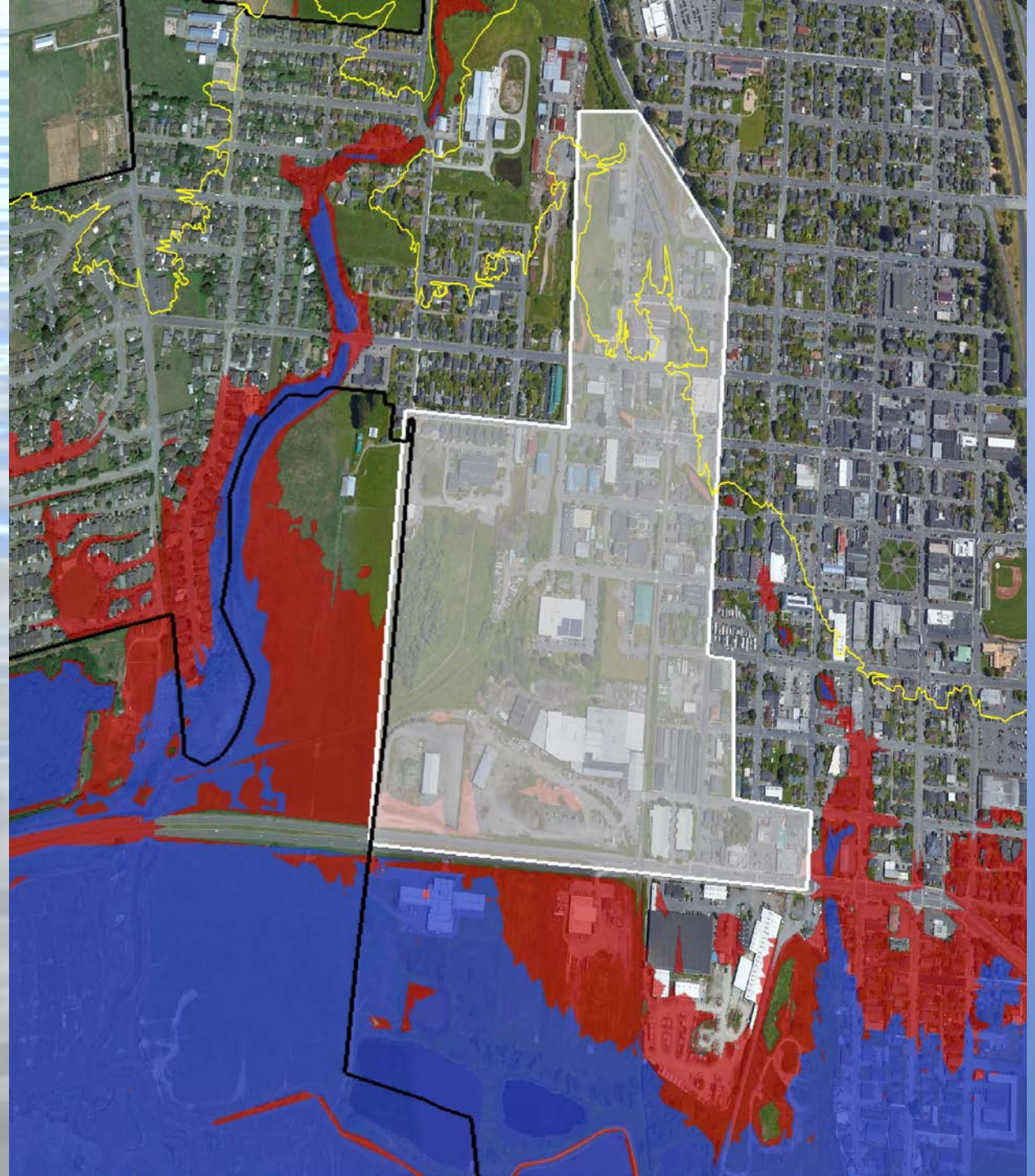
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Areas Vulnerable to Sea Level Rise

