FACET

BLUE COAST ENGINEERING

KITSAP COUNTY

Sea Level Rise Vulnerability and Risk Assessment

Technical Advisory Meeting #2

formerly DCG/Watershed

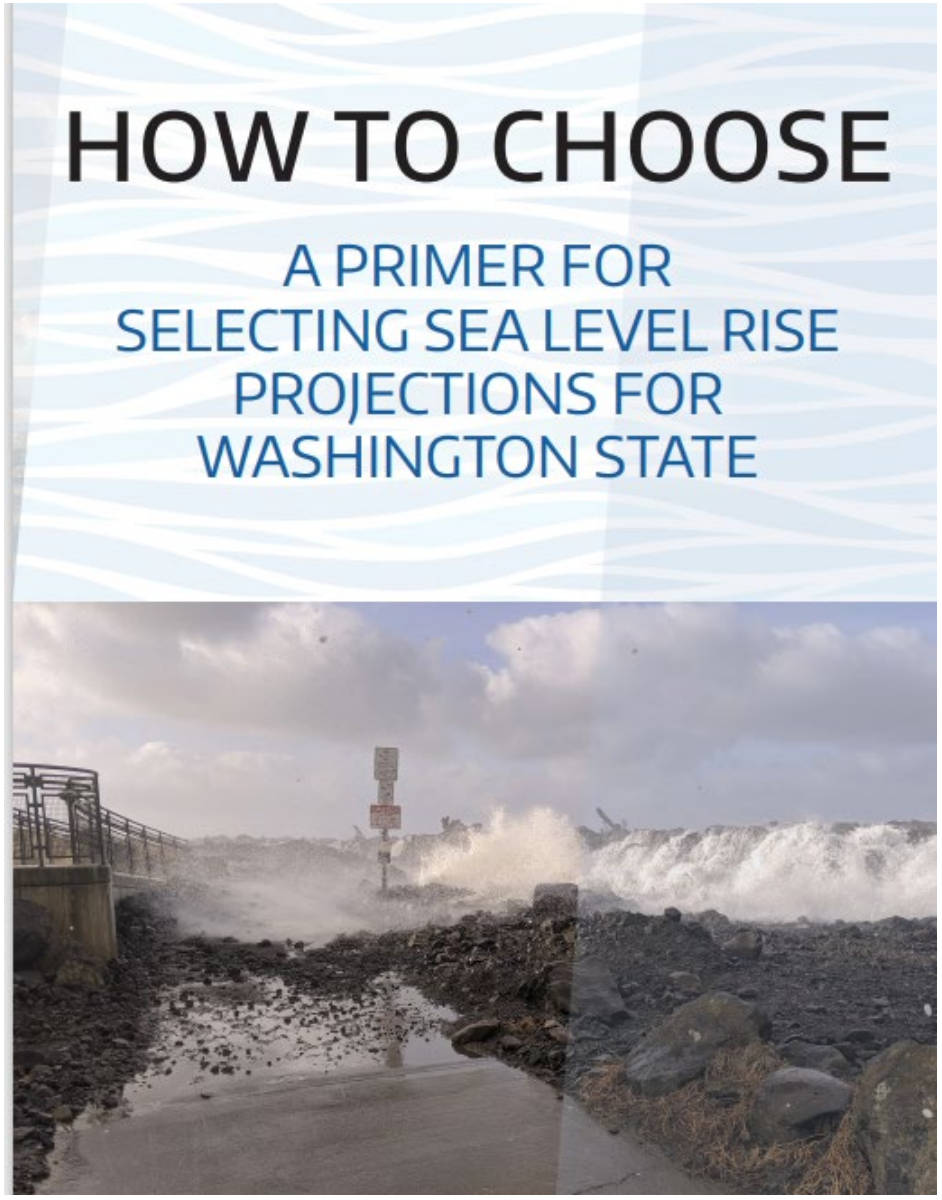
Agenda

- Planning Scenarios – SLR Projections
- Vulnerability Assessment – Assets
- Wind/Wave Modeling – Focus Areas
- Timeline
- Next Steps

