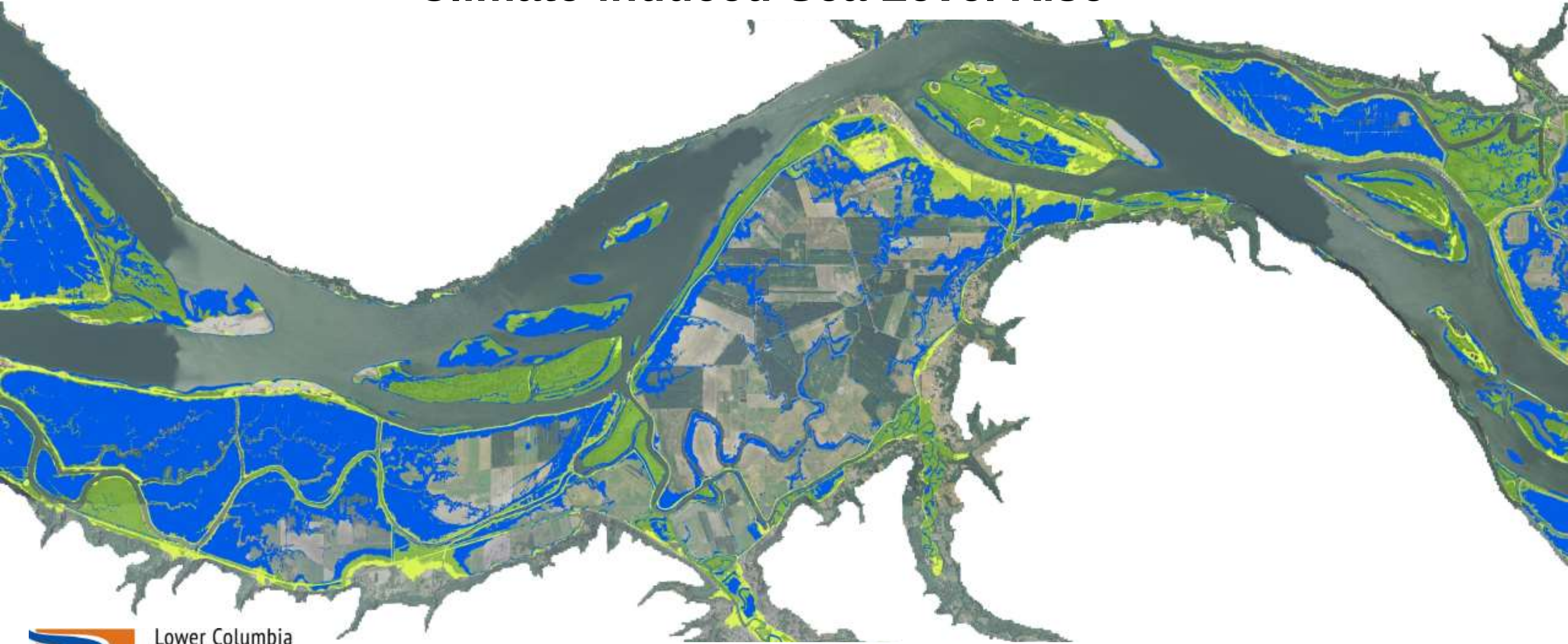
Assessing the Resiliency of Lower Columbia River Wetlands to Climate-induced Sea Level Rise



Lower Columbia Estuary Partnership

**Keith Marcoe*, Niko Peha, Sarah Kidd, Catherine Corbett

Project Background

- EPA-funded study to map predicted impacts on lower Columbia River wetlands due to expected sea level rise (SLR).
- Completed in 2018
- *Applied three SLR scenarios:
  0.5, 1.0, 1.5 meters

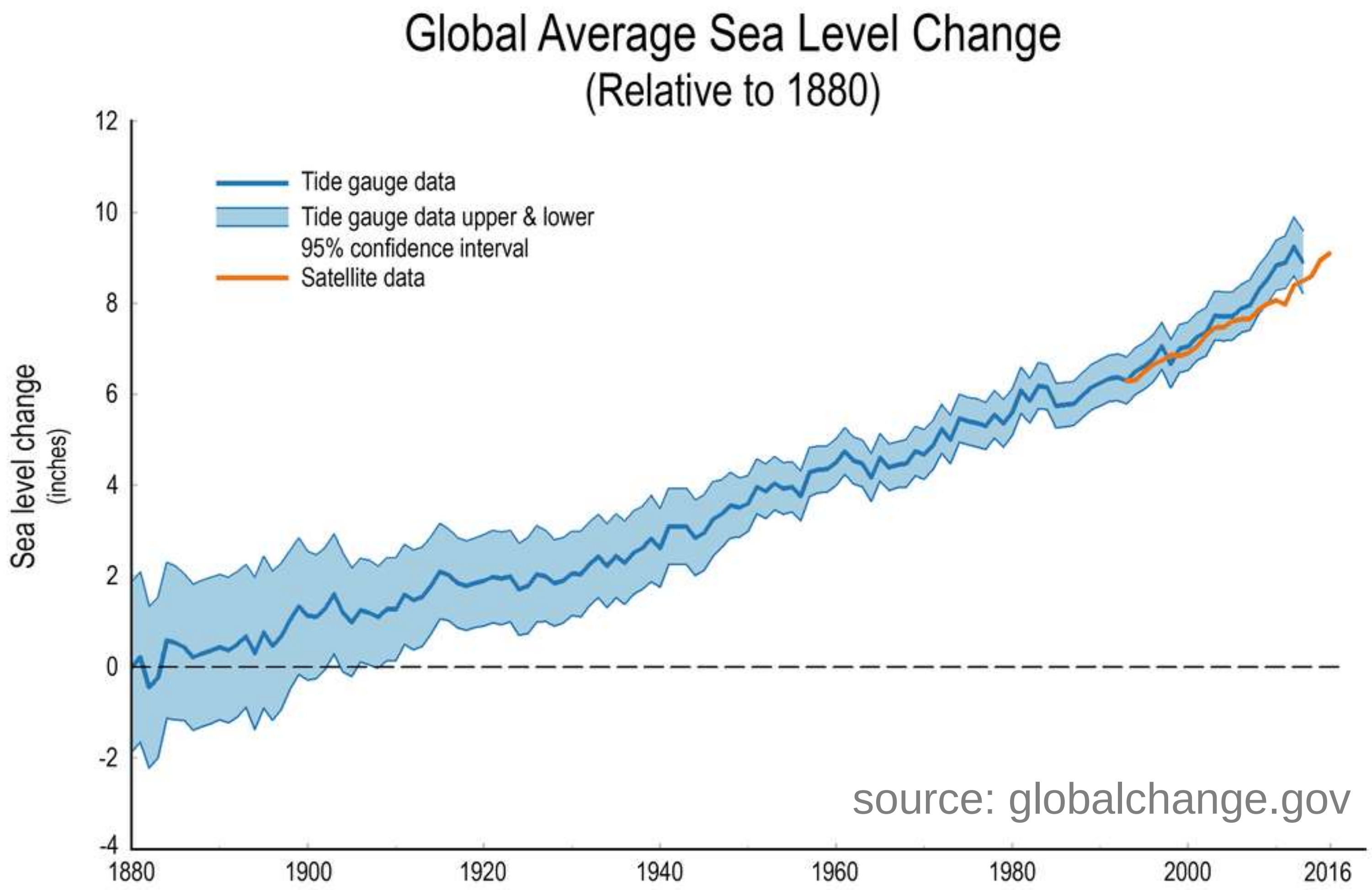
*Scenarios were selected based on available hydraulic information (**US Army Corps of Engineers Adaptive Hydraulic Model**)

Lower Columbia Tidal Wetlands

- Flooded by tides/fluvial discharge typically daily to monthly
- Roughly 68% loss since late 1800's
- Important to assess SLR impacts
  - how much more will be lost?
  - How might loss be offset by gains?
  - where will restoration/protection be most effective, in light of SLR impacts?

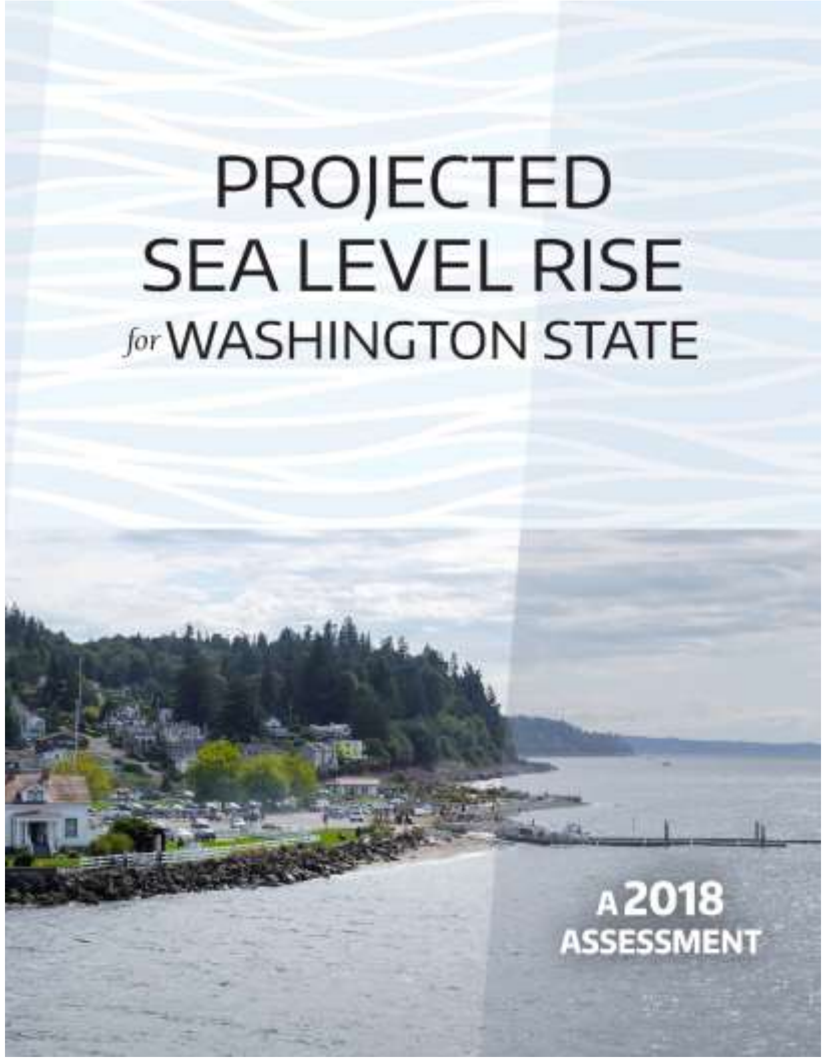
Global SLR

- Accelerating in recent decades: 1 mm/yr ⟶ 3 mm/yr
- Result of climate change: warming of oceans and atmosphere
- Not uniform across globe due to regional and local effects



Regional SLR Estimates

WA Coastal Resiliency Project (Miller et al. 2018)



Columbia R. mouth

PROJECTED ABSOLUTE SEA LEVEL CHANGE
(feet, averaged over each 19-year time period)

Time Period	Greenhouse Gas Scenario	Central Estimate (50%)	Likely[5] Range (83-17%)	Higher magnitude, but lower likelihood possibilities		
				10% probability of exceedance	1% probability of exceedance	0.1% probability of exceedance
2050	Low	0.2	0 – 0.4			
	High	0.3	0 – 0.5			
2100	Low	0.7	[illegible] – 1.4			
	High	1.2	0.5 – 2.0			
2150	Low	1.3	[illegible] – 2.6			
	High	2.2	[illegible] – 3.7			