1.0 meters ~ 11 feet

2.0 meters ~ 14 feet

3.0 meters ~ 19 feet



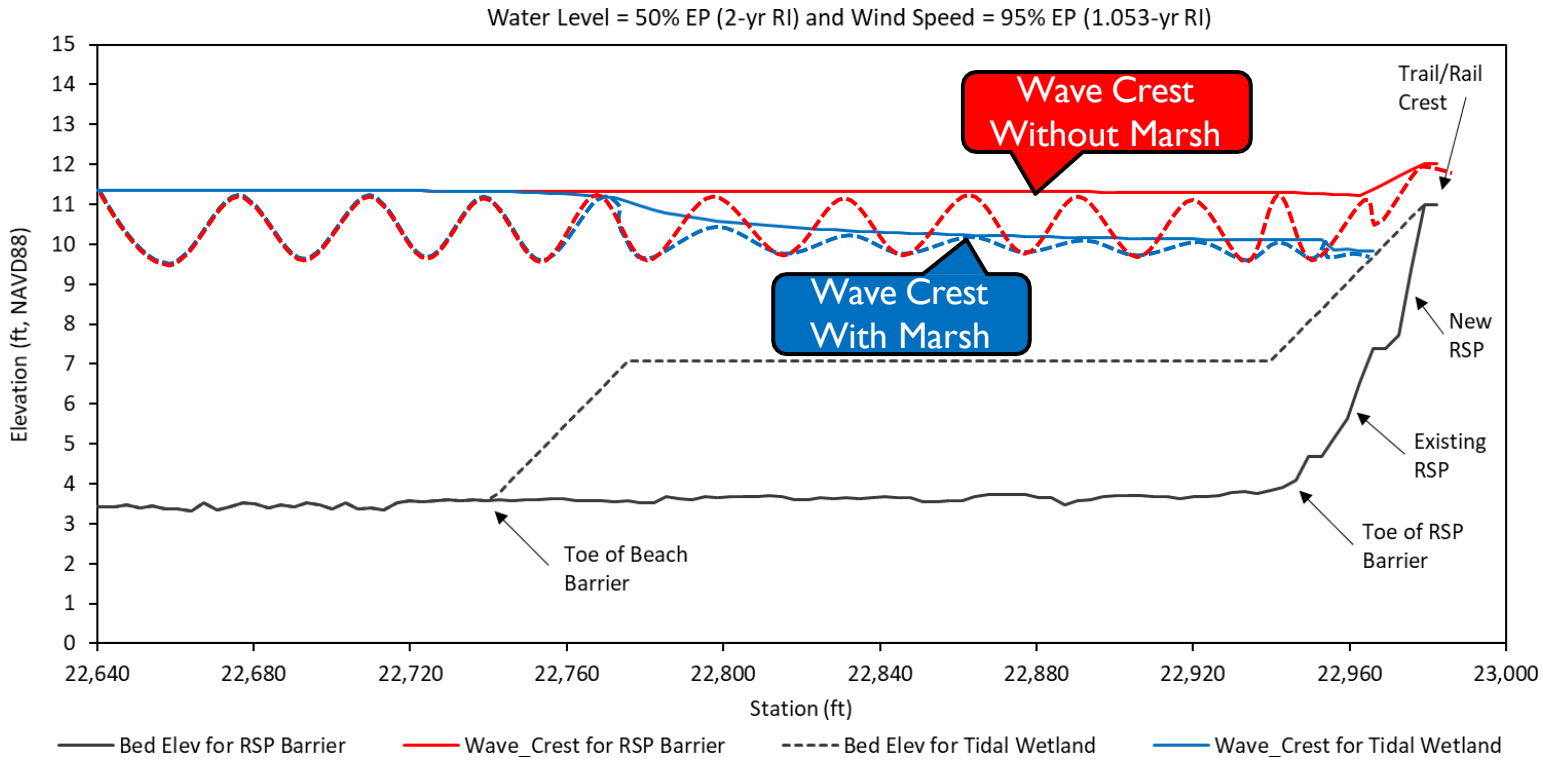
Thank-You



Links to Slides for Panelists

- Jeff Ecosystem Services
- Jeff Extreme Water Levels
- Aldaron Saltmarsh
- Aldaron 2 meters overall
- Aldaron 3 meters
- Gwen What about Locally?