FACET

BLUE COAST ENGINEERING

Background


HOW TO CHOOSE
A PRIMER FOR
SELECTING SEA LEVEL RISE
PROJECTIONS FOR
WASHINGTON STATE

Projections – What are the options

1. **RCP**: 4.5 (low emissions) or 8.5 (high emissions)
2. **Timeframe**: 2050? 2060? 2100? Other?
3. **Certainty/Level of Risk**: 1% (less likely), 50%, 99% (very likely)? Something in between?

FACET

BLUE COAST ENGINEERING

Examples from other projects

	RCP	Dates	Certainties
KC CC Risk Assessment (2020)	4.5, 8.5	2030, 2050, 2100	**50**,90,95,**99**%
KC SW (Task 700) CC Assessment (2019)	4.5, 8.5	2030, 2100	90%
BI SLR Risk Assessment (2019)	8.5	2060, 2100, 2150	1% (Rapid Ice Melt), 50%
BI Adaptation Cert Tool (2023)	8.5	2100	50% (also 1%, 99%)
PGST Climate Proj, SLR, Ex Precip (2018)	4.5, 8.5	2050, 2100, 2150	50% (Central), 17-83% range (Likely), 10%, 1%, 0.1%
Seattle's mapping site (current)	8.5	2050, 2100	50%, also uses a range to estimate then map 1ft intervals
Pacific County (2023)	8.5	2050, 2100	87%
Island County (2017)	8.4	2030, 2050, 2100	50%, 25%, 5%, 1%

SLR Projections – Dyes Inlet

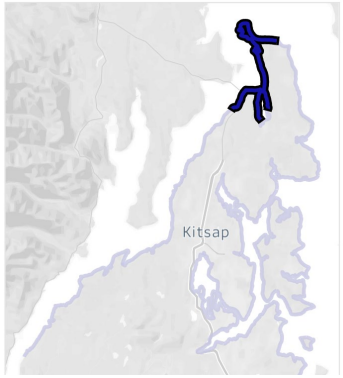
RCP 8.5

	Assessed Probability of Exceedance:									
	99	**95**	**90**	**83**	**50**	**17**	**10**	**5**	**1**	**0.1**
2010	0	0	0	0	**0.1**	0.1	0.2	0.2	0.2	0.3
2020	0	0.1	0.1	0.1	**0.2**	0.3	0.3	0.4	0.4	0.5
2030	0.1	0.2	0.2	0.2	**0.4**	0.5	0.5	0.6	0.7	0.8
2040	0.1	0.2	0.3	0.4	**0.5**	0.7	0.8	0.9	1	1.3
2050	0.2	0.3	0.4	0.5	**0.8**	1	1.1	1.2	1.5	2.1
2060	0.3	0.5	0.6	0.7	**1**	1.3	1.4	1.6	2	3
2070	0.4	0.6	0.8	0.9	**1.3**	1.7	1.8	2	2.6	4.1
2080	0.5	0.8	1	1.1	**1.6**	2.1	2.3	2.5	3.3	5.4
2090	0.6	0.9	1.1	1.3	**1.9**	2.5	2.7	3.1	4.1	6.8
2100	0.6	1.1	1.3	1.5	**2.2**	3	3.3	3.7	5	8.5
2110	0.8	1.2	1.5	1.7	**2.4**	3.2	3.5	4	5.7	10.1
2120	0.9	1.4	1.7	1.9	**2.7**	3.7	4.1	4.7	6.7	11.9
2130	1	1.5	1.8	2.1	**3**	4.2	4.7	5.4	7.8	13.8
2140	1.1	1.7	2	2.3	**3.4**	4.7	5.2	6.1	9	16.3
2150	1.1	1.8	2.1	2.5	**3.7**	5.2	5.9	6.9	10.2	18.5