- 2050 → **0 – 15 cm**
- 2100 → **20 – 60 cm**
- 2150 → **40 – 110 cm**

LCEP SLR analysis: **50, 100, 150 cm**

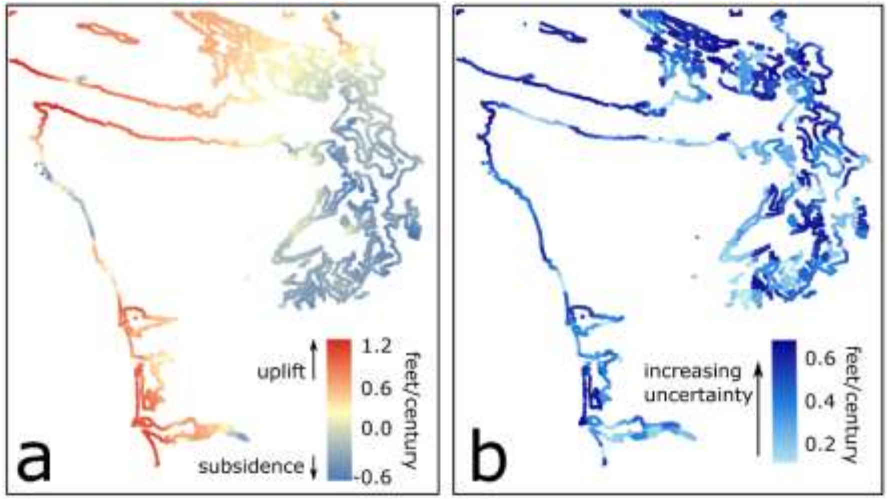
Local SLR Effects

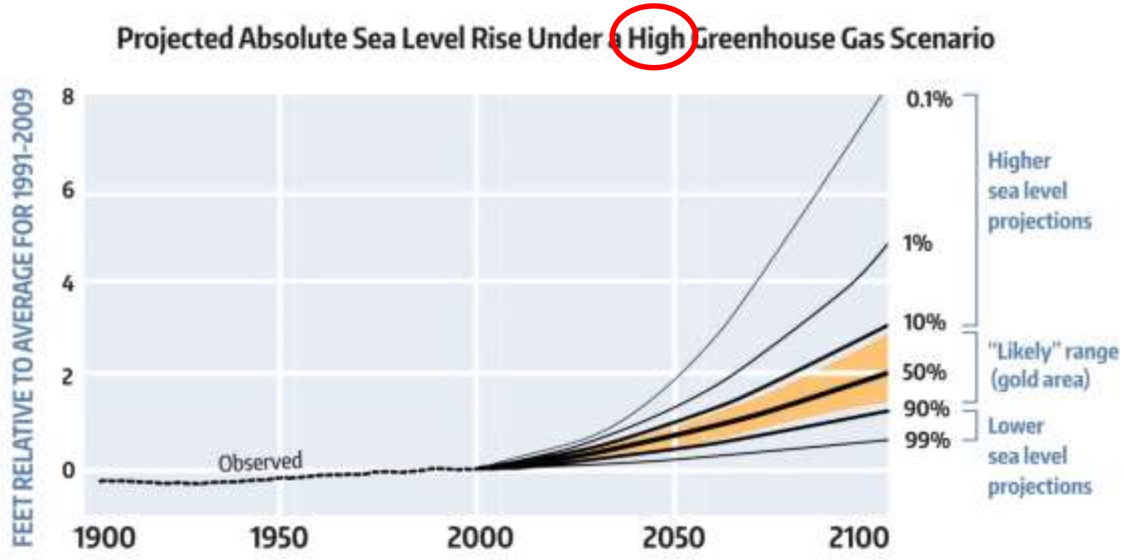
- Uncertainty in regional and local SLR projections based on:

  <u>global uncertainties</u>
  - emissions scenarios
  - glacial/ice-cap response
  - terrestrial water exchange

  <u>Regional/local uncertainties</u>
  - ocean circulation
  - winds
  - short term SLR, storm surges
  - sediment accumulation
  - tectonic land motion

Tectonics SLR

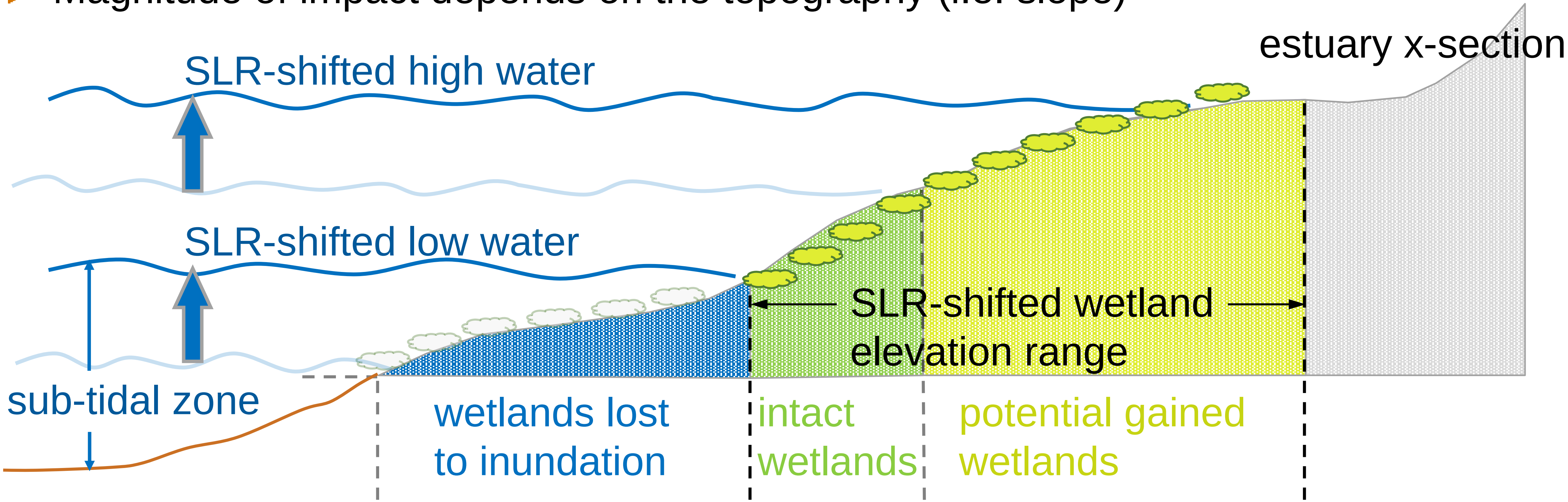




From Miller et al. 2018

SLR and Wetlands Change

- As water levels rise with SLR, we assume wetland elevations rise by the same amount:
- Resulting impacts to wetlands from SLR include areas of:
  loss (inundation); intact wetlands; potential gains (landward migration)
- Magnitude of impact depends on the topography (i.e. slope)

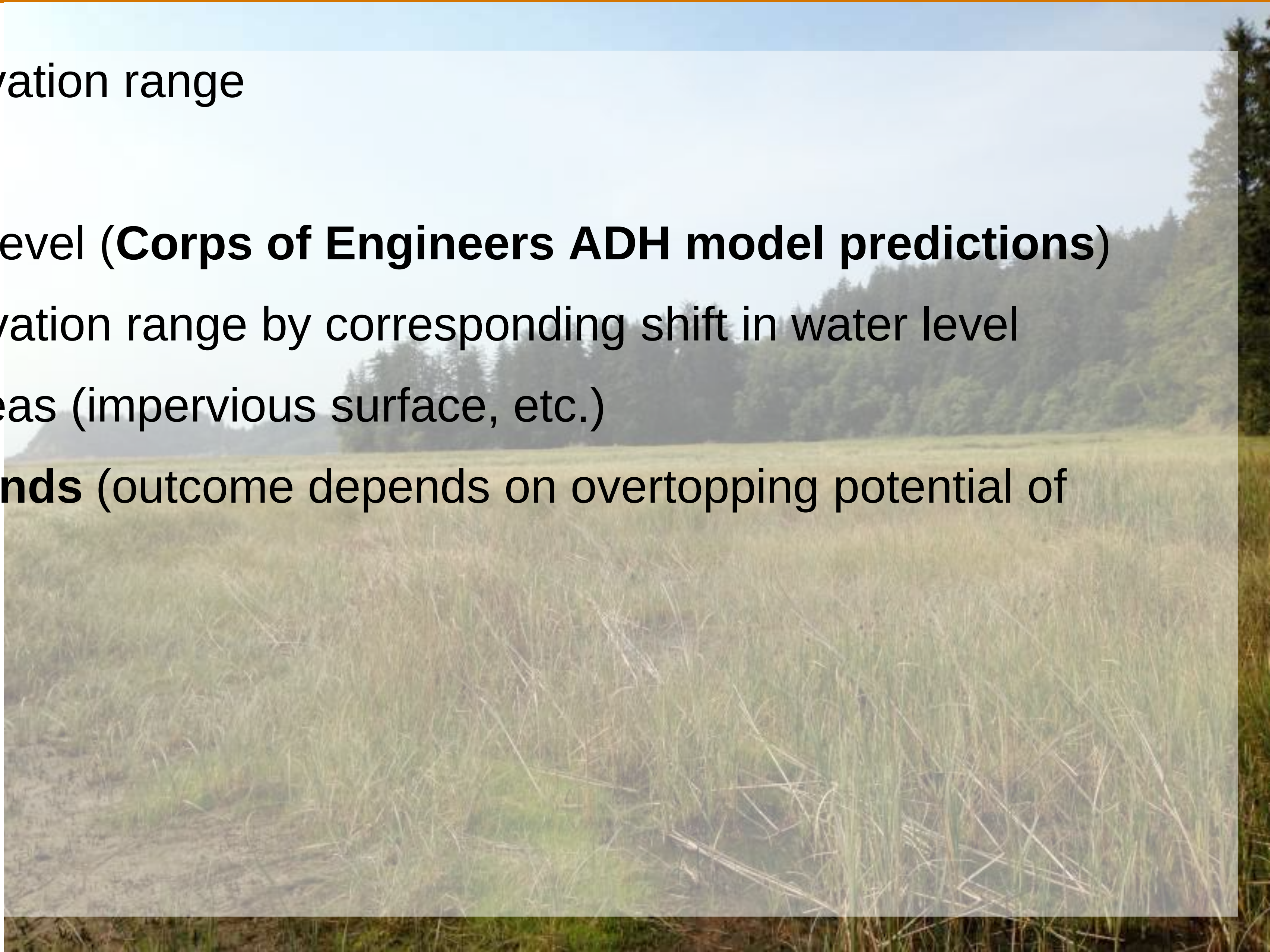


Mapping SLR Impacts on Lower Columbia R. Wetlands

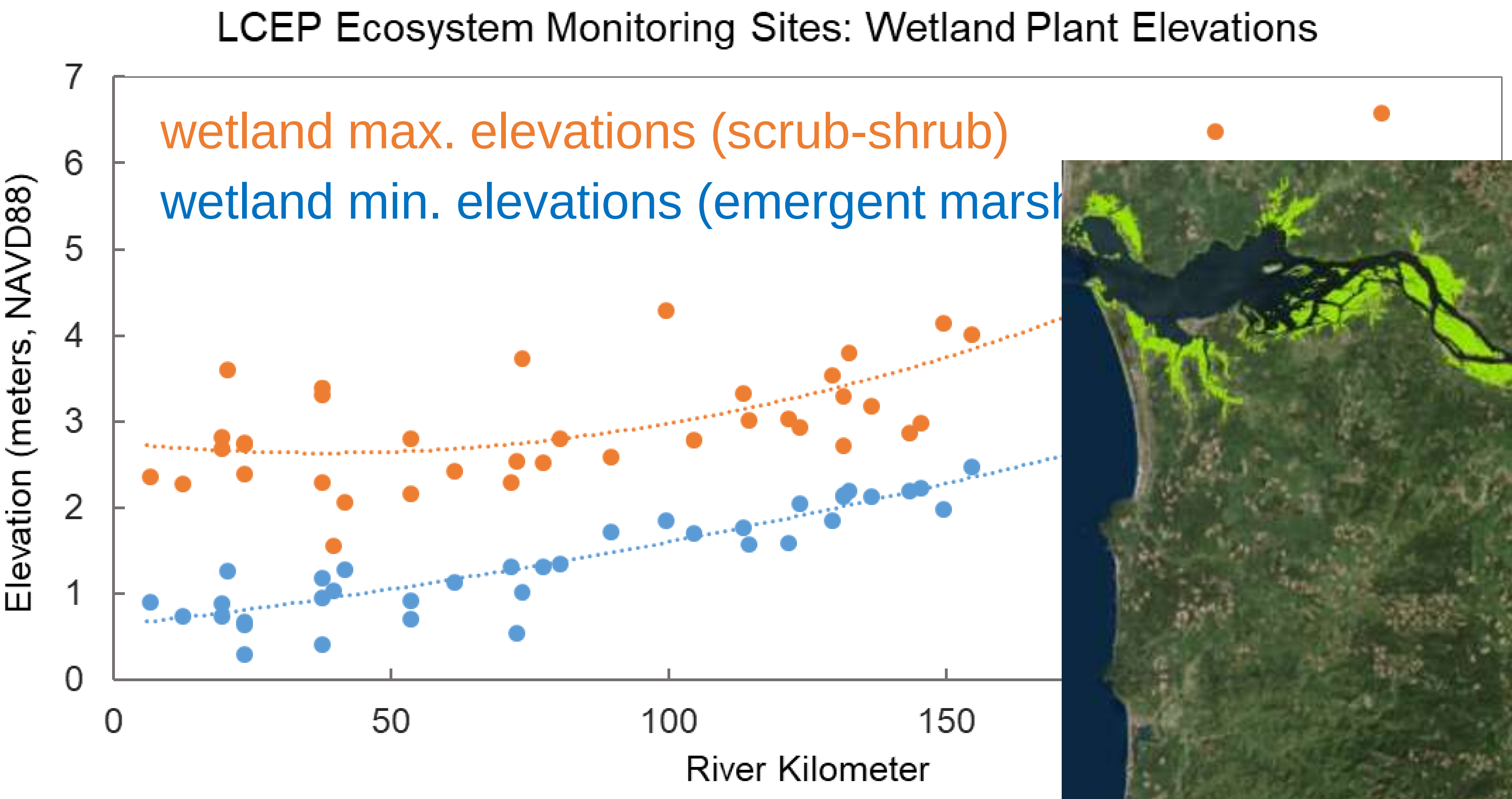
- Map current wetland elevation range

For each SLR scenario:

- Determine shift in water level (**Corps of Engineers ADH model predictions**)
- Shift current wetland elevation range by corresponding shift in water level
- Remove non-wetland areas (impervious surface, etc.)
- **Analysis of diked wetlands** (outcome depends on overtopping potential of existing levees)



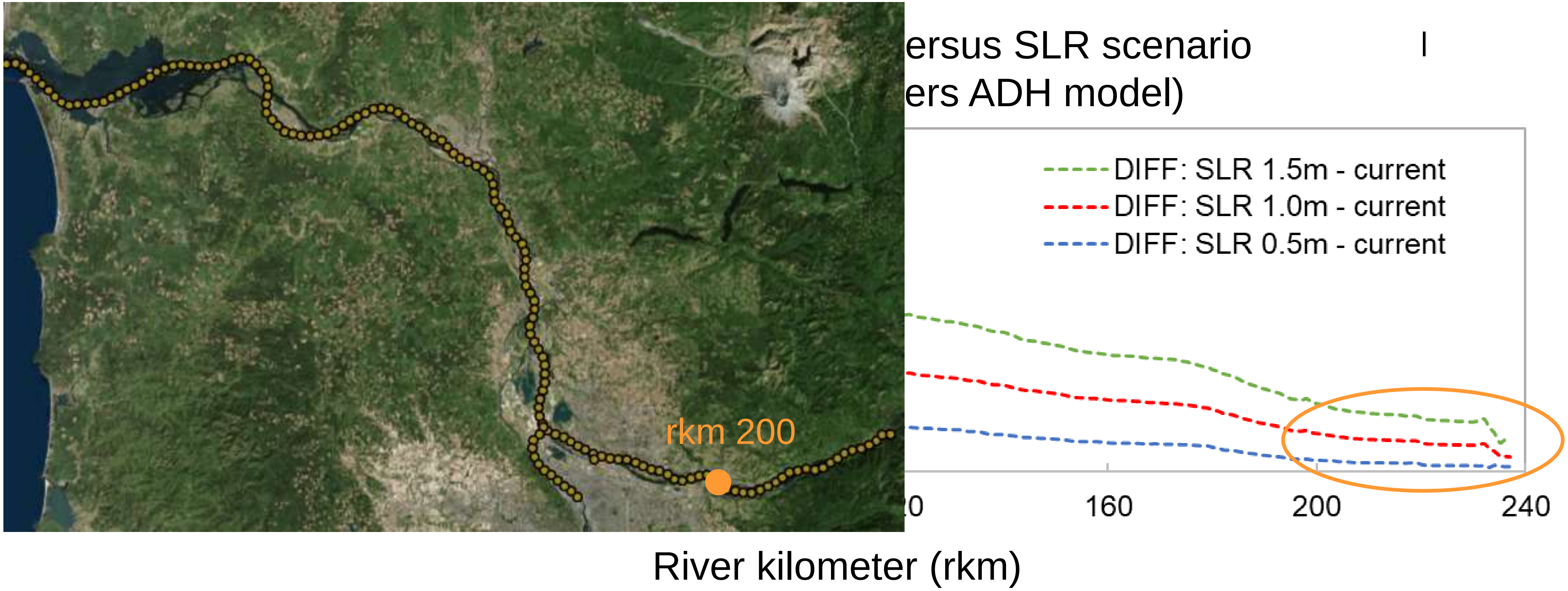
Current Lower Columbia Wetland Elevation Range



Sources:

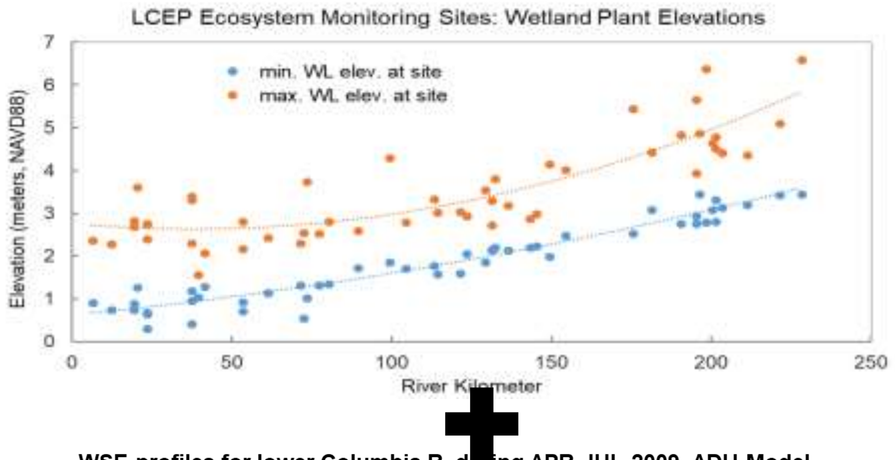
- Marsh elevations from LCEP Ecosystem Monitoring and Kidd (2005–2017,136 sites)
- LCEP 2010 landcover (scrub-shrub wetlands)

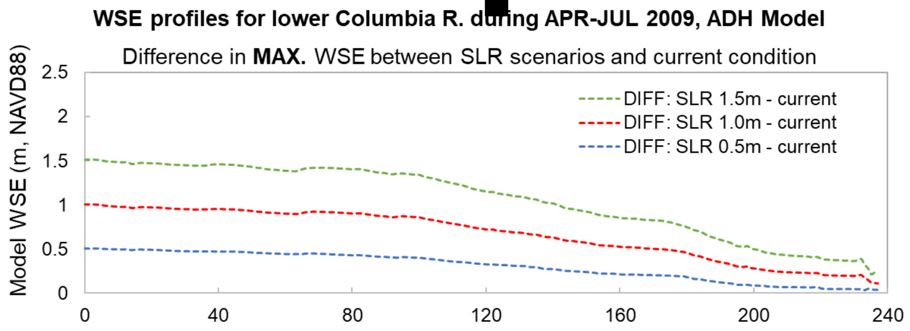
Estimated Change in Columbia R Water Levels Due to SLR

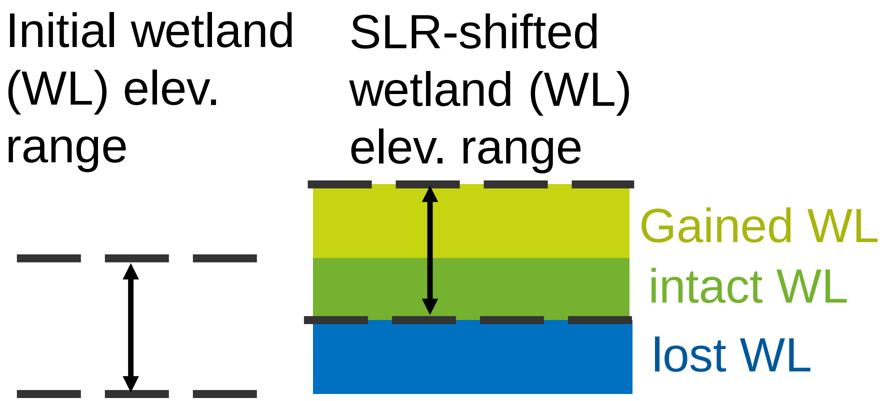


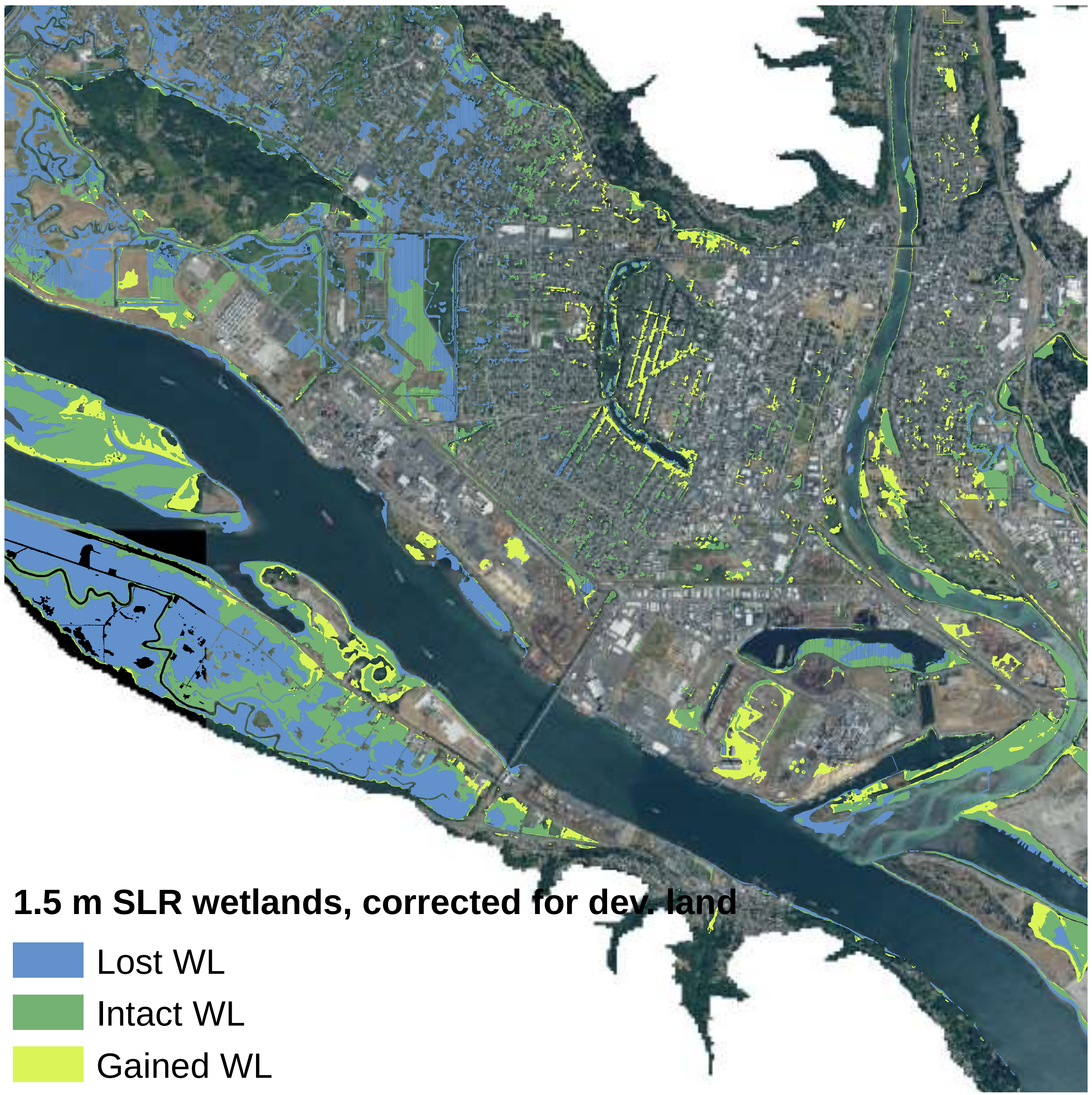
- **Water level does not increase uniformly throughout river when SLR value is applied at ocean boundary!**
- Use hydraulic model results to assess SLR impacts

SLR-adjusted Wetland Elevation Range (1.5 m scenario)