Ecosystem Services and Project Benefits: Reduced Flooding and Erosion



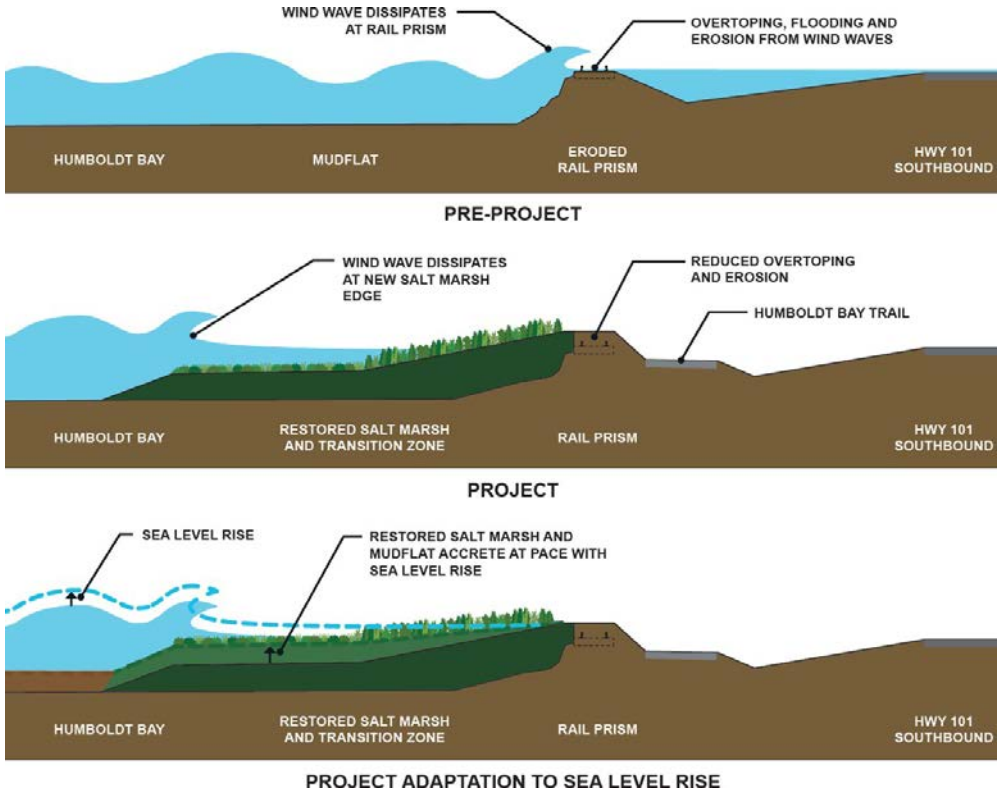
Ecosystem Services and Project Benefits: Reduced Flooding and Erosion

Water Level (RI)	Wind Speed	Pre-Project		Post-Project
		Flooding	Damage	Flooding/Damage
10.7 ft (100-yr)	48 mph (100-yr)	Flooding of Highway 101 South Bound Lanes	Damage to Pavement	No Overtopping, Flooding, or Damage with Marsh
	44 mph (10-yr)			
	40 mph (2-yr)		Damage to Rail Prism	
	38 mph (1.053-yr)			
10.0 ft (10-yr)	48 mph (100-yr)			
	44 mph (10-yr)			
	40 mph (2-yr)		Trail Usability Compromised	
	38 mph (1.053-yr)			
9.4 ft (2-yr)	48 mph (100-yr)			
	44 mph (10-yr)			
	40 mph (2-yr)		No Damage	
	38 mph (1.053-yr)			
8.4 ft (MMMW)	48 mph (100-yr)	Flooding of Trail and Highway Shoulder		
	44 mph (10-yr)	Flooding of Trail		
	40 mph (2-yr)			
	38 mph (1.053-yr)	No Overtopping, Flooding, or Damage pre- or post-project		
7.1 ft (MHHW)	48 mph (100-yr)			
	44 mph (10-yr)			
	40 mph (2-yr)			
	38 mph (1.053-yr)			