RCP 4.5

	Assessed Probability of Exceedance:									
	99	**95**	**90**	**83**	**50**	**17**	**10**	**5**	**1**	**0.1**
2010	0	0	0	0	**0.1**	0.1	0.2	0.2	0.2	0.3
2020	0	0.1	0.1	0.1	**0.2**	0.3	0.3	0.4	0.4	0.5
2030	0	0.1	0.2	0.2	**0.4**	0.5	0.5	0.6	0.7	0.8
2040	0.1	0.2	0.3	0.3	**0.5**	0.7	0.8	0.8	1	1.3
2050	0.1	0.3	0.4	0.5	**0.7**	1	1	1.1	1.4	2
2060	0.2	0.4	0.5	0.6	**0.9**	1.2	1.3	1.5	1.8	2.8
2070	0.2	0.5	0.6	0.8	**1.1**	1.5	1.7	1.8	2.3	3.7
2080	0.3	0.6	0.7	0.9	**1.3**	1.8	2	2.2	2.9	4.9
2090	0.3	0.6	0.8	1	**1.5**	2.1	2.3	2.6	3.6	6.2
2100	0.3	0.7	0.9	1.1	**1.8**	2.4	2.7	3.1	4.3	7.6
2110	0.3	0.8	1	1.3	**2**	2.8	3.1	3.6	5.1	9.1
2120	0.3	0.8	1.1	1.4	**2.2**	3.1	3.5	4	5.9	10.6
2130	0.3	0.9	1.2	1.5	**2.4**	3.4	3.9	4.5	6.8	12.6
2140	0.2	0.9	1.2	1.5	**2.6**	3.8	4.3	5.1	7.8	14.4
2150	0.2	0.9	1.3	1.6	**2.8**	4.1	4.7	5.6	8.7	16.8

SLR Projections – North



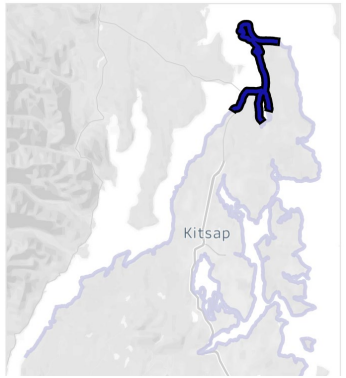
RCP 8.5

	Assessed Probability of Exceedance:									
	99	**95**	**90**	**83**	**50**	**17**	**10**	**5**	**1**	**0.1**
2010	-0.1	0	0	0	**0.1**	0.2	0.2	0.2	0.3	0.3
2020	-0.1	0	0.1	0.1	**0.2**	0.3	0.4	0.4	0.5	0.6
2030	0	0.1	0.1	0.2	**0.4**	0.5	0.6	0.7	0.8	0.9
2040	0	0.1	0.2	0.3	**0.5**	0.8	0.9	1	1.1	1.4
2050	0	0.2	0.4	0.5	**0.8**	1.1	1.2	1.3	1.6	2.2
2060	0.1	0.4	0.5	0.6	**1**	1.4	1.5	1.7	2.1	3
2070	0.2	0.5	0.7	0.8	**1.3**	1.8	1.9	2.2	2.7	4.2
2080	0.3	0.6	0.8	1	**1.6**	2.2	2.4	2.7	3.4	5.5
2090	0.3	0.8	1	1.2	**1.9**	2.6	2.9	3.2	4.2	7
2100	0.4	0.9	1.2	1.4	**2.2**	3.1	3.4	3.9	5.1	8.6
2110	0.5	1	1.3	1.6	**2.4**	3.3	3.7	4.2	5.7	9.9
2120	0.6	1.2	1.5	1.8	**2.7**	3.8	4.3	4.9	6.8	11.6
2130	0.7	1.3	1.7	2	**3.1**	4.3	4.8	5.6	7.9	14.2
2140	0.7	1.4	1.8	2.2	**3.4**	4.8	5.4	6.3	9.1	16.4
2150	0.8	1.5	2	2.4	**3.7**	5.4	6.1	7.1	10.3	18.7