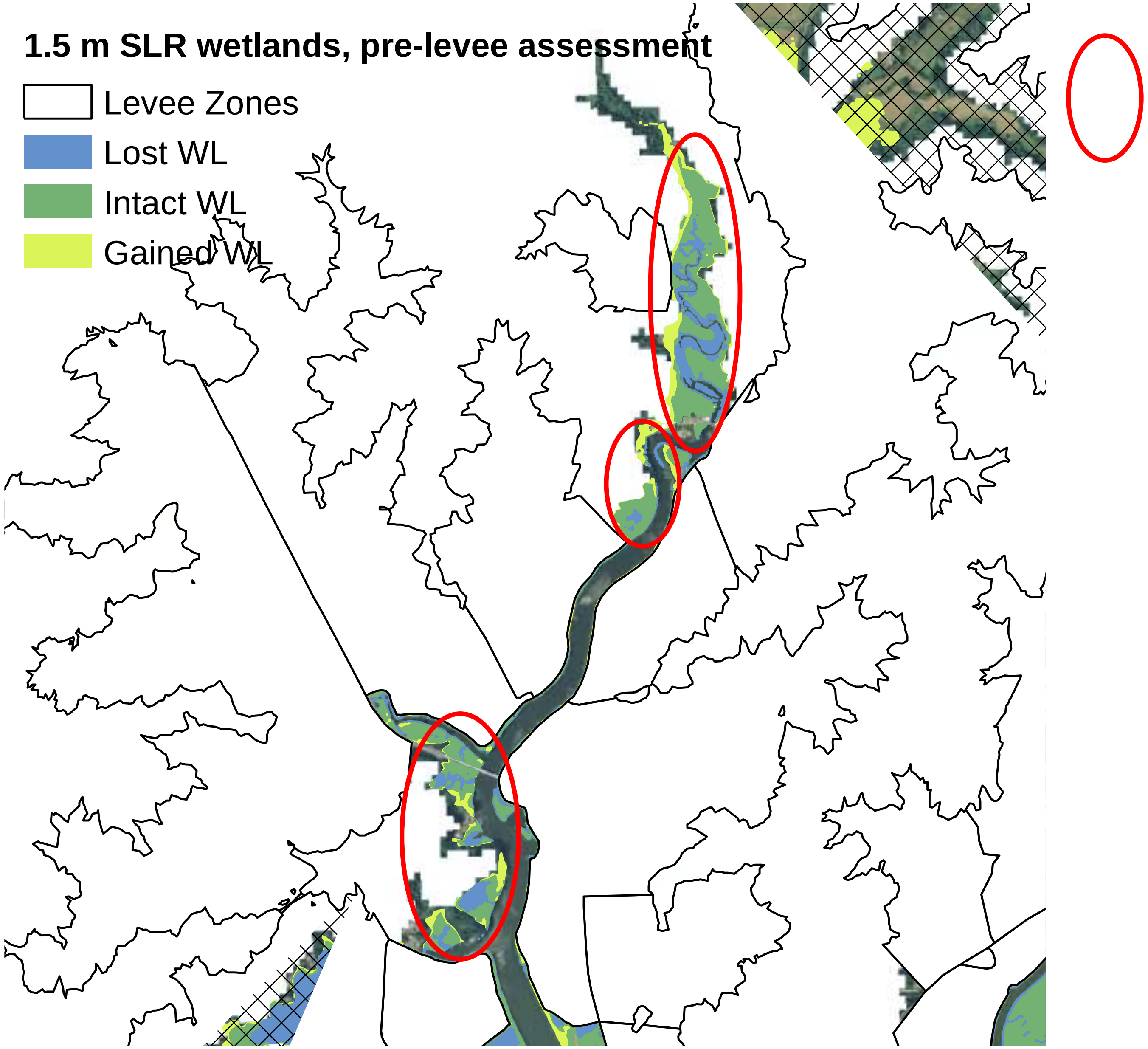






Assess Levee Response

- Prior results only apply to tidal wetlands (i.e. non-diked)
- **Diked wetlands will only be impacted by SLR if the surrounding levee overtops:**
- **Potential for tidal wetland gain**



Tidal wetlands

All other wetlands in this area are diked

Levee Response – Assessing Overtopping

- Compare water levels from ADH model to DEM levee elevations
- Apply overtop criteria: **10 m long x 0.2 m depth**

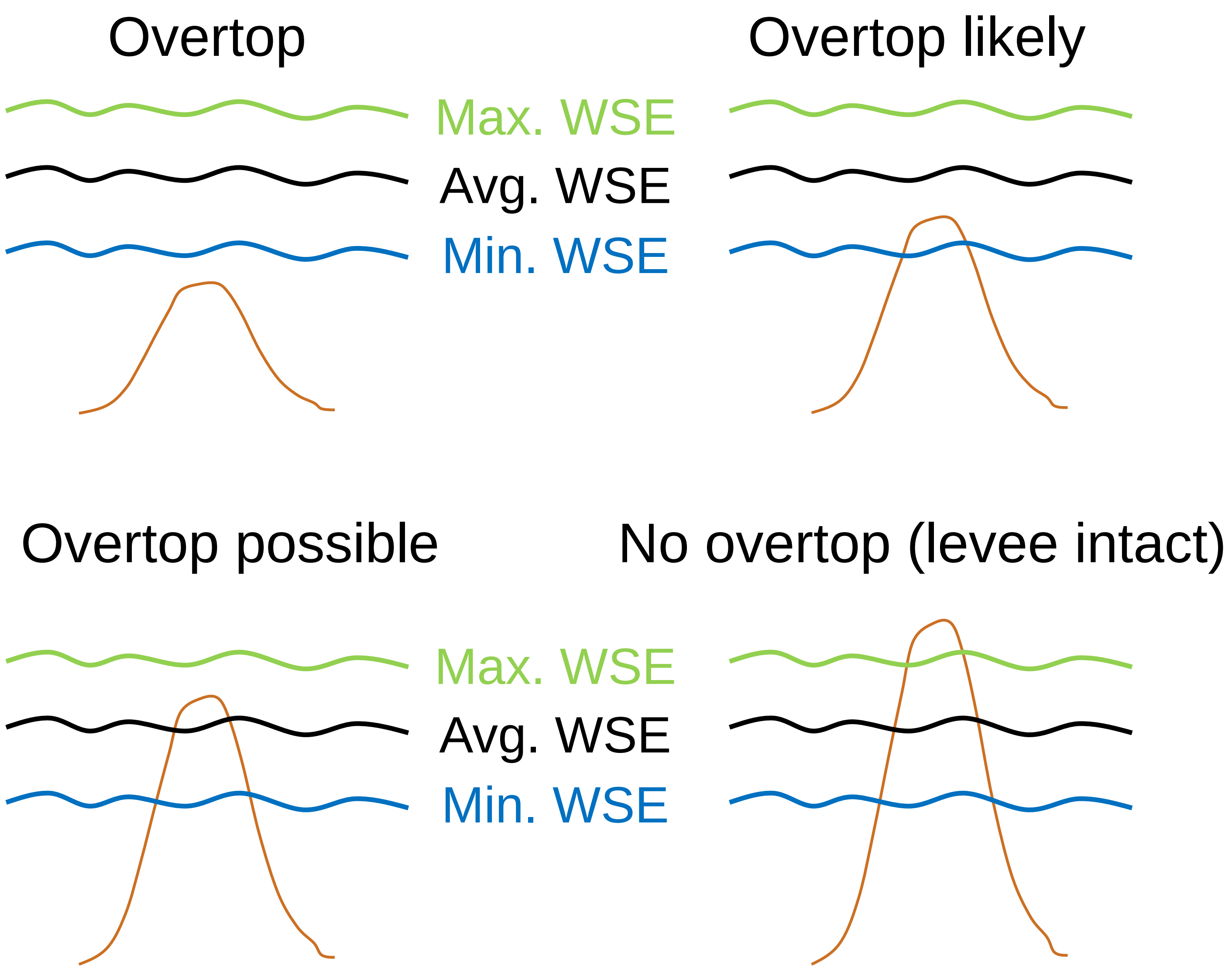
0.5 m SLR max. high water

1.5 m SLR max. high water

levee overtop areas

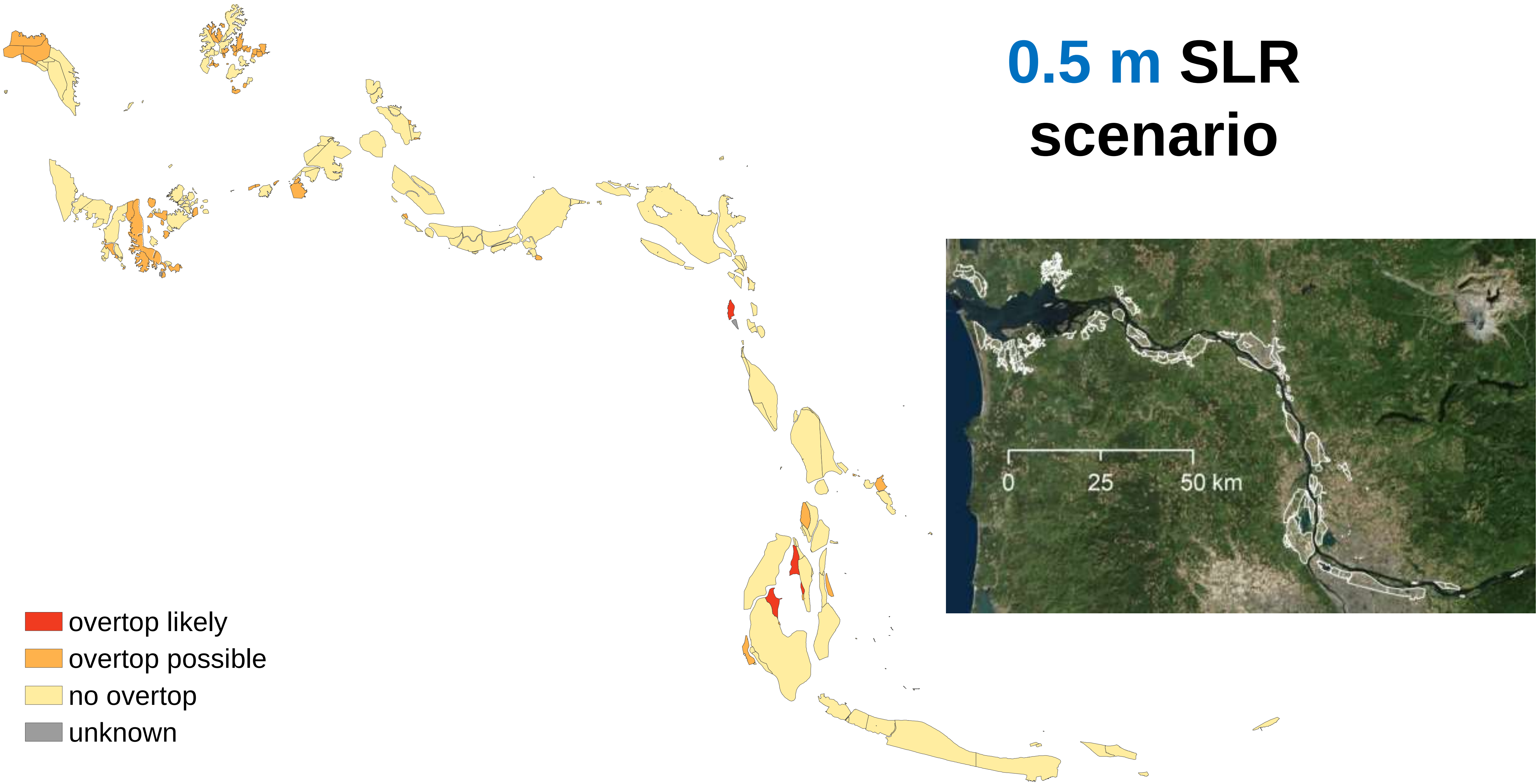
Levee Response – Assessing Overtopping

- Compare water levels from ADH model to DEM elevations
- Apply range of uncertainty for overtopping