EP = Exceedance Probability, RI = Return Interval

Ecosystem Services and Project Benefits: SLR Resiliency & Adaptability

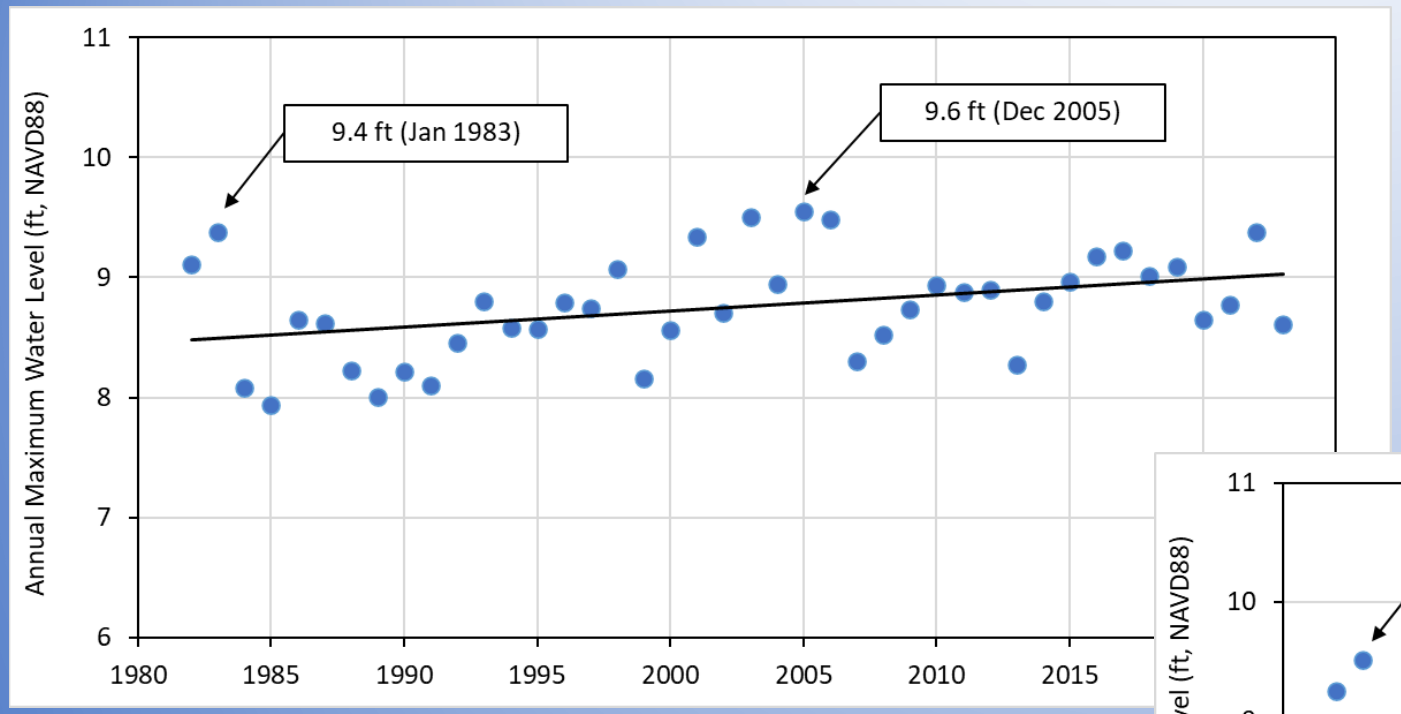
Water Level	Wind Speed	SLR 0 ft	SLR 1 ft	SLR 2 ft	SLR 3 ft
10.7 ft (100-yr)	38 mph (1.053-yr)		Overtopping and flooding with or without marsh		
	40 mph (2-yr)				
	44 mph (10-yr)				
	48 mph (100-yr)				
10.0 ft (10-yr)	38 mph (1.053-yr)				
	40 mph (2-yr)				
	44 mph (10-yr)				
	48 mph (100-yr)	Avoided overtopping and flooding with implementation of marsh			
9.4 ft (2-yr)	38 mph (1.053-yr)				
	40 mph (2-yr)				
	44 mph (10-yr)				
	48 mph (100-yr)				
8.4 ft (MMMW)	38 mph (1.053-yr)				
	40 mph (2-yr)				
	44 mph (10-yr)				
	48 mph (100-yr)				
7.1 ft (MHHW)	38 mph (1.053-yr)	No overtopping with or without marsh			
	40 mph (2-yr)				
	44 mph (10-yr)				
	48 mph (100-yr)				