RCP 4.5

	Assessed Probability of Exceedance:									
	99	**95**	**90**	**83**	**50**	**17**	**10**	**5**	**1**	**0.1**
2010	-0.1	0	0	0	**0.1**	0.2	0.2	0.2	0.3	0.3
2020	-0.1	0	0.1	0.1	**0.2**	0.3	0.4	0.4	0.5	0.6
2030	-0.1	0.1	0.1	0.2	**0.4**	0.5	0.6	0.7	0.8	0.9
2040	0	0.1	0.2	0.3	**0.5**	0.8	0.8	0.9	1.1	1.4
2050	0	0.2	0.3	0.4	**0.7**	1	1.1	1.3	1.5	2
2060	0	0.3	0.4	0.5	**0.9**	1.3	1.4	1.6	2	2.8
2070	0	0.4	0.5	0.7	**1.1**	1.6	1.8	2	2.5	3.9
2080	0.1	0.4	0.6	0.8	**1.3**	1.9	2.1	2.4	3.1	5
2090	0.1	0.5	0.7	0.9	**1.5**	2.2	2.5	2.8	3.7	6.2
2100	0.1	0.5	0.8	1	**1.8**	2.6	2.9	3.3	4.4	7.7
2110	0	0.6	0.9	1.2	**2**	2.9	3.2	3.7	5.2	9.1
2120	0	0.6	1	1.3	**2.2**	3.2	3.6	4.2	6	10.8
2130	0	0.7	1	1.4	**2.4**	3.6	4	4.7	6.9	12.7
2140	-0.1	0.6	1	1.4	**2.6**	3.9	4.5	5.2	7.9	14.4
2150	-0.1	0.7	1.1	1.5	**2.8**	4.3	4.9	5.8	8.9	16.7

SLR Projections – 4.5

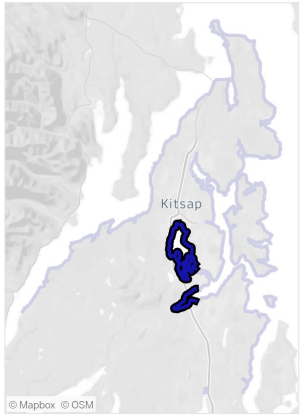


RCP 4.5

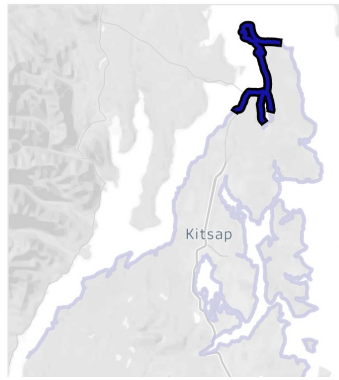
	Assessed Probability of Exceedance:									
	99	**95**	**90**	**83**	**50**	**17**	**10**	**5**	**1**	**0.1**
2010	0	0	0	0	**0.1**	0.1	0.2	0.2	0.2	0.3
2020	0	0.1	0.1	0.1	**0.2**	0.3	0.3	0.4	0.4	0.5
2030	0	0.1	0.2	0.2	**0.4**	0.5	0.5	0.6	0.7	0.8
2040	0.1	0.2	0.3	0.3	**0.5**	0.7	0.8	0.8	1	1.3
2050	0.1	0.3	0.4	0.5	**0.7**	1	1	1.1	1.4	2
2060	0.2	0.4	0.5	0.6	**0.9**	1.2	1.3	1.5	1.8	2.8
2070	0.2	0.5	0.6	0.8	**1.1**	1.5	1.7	1.8	2.3	3.7
2080	0.3	0.6	0.7	0.9	**1.3**	1.8	2	2.2	2.9	4.9
2090	0.3	0.6	0.8	1	**1.5**	2.1	2.3	2.6	3.6	6.2
2100	0.3	0.7	0.9	1.1	**1.8**	2.4	2.7	3.1	4.3	7.6
2110	0.3	0.8	1	1.3	**2**	2.8	3.1	3.6	5.1	9.1
2120	0.3	0.8	1.1	1.4	**2.2**	3.1	3.5	4	5.9	10.6
2130	0.3	0.9	1.2	1.5	**2.4**	3.4	3.9	4.5	6.8	12.6
2140	0.2	0.9	1.2	1.5	**2.6**	3.8	4.3	5.1	7.8	14.4
2150	0.2	0.9	1.3	1.6	**2.8**	4.1	4.7	5.6	8.7	16.8