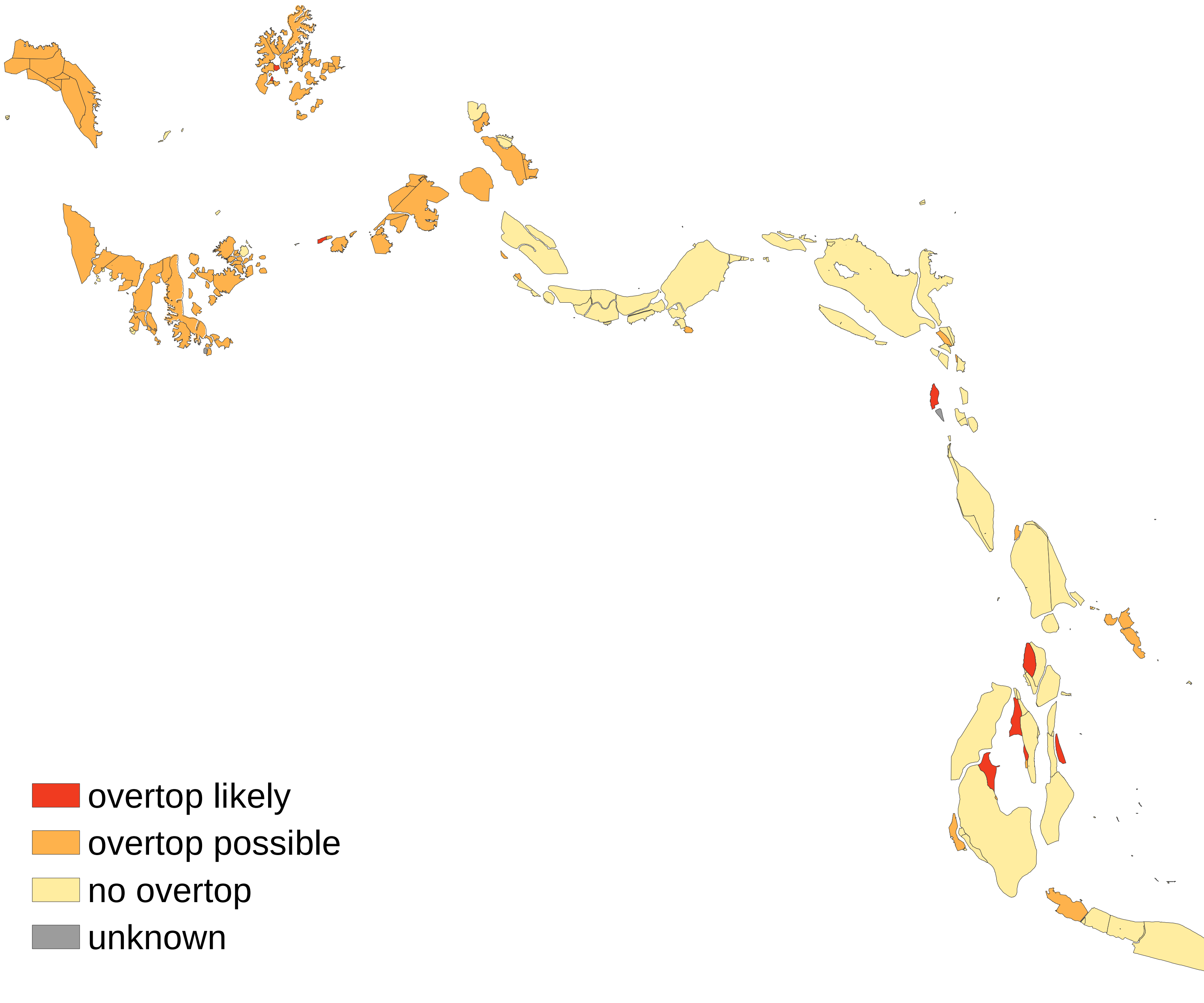
Levee Response – Overtop Potential

0.5 m SLR scenario

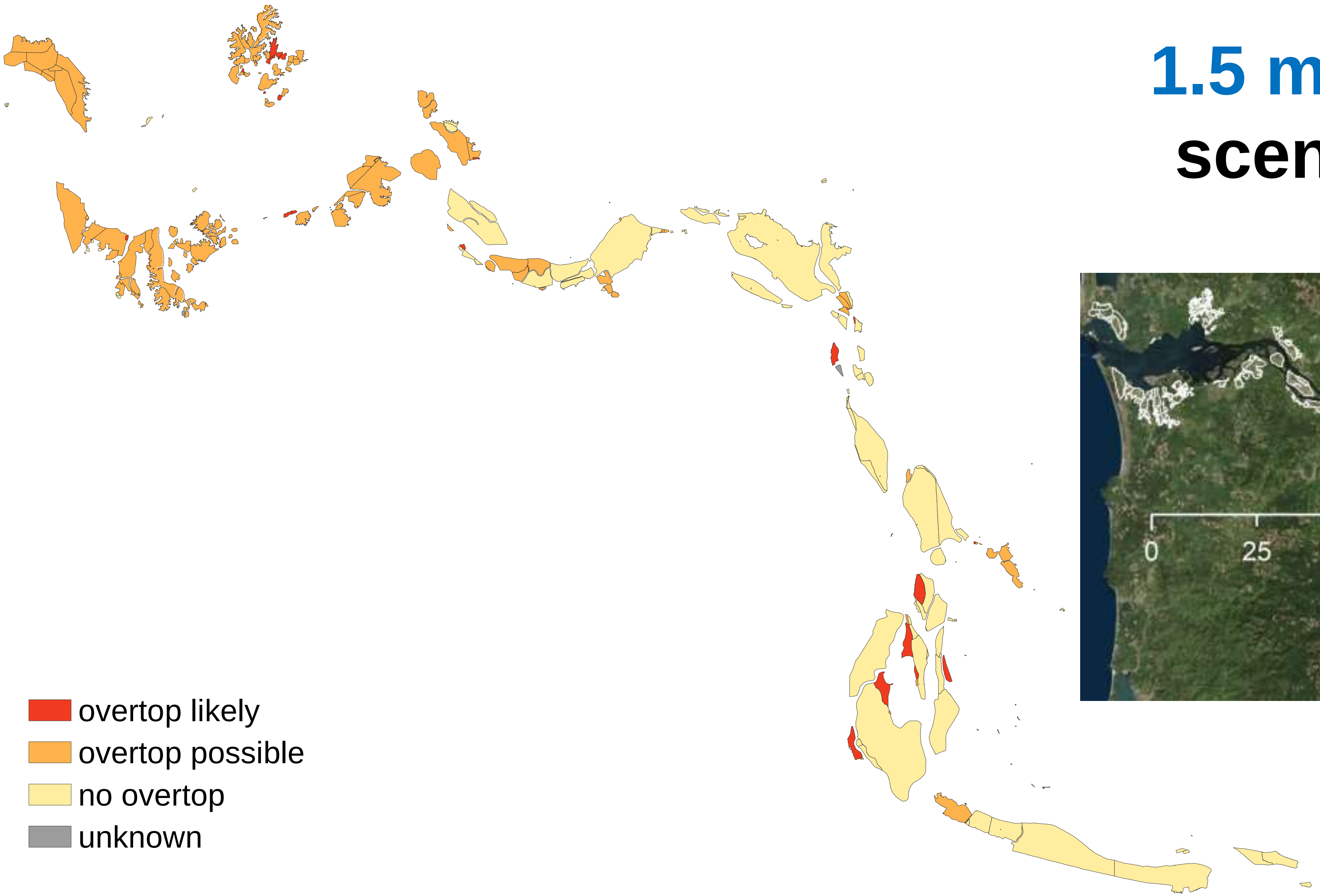


Levee Response – Overtop Potential

1.0 m SLR scenario



Levee Response – Overtop Potential



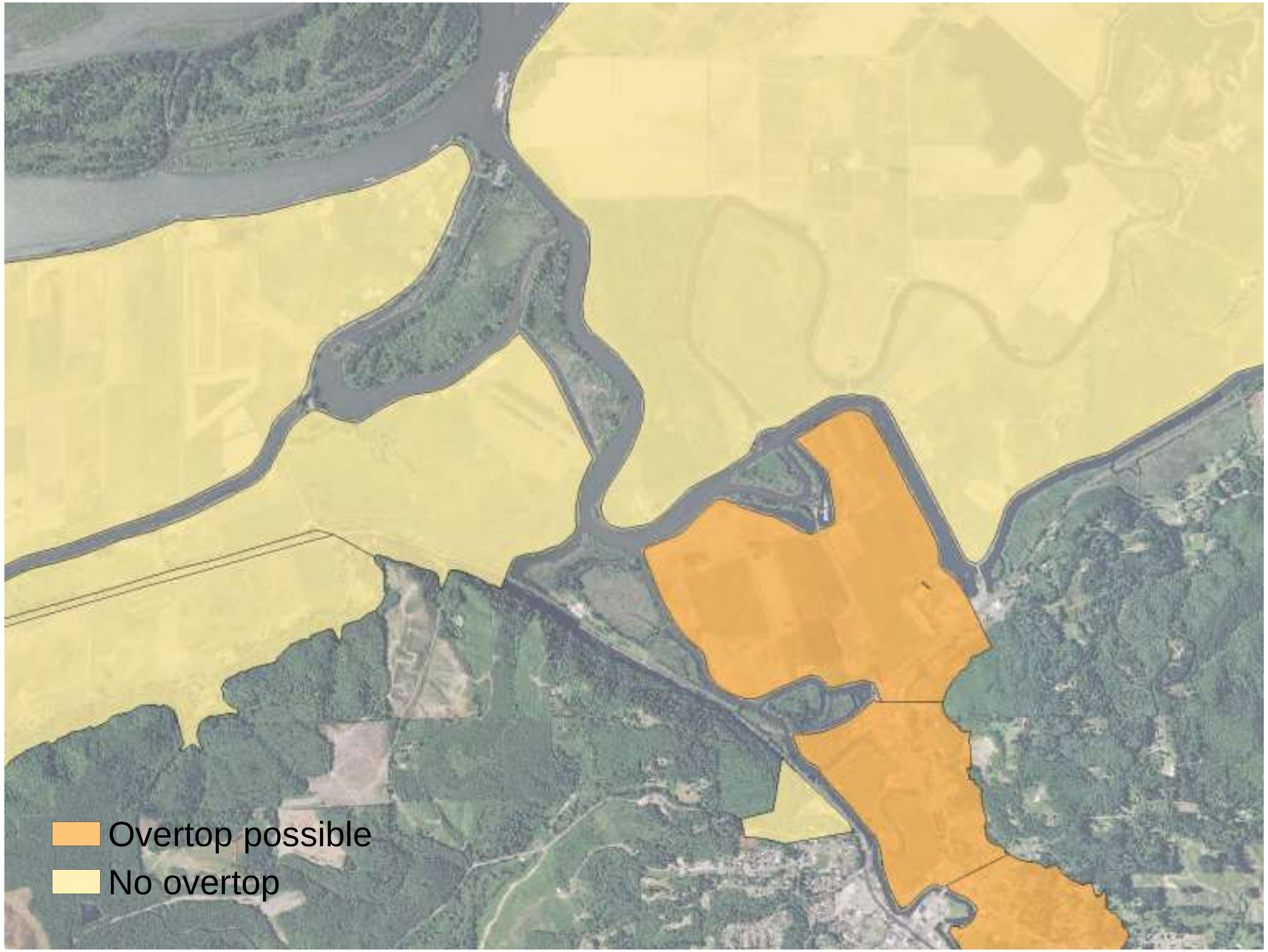
1.5 m SLR scenario

Levee Response – Wetlands Re-classification

Inputs	Action 1	Initial Classes	Action 2	Re-class with levee assessment				
				no levee	levee present, overtop potential:			
					overtop	overtop likely	overtop possible	No overtop
Current WL Range	Apply SLR shift	Lost WL	Assess over-topping	Lost TWL	Lost DWL	Lost DWL - likely	Lost DWL - possible	Intact DWL
		Intact WL		Intact TWL	Gained TWL	Gained TWL - likely	Gained TWL - possible	Intact DWL
		Gained WL		Gained TWL	Gained TWL	Gained TWL - likely	Gained TWL - possible	Intact DWL
Subsided wetlands				not likely to occur	Lost DWL	Lost DWL - likely	Lost DWL - possible	Intact DWL