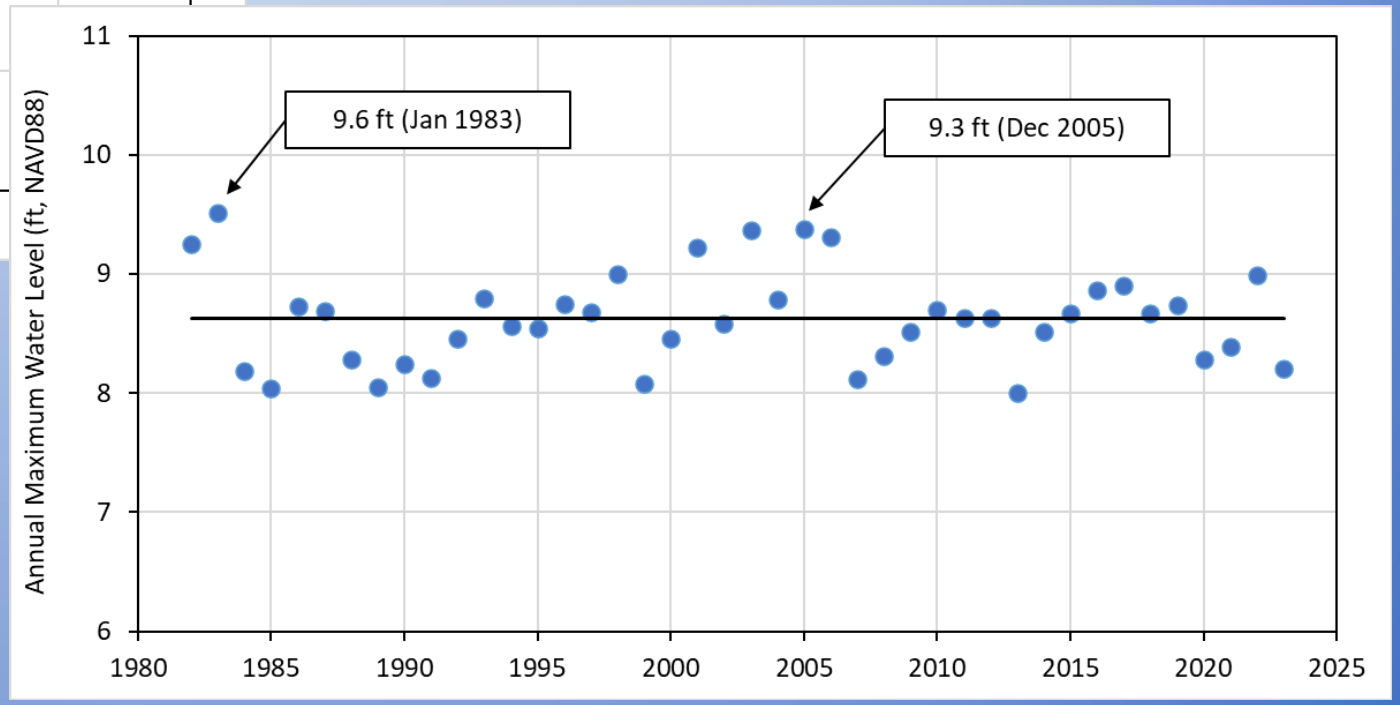


Humboldt Bay Sea-Level Change

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Extreme Water Levels

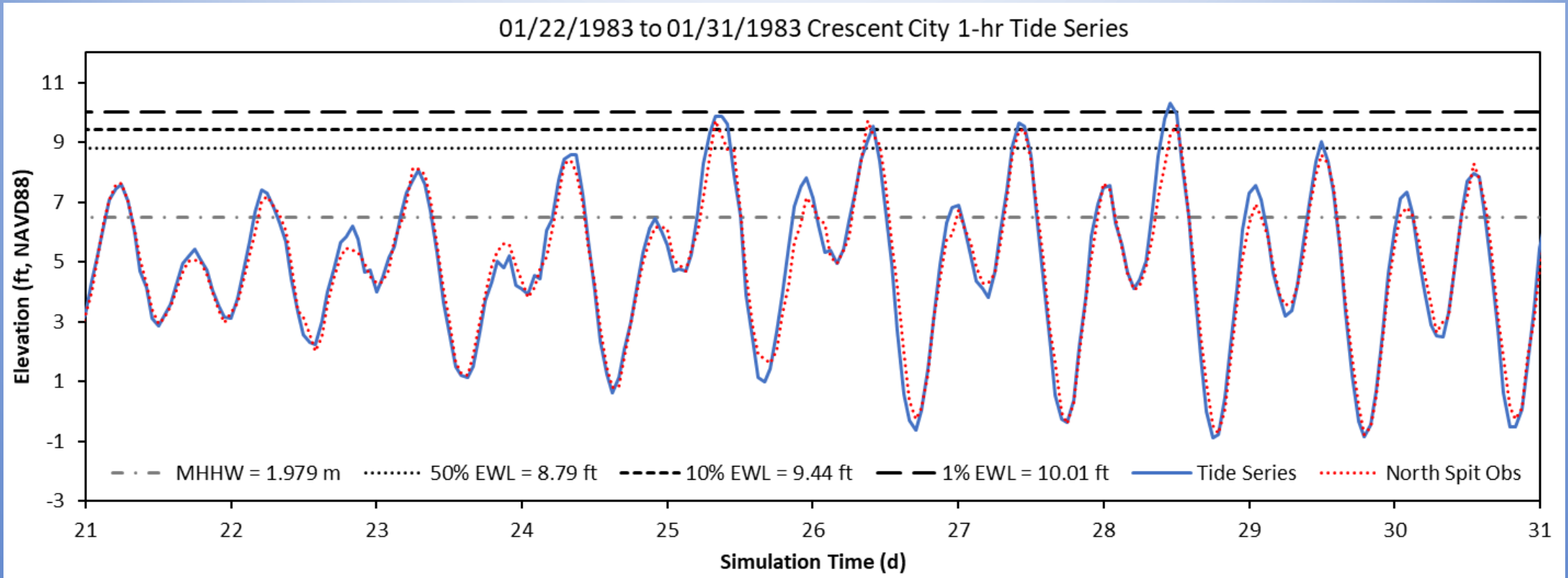




Humboldt Bay Sea-Level Change

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Extreme Water Levels



Tidal open boundary condition (blue line) used for the NSI Model simulations. Tidal series based on Crescent City tide station (NOAA Station ID: 9419750). Observed North Spit tide station (NOAA Station ID: 9418767) observations (red dotted line) corrected for ~2.3 mm sea-level change from 1982 to 2012. MHHW is mean higher high water; #% EWL (e.g. 1% EWL) represents the #% annual chance extreme high-water level (e.g. 1% chance extreme high-water level).