RCP 4.5

	Assessed Probability of Exceedance:									
	99	**95**	**90**	**83**	**50**	**17**	**10**	**5**	**1**	**0.1**
2010	-0.1	0	0	0	**0.1**	0.2	0.2	0.2	0.3	0.3
2020	-0.1	0	0.1	0.1	**0.2**	0.3	0.4	0.4	0.5	0.6
2030	-0.1	0.1	0.1	0.2	**0.4**	0.5	0.6	0.7	0.8	0.9
2040	0	0.1	0.2	0.3	**0.5**	0.8	0.8	0.9	1.1	1.4
2050	0	0.2	0.3	0.4	**0.7**	1	1.1	1.3	1.5	2
2060	0	0.3	0.4	0.5	**0.9**	1.3	1.4	1.6	2	2.8
2070	0	0.4	0.5	0.7	**1.1**	1.6	1.8	2	2.5	3.9
2080	0.1	0.4	0.6	0.8	**1.3**	1.9	2.1	2.4	3.1	5
2090	0.1	0.5	0.7	0.9	**1.5**	2.2	2.5	2.8	3.7	6.2
2100	0.1	0.5	0.8	1	**1.8**	2.6	2.9	3.3	4.4	7.7
2110	0	0.6	0.9	1.2	**2**	2.9	3.2	3.7	5.2	9.1
2120	0	0.6	1	1.3	**2.2**	3.2	3.6	4.2	6	10.8
2130	0	0.7	1	1.4	**2.4**	3.6	4	4.7	6.9	12.7
2140	-0.1	0.6	1	1.4	**2.6**	3.9	4.5	5.2	7.9	14.4
2150	-0.1	0.7	1.1	1.5	**2.8**	4.3	4.9	5.8	8.9	16.7



SLR Projections – 8.5



RCP 8.5

	Assessed Probability of Exceedance:									
	99	95	90	83	50	17	10	5	1	0.1
2010	0	0	0	0	0.1	0.1	0.2	0.2	0.2	0.3
2020	0	0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.5
2030	0.1	0.2	0.2	0.2	0.4	0.5	0.5	0.6	0.7	0.8
2040	0.1	0.2	0.3	0.4	0.5	0.7	0.8	0.9	1	1.3
2050	0.2	0.3	0.4	0.5	0.8	1	1.1	1.2	1.5	2.1
2060	0.3	0.5	0.6	0.7	1	1.3	1.4	1.6	2	3
2070	0.4	0.6	0.8	0.9	1.3	1.7	1.8	2	2.6	4.1
2080	0.5	0.8	1	1.1	1.6	2.1	2.3	2.5	3.3	5.4
2090	0.6	0.9	1.1	1.3	1.9	2.5	2.7	3.1	4.1	6.8
2100	0.6	1.1	1.3	1.5	2.2	3	3.3	3.7	5	8.5
2110	0.8	1.2	1.5	1.7	2.4	3.2	3.5	4	5.7	10.1
2120	0.9	1.4	1.7	1.9	2.7	3.7	4.1	4.7	6.7	11.9
2130	1	1.5	1.8	2.1	3	4.2	4.7	5.4	7.8	13.8
2140	1.1	1.7	2	2.3	3.4	4.7	5.2	6.1	9	16.3
2150	1.1	1.8	2.1	2.5	3.7	5.2	5.9	6.9	10.2	18.5