WL = wetland, TWL = tidal wetland, DWL = diked wetland

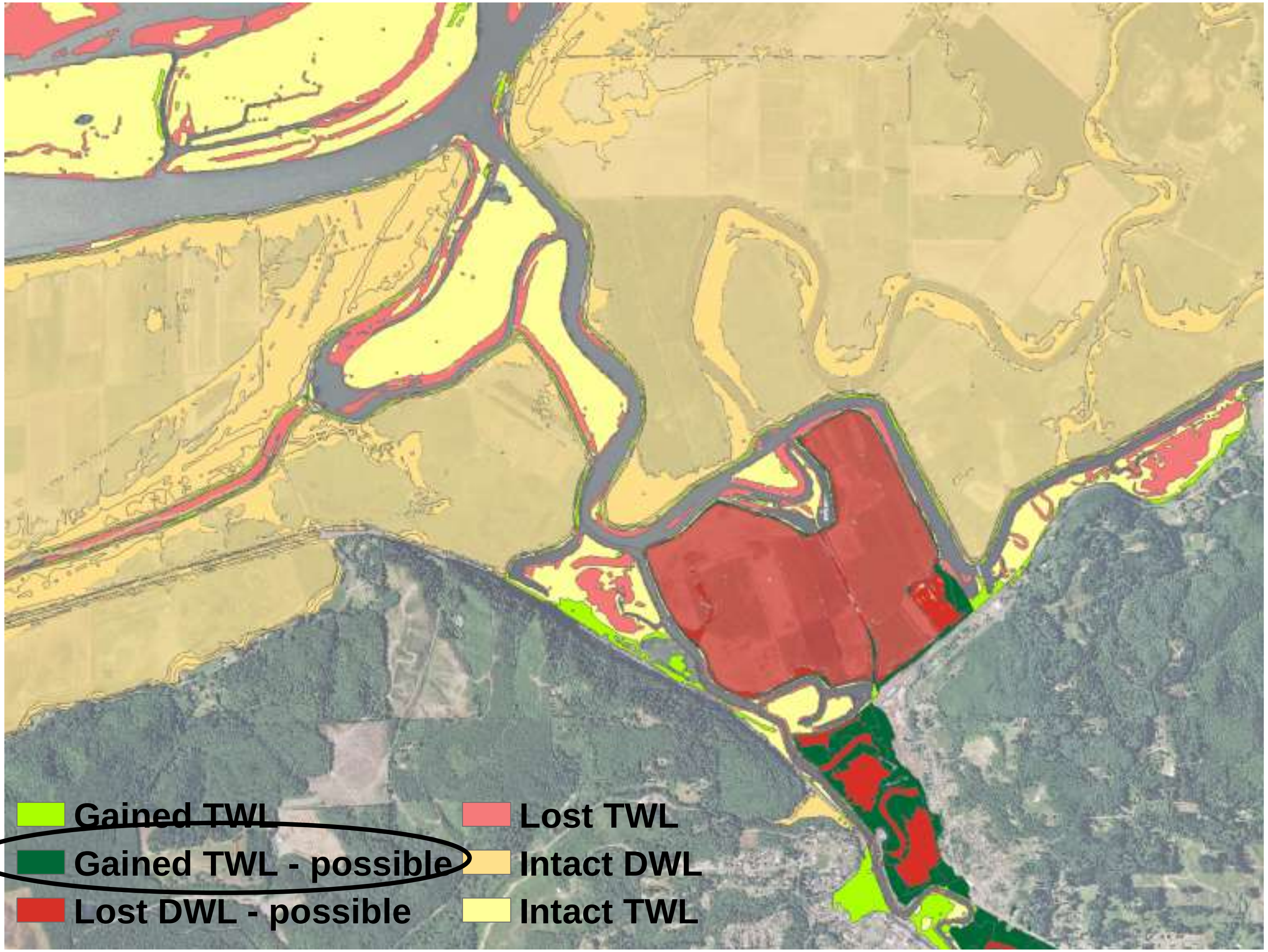
Diked Wetland Re-class Example



1.5 m SLR scenario

Assess levee overtopping potential

Diked Wetland Re-class Example



1.5 m SLR scenario

re-classified wetlands impacts based on levee response in this area (potential overtopping)

Wetlands Impacts due to SLR, Results Interpretation

Range of outcomes based on levee overtopping predictions:

Potential wetland transitions (acres):

SLR	Lost DWL-poss.	Lost DWL-likely	Lost TWL	Intact DWL	Intact TWL	Gained TWL-poss	Gained TWL-likely	Gained TWL
0.5	-902	0	-6,521	69,809	43,422	5,609	875	3,113
1.0	-8,850	-166	-11,762	55,376	38,181	14,589	1,221	6,409
1.5	-17,648	-473	-19,073	53,656	30,858	9,599	1,474	9,506

1. Wetland transitions grouped for minimal predicted overtopping

SLR	Lost DWL	Lost TWL	Intact DWL	Intact TWL	Gained TWL	Net change TWL
0.5	0	-6,521	76,321	43,422	3,988	-5 (%)
1.0	-166	-11,762	78,814	38,181	7,630	-8 (%)
1.5	-473	-19,073	80,903	30,858	10,980	-16 (%)

Wetlands Impacts due to SLR, Results Interpretation

Range of outcomes based on levee overtopping predictions:

Possible wetland transitions (acres):

SLR	Lost DWL-poss.	Lost DWL-likely	Lost TWL	Intact DWL	Intact TWL	Gained TWL-poss	Gained TWL-likely	Gained TWL
0.5	-902	0	-6,521	69,809	43,422	5,609	875	3,113
1.0	-8,850	-166	-11,762	55,376	38,181	14,589	1,221	6,409
1.5	-17,648	-473	-19,073	53,656	30,858	9,599	1,474	9,506

1. Minimal tidal wetland formation behind levees (‘possible’ areas remain ‘diked’ WL):

SLR	Lost DWL	Lost TWL	Intact DWL	Intact TWL	Gained TWL	Net change TWL
0.5	0	-6,521	76,321	43,422	3,988	-5 (%)
1.0	-166	-11,762	78,814	38,181	7,630	-8 (%)
1.5	-473	-19,073	80,903	30,858	10,980	-16 (%)

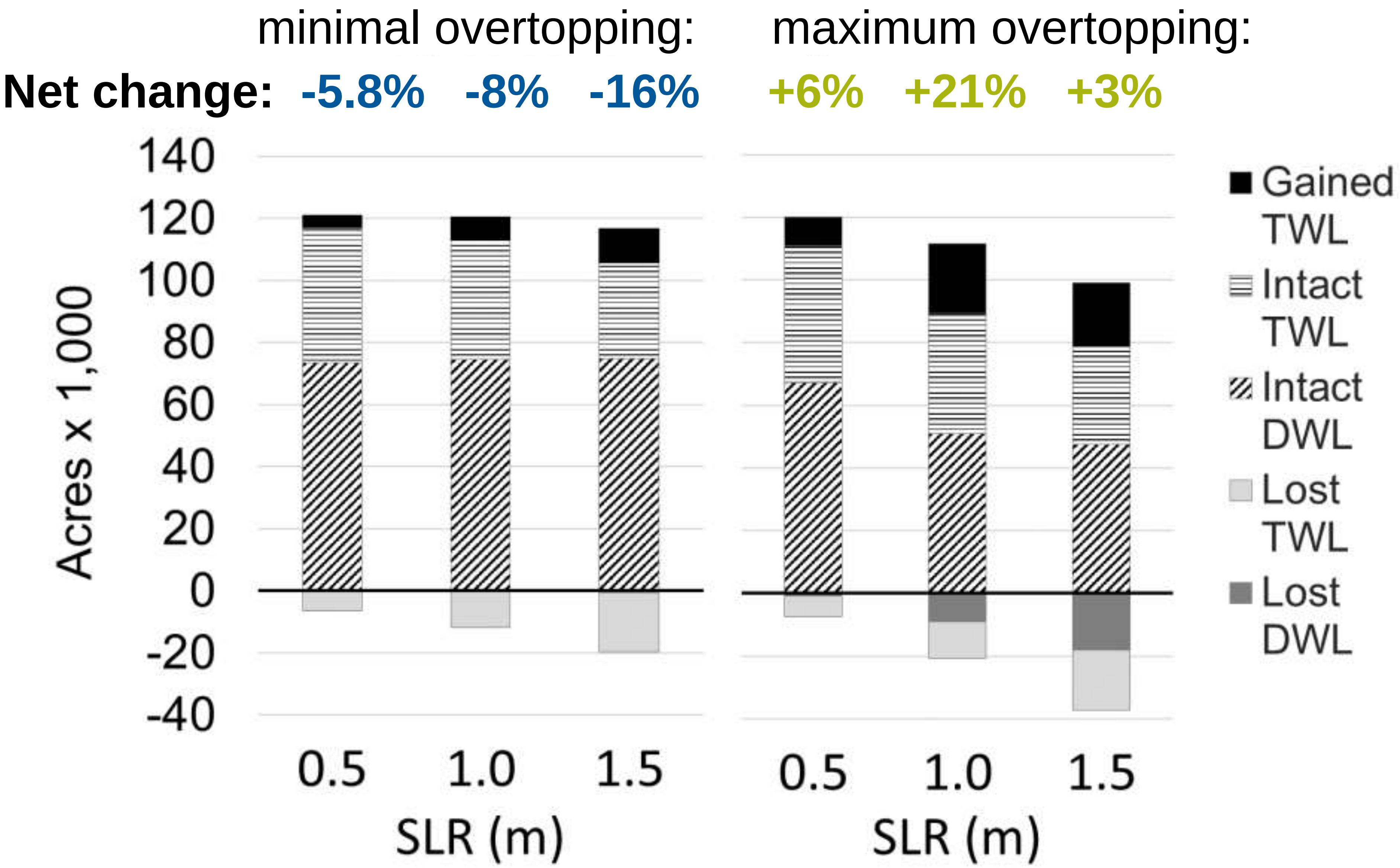
2. Maximum tidal wetland formation behind levees (‘possible’ areas transition to tidal WL):

SLR	Lost DWL	Lost TWL	Intact DWL	Intact TWL	Gained TWL	Net change TWL (%)
0.5	-902	-6,521	69,809	43,422	9,597	6 (%)
1.0	-9,016	-11,762	55,376	38,181	22,219	21 (%)
1.5	-18,121	-19,073	53,656	30,858	20,579	3 (%)

Wetlands Impacts due to SLR, Final Results

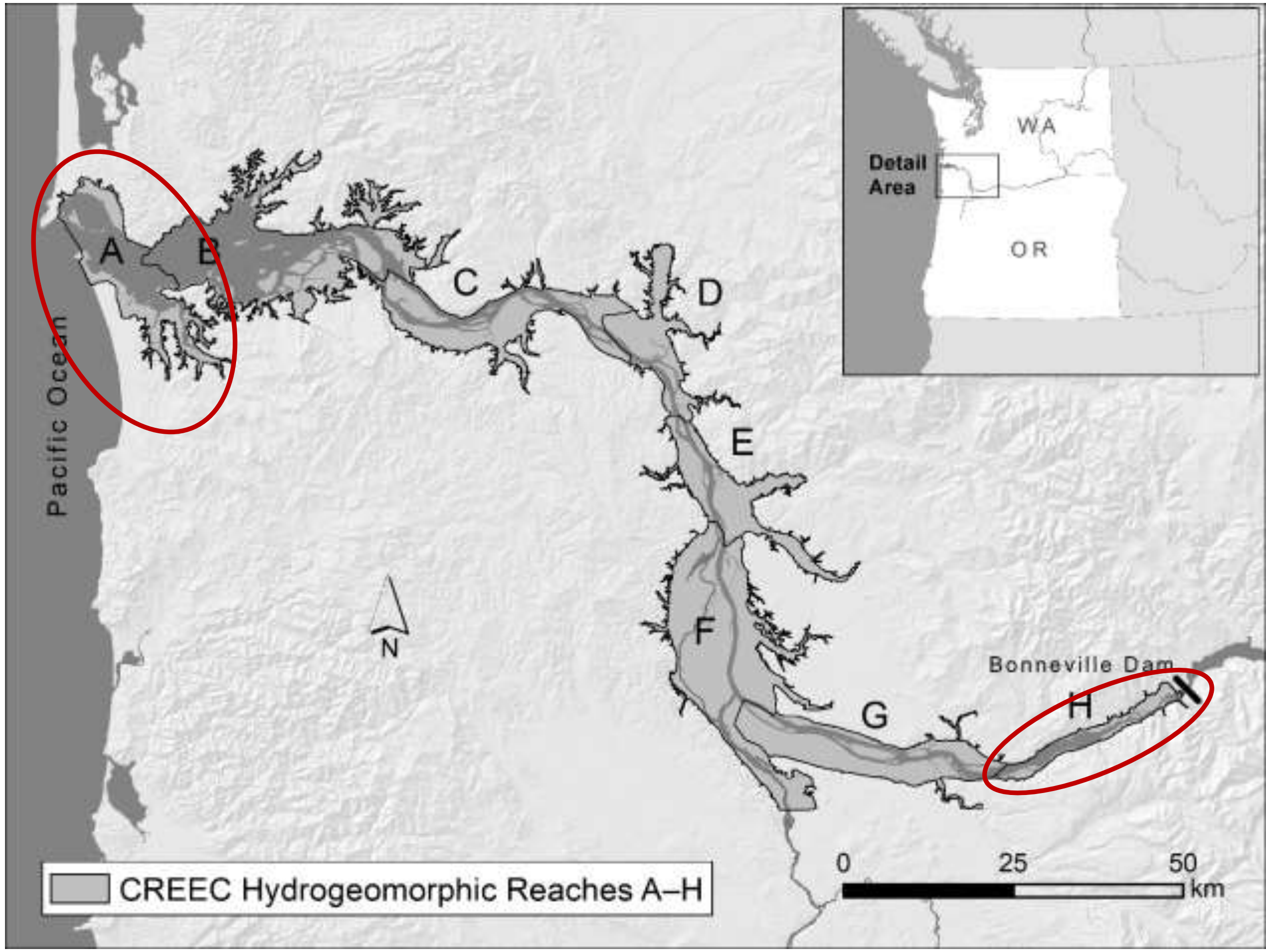
- conservative overtop estimate(left): **net WL loss**
- less conservative estimate (right): **potential WL gain**