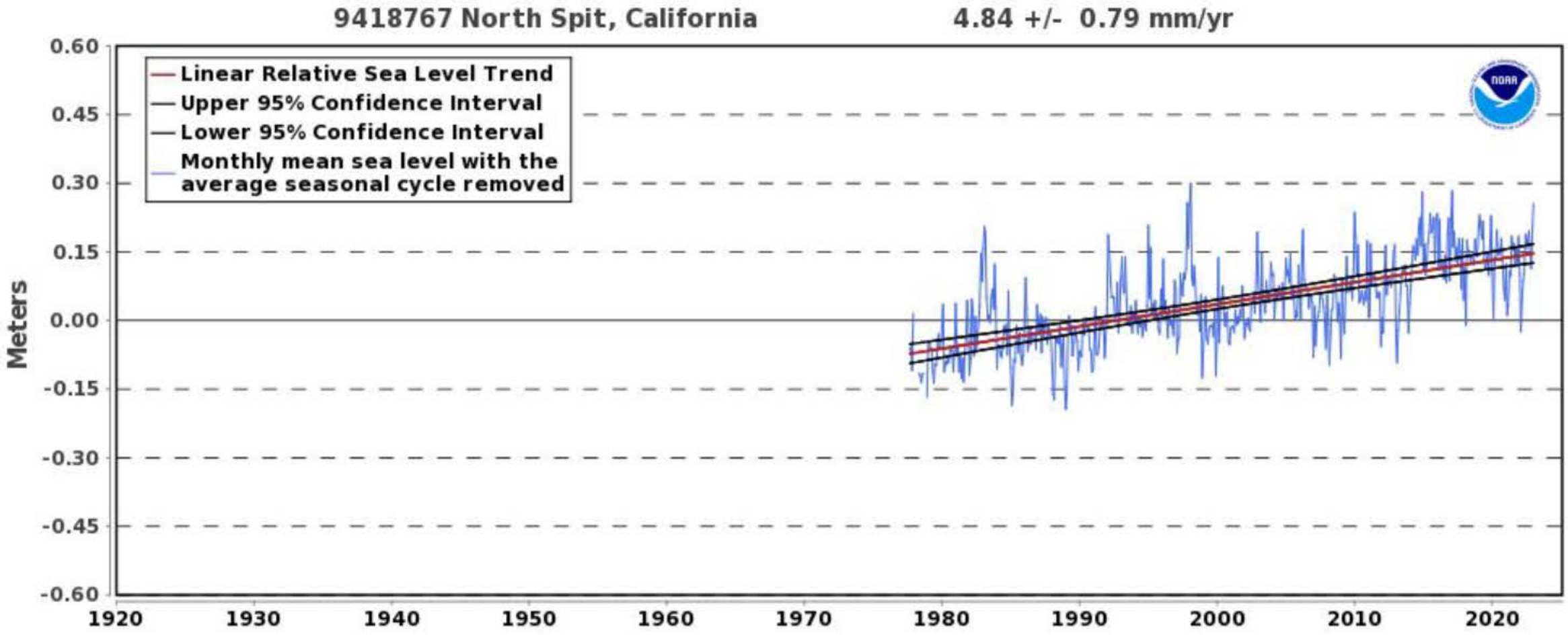
What about locally?

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What about locally?