RCP 8.5

	Assessed Probability of Exceedance:									
	99	95	90	83	50	17	10	5	1	0.1
2010	-0.1	0	0	0	0.1	0.2	0.2	0.2	0.3	0.3
2020	-0.1	0	0.1	0.1	0.2	0.3	0.4	0.4	0.5	0.6
2030	0	0.1	0.1	0.2	0.4	0.5	0.6	0.7	0.8	0.9
2040	0	0.1	0.2	0.3	0.5	0.8	0.9	1	1.1	1.4
2050	0	0.2	0.4	0.5	0.8	1.1	1.2	1.3	1.6	2.2
2060	0.1	0.4	0.5	0.6	1	1.4	1.5	1.7	2.1	3
2070	0.2	0.5	0.7	0.8	1.3	1.8	1.9	2.2	2.7	4.2
2080	0.3	0.6	0.8	1	1.6	2.2	2.4	2.7	3.4	5.5
2090	0.3	0.8	1	1.2	1.9	2.6	2.9	3.2	4.2	7
2100	0.4	0.9	1.2	1.4	2.2	3.1	3.4	3.9	5.1	8.6
2110	0.5	1	1.3	1.6	2.4	3.3	3.7	4.2	5.7	9.9
2120	0.6	1.2	1.5	1.8	2.7	3.8	4.3	4.9	6.8	11.6
2130	0.7	1.3	1.7	2	3.1	4.3	4.8	5.6	7.9	14.2
2140	0.7	1.4	1.8	2.2	3.4	4.8	5.4	6.3	9.1	16.4
2150	0.8	1.5	2	2.4	3.7	5.4	6.1	7.1	10.3	18.7

Discussion/Decision

1. RCP
2. Timeframe
3. Certainty/Level of Risk

FACET

Assets

- Roads, Transportation
- Hospitals, Police Stations, Fire Depts
- Schools, Libraries
- Residences
- Agricultural, Farmland
- On-site septic systems
- Electrical Substations
- Historic and Cultural Resources
- Group A Wells, WWTPs
- Beach Access, Parks
- Wetlands, Estuaries
- Marinas, Bays
- Brownfield Sites, Landfills