- **SLR impacts will depend largely on levee response. More analysis needed.**



Wetlands Impacts due to SLR, Final Results

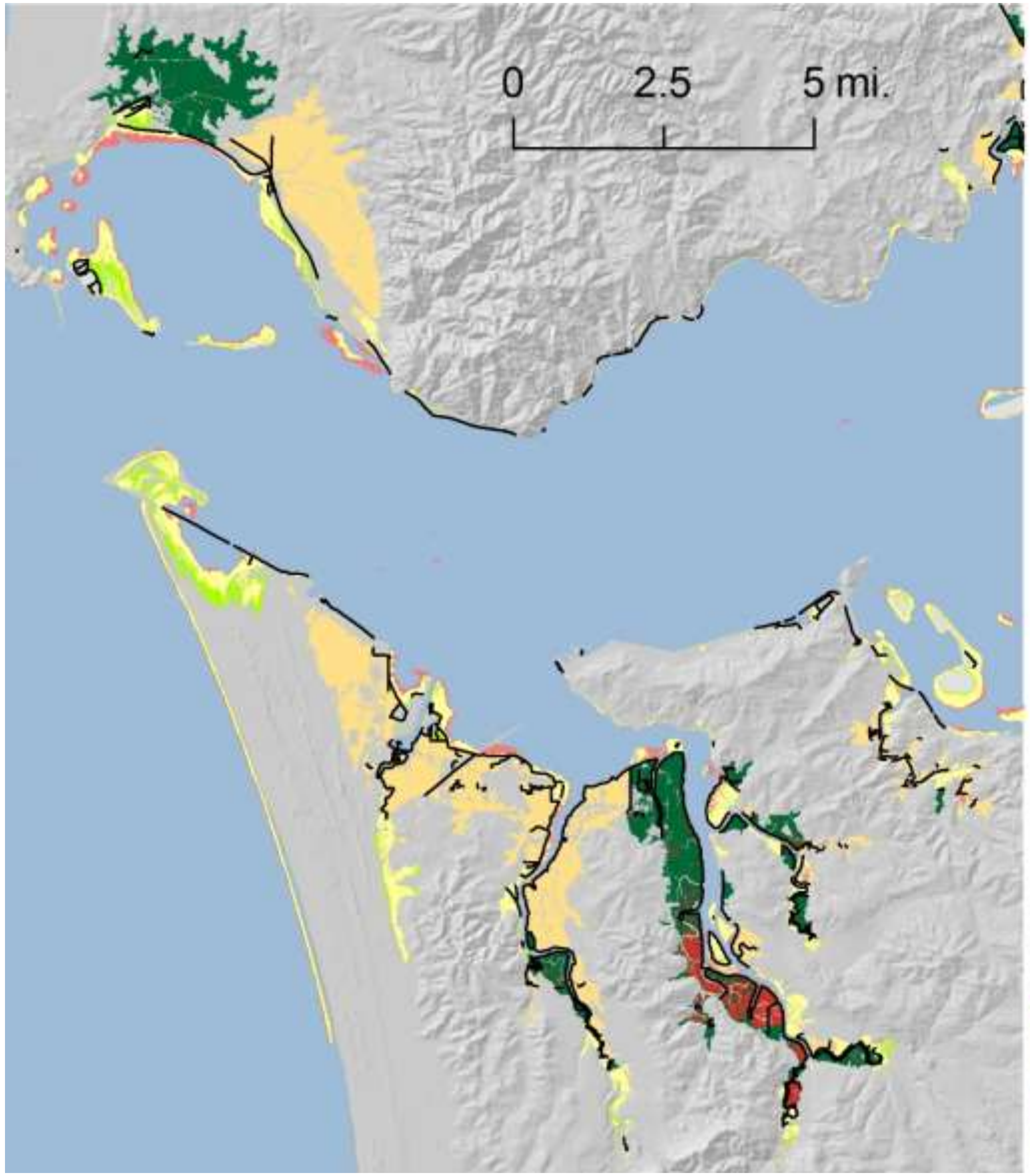
Hydro-Reach	% change in wetland area, Likely Outcome SLR (meters)			% change in wetland area, Possible Outcome SLR (meters)		
	0.5	1.0	1.5	0.5	1.0	1.5
A	- 6	-3	-4	65	156	109
B	-11	-18	-33	-4	13	-18
C	-3	-7	-18	-3	-6	-13
D	24	31	18	25	44	43
E	2	7	8	2	12	13
F	-4	-9	-15	-1	-7	-15
G	-5	-4	-2	-5	24	12
H	-3	-4	-5	-3	-4	-5



Net gain of tidal wetlands

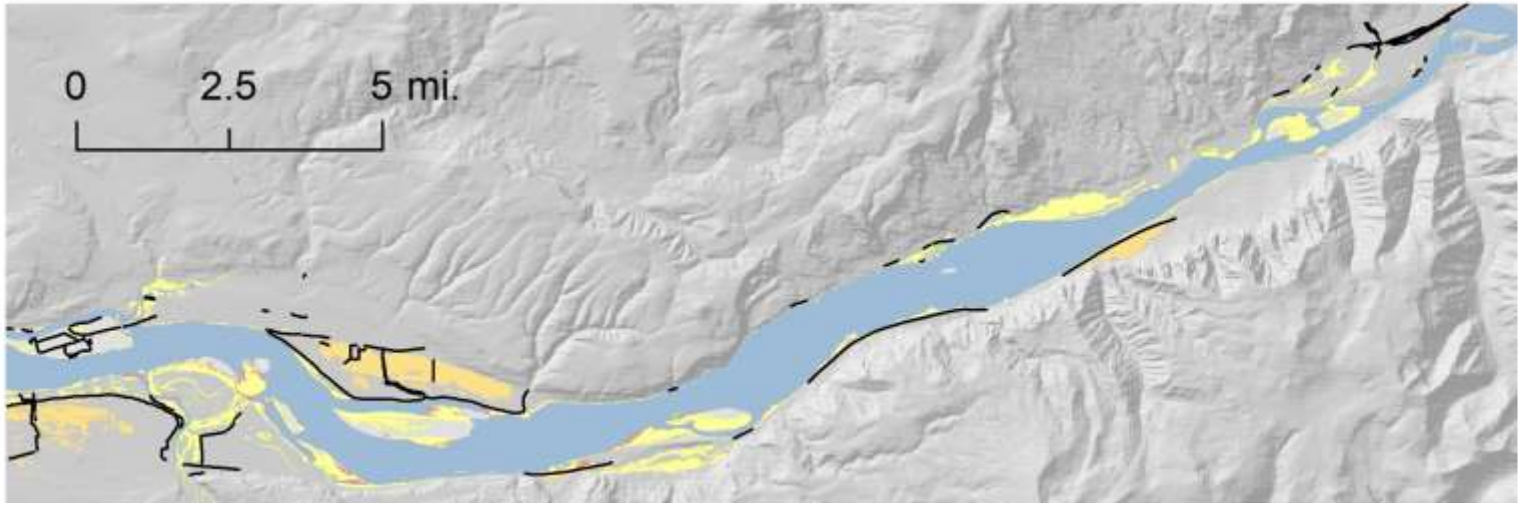
Net loss of tidal wetlands

Wetlands Impacts due to SLR, Results Interpretation

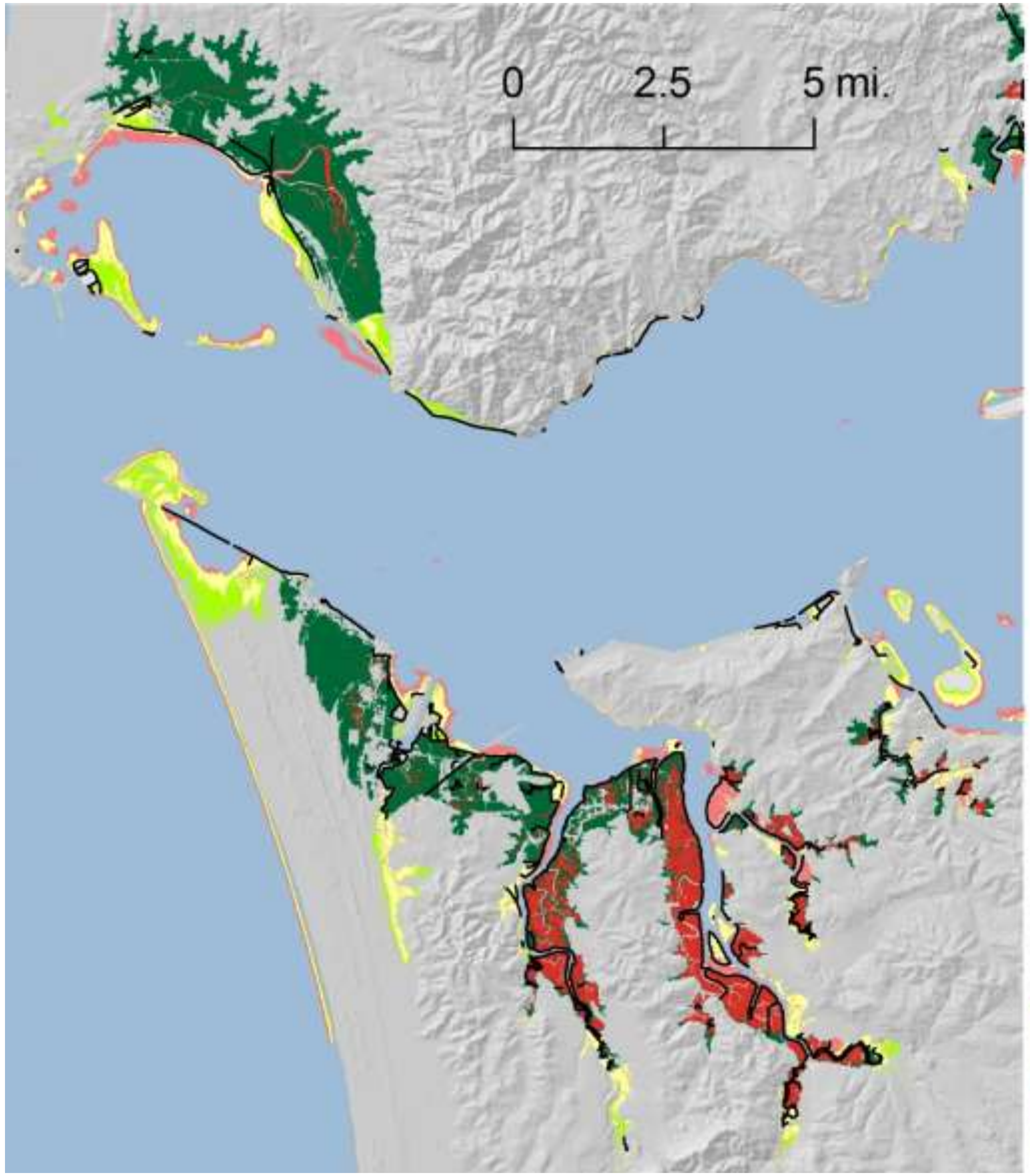


0.5 m SLR

- Gain TWL
- Gain TWL likely
- GainTWL poss.
- Lost DWL likely
- Lost DWL poss.
- Lost TWL
- Intact DWL
- Intact TWL