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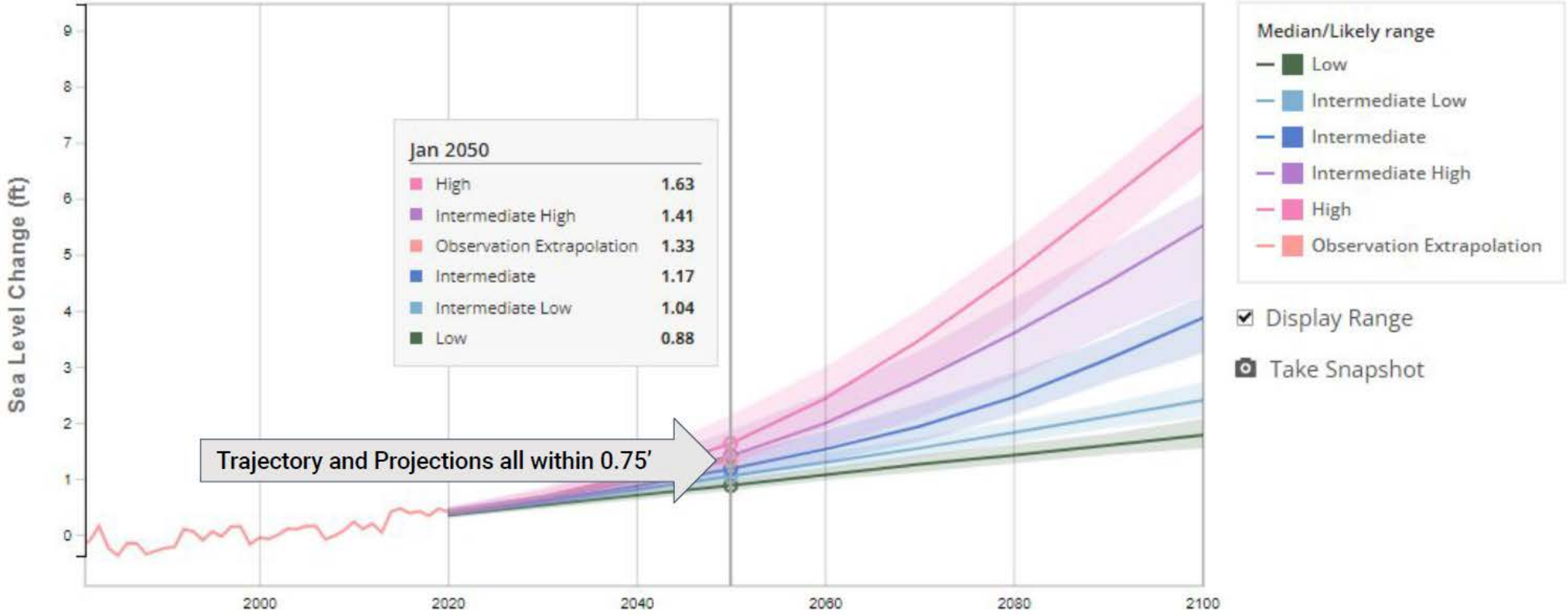
1977 to 2022 - 1.59 feet in 100 years.

What about locally?

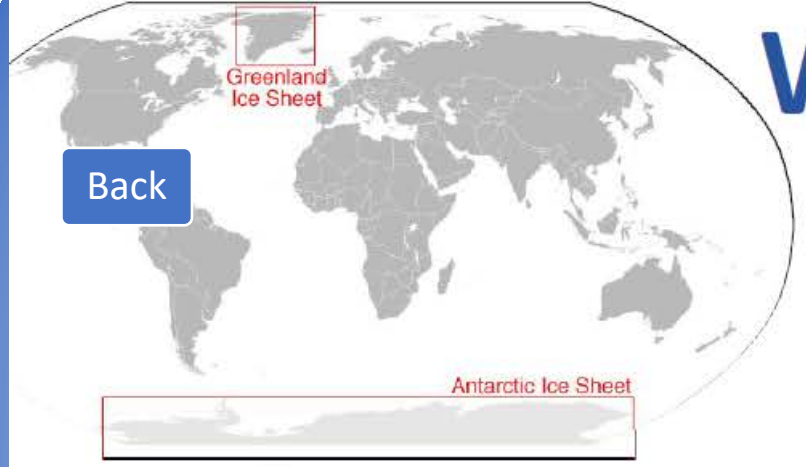
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North Spit, Humboldt Bay tide gauge (9418767)



What about locally?



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North Spit, Humboldt Bay tide gauge (9418767)