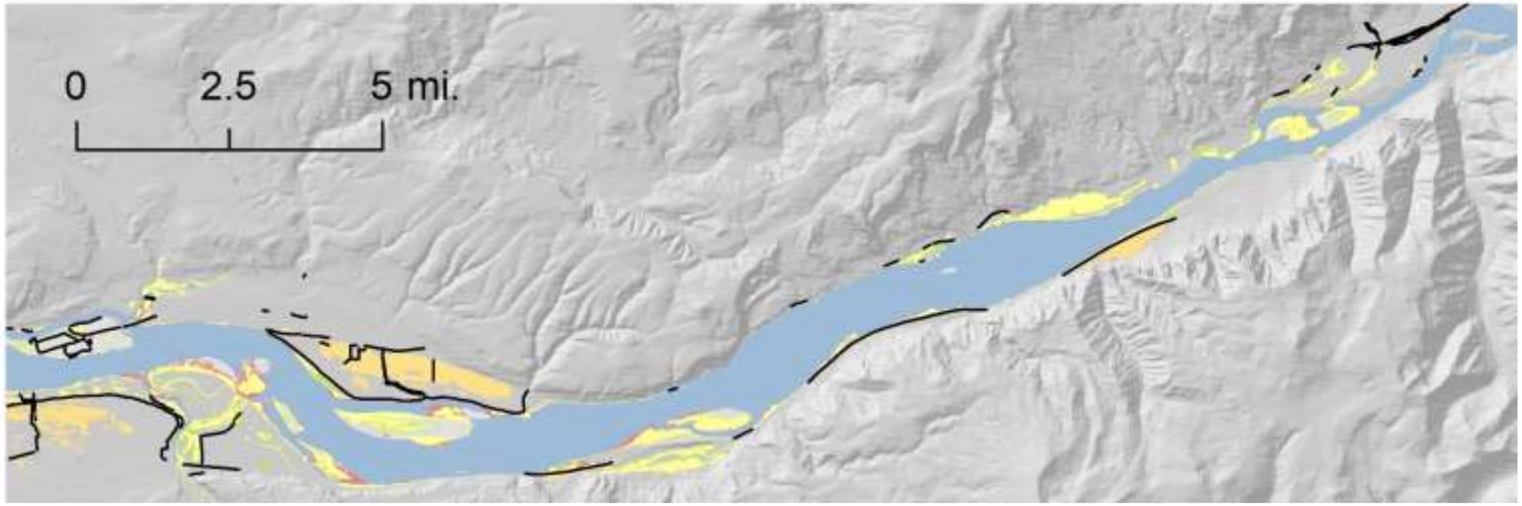


Wetlands Impacts due to SLR, Results Interpretation



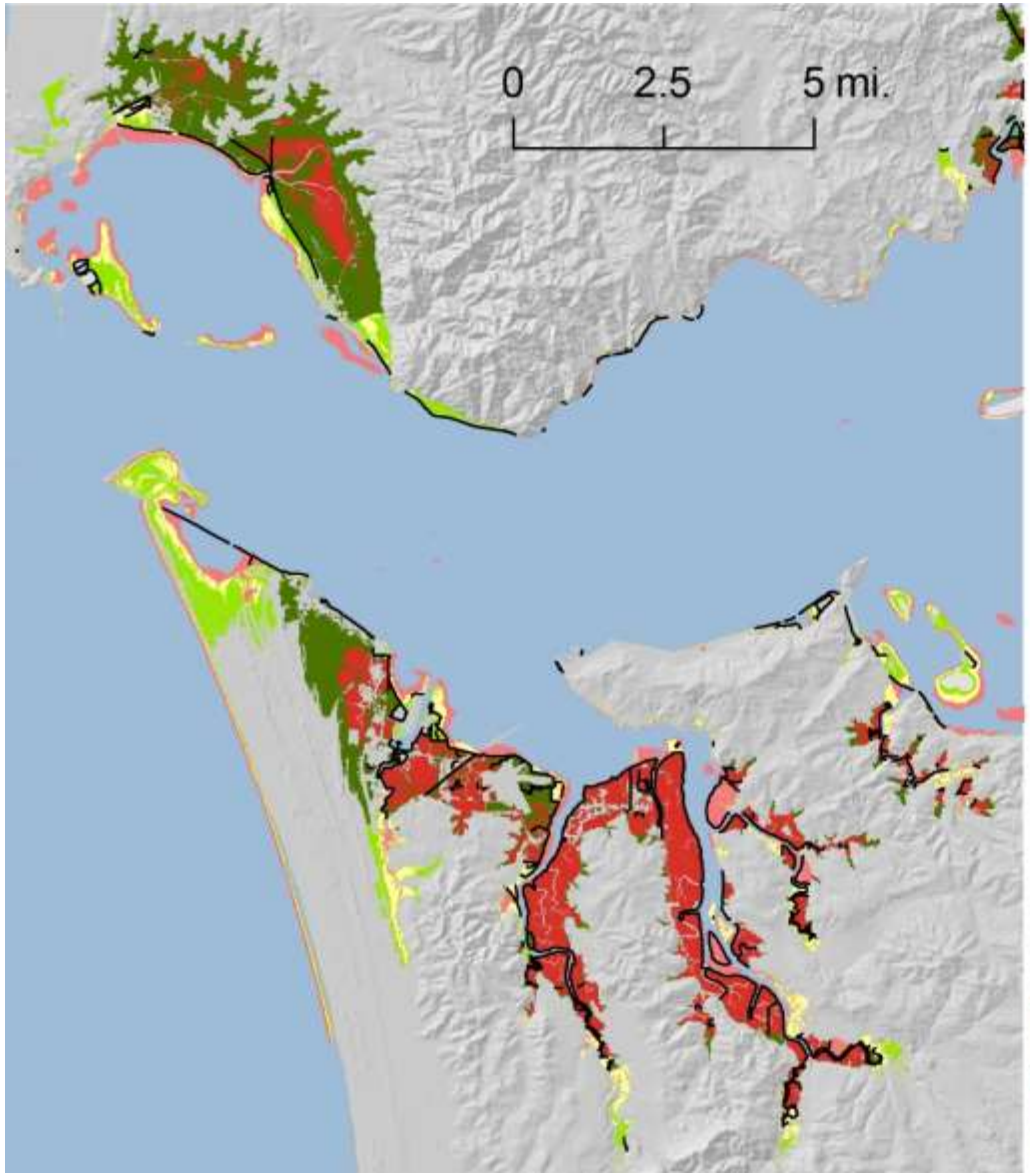
1.0 m SLR

- Gain TWL
- Gain TWL likely
- GainTWL poss.
- Lost DWL likely
- Lost DWL poss.
- Lost TWL
- Intact DWL
- Intact TWL

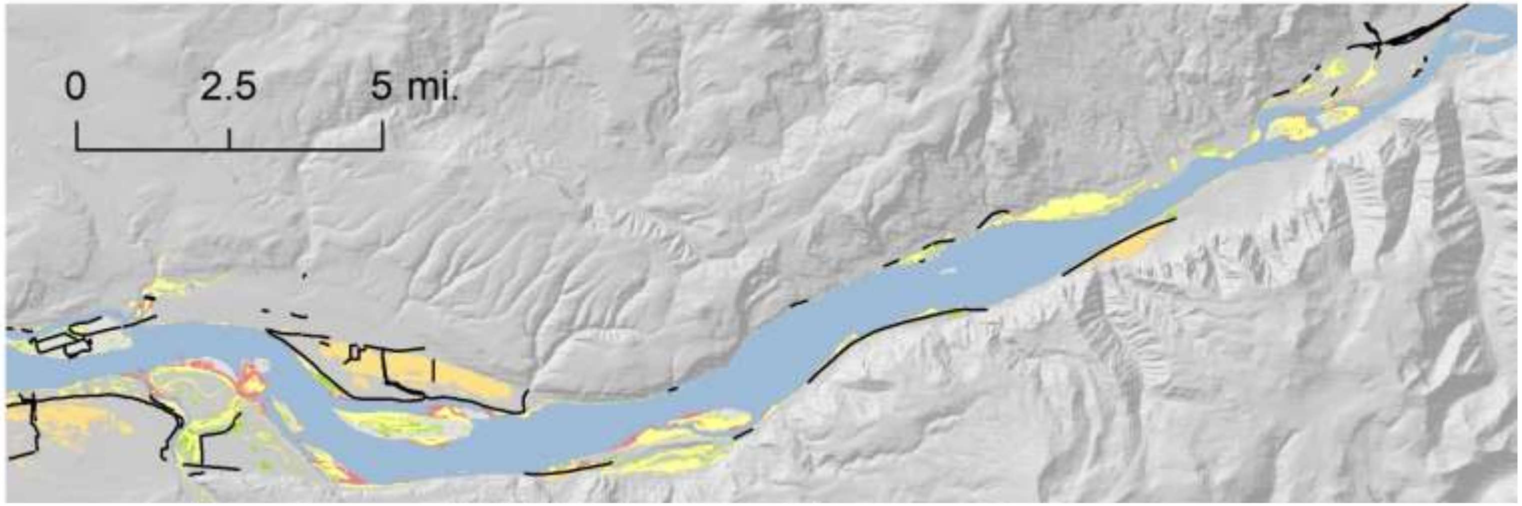


Wetlands Impacts due to SLR, Results Interpretation

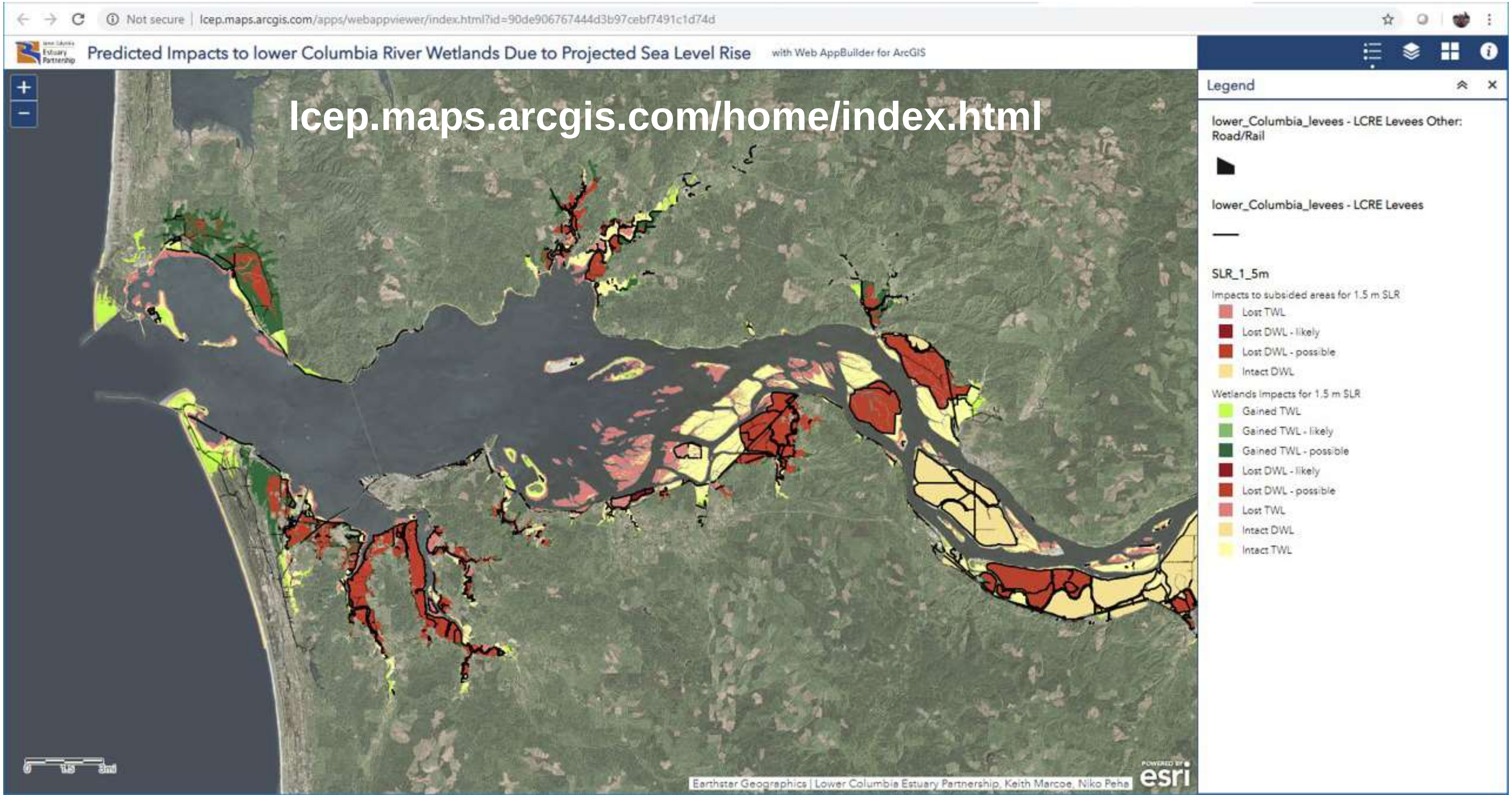
1.5 m SLR



- Gain TWL
- Gain TWL likely
- GainTWL poss.
- Lost DWL likely
- Lost DWL poss.
- Lost TWL
- Intact DWL
- Intact TWL



Wetlands Impacts Study Online Planning Tool



Conclusions and Next Steps

Conclusions:

- Available data provides a good baseline assessment of SLR impacts to LCR wetlands. More data needed to address remaining factors:
  - Sediment accretion, localized tectonic uplift, changes in other climate variables, expected Bonneville discharge
- Significant uncertainty in SLR impacts to wetlands remains based on how levees will respond.
- Levee response should be looked at when prioritizing restoration/protection

Next Steps:

- Address uncertainties in areas vulnerable to loss, areas of potential gain
- Incorporate results into LCEP Restoration Targets for the Lower Columbia R.

Thank You!

Questions

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Acknowledgements

U.S Army Corps of Engineers
EPA

Lower Columbia Estuary Partnership

La Center Wetlands Restoration, East Fork Lewis River, La Center WA, OR