FACET

BLUE COAST ENGINEERING

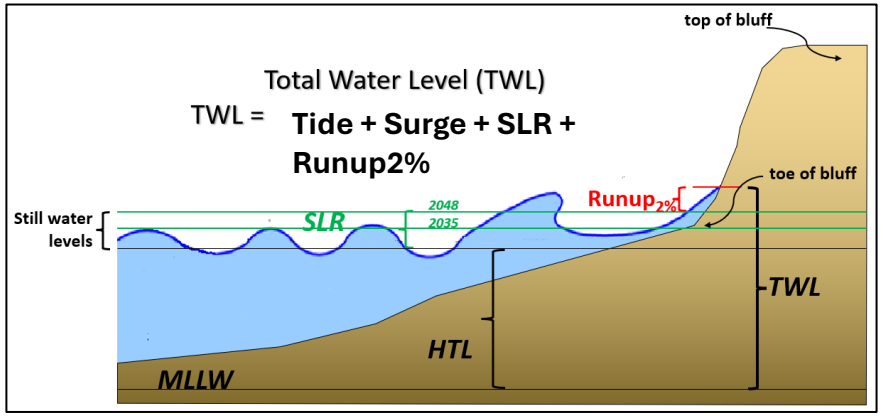
Wind-wave modeling focus areas

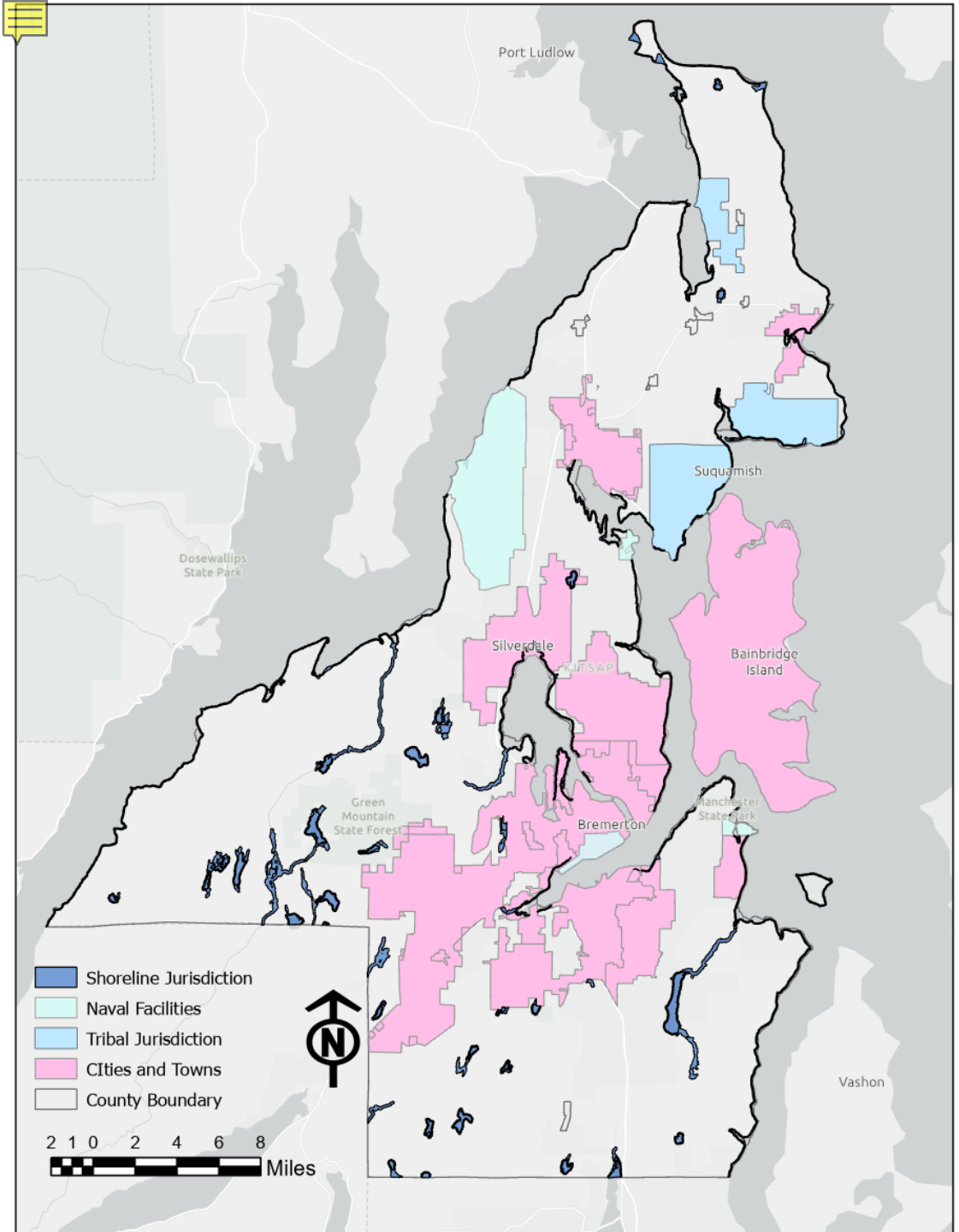
Description:

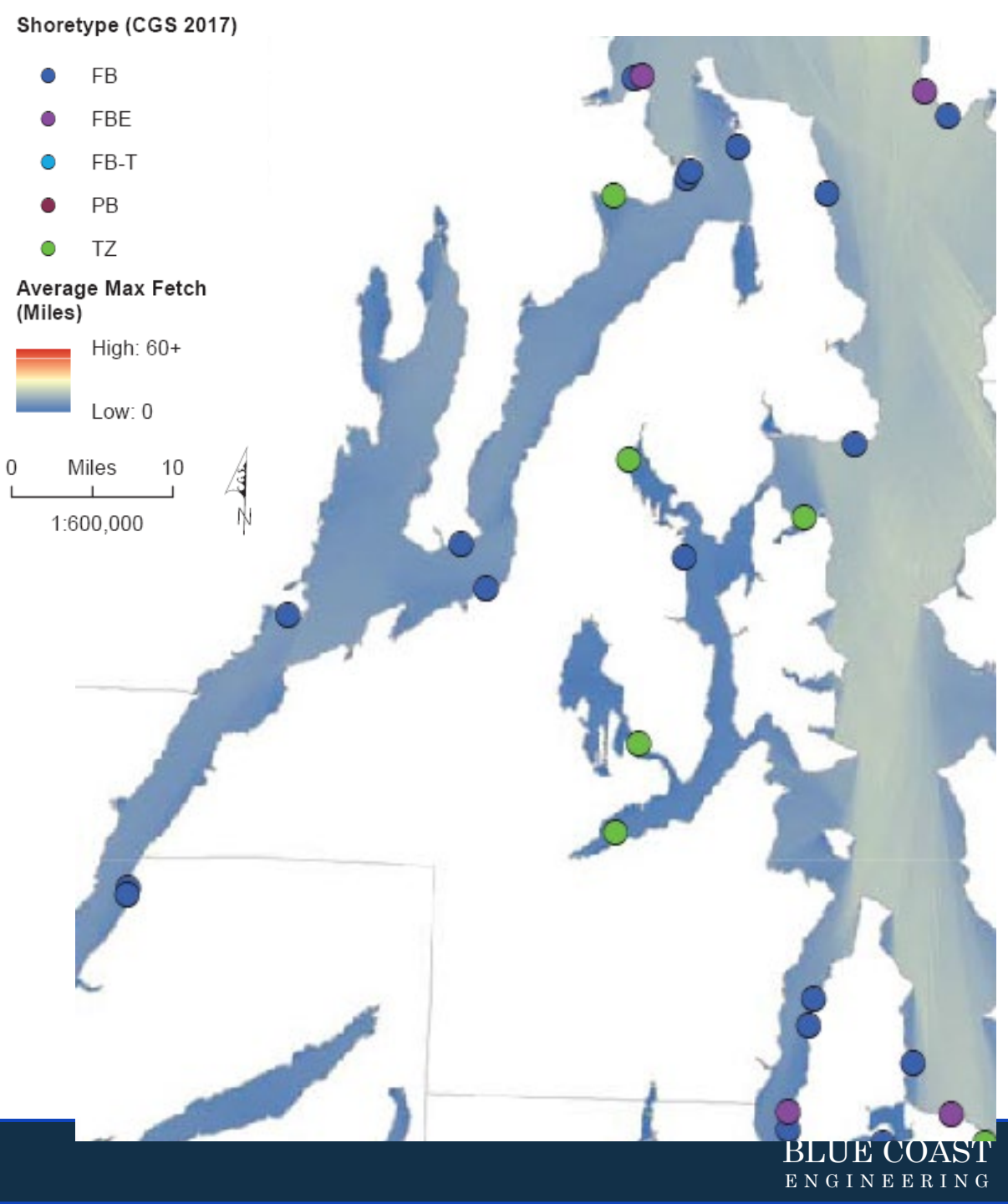
- 1-D wind-wave hindcast for shoreline reaches of concern. Estimate wind-wave runup using empirical methods
- Calculation of total dynamic water level

Selection Criteria:

- 1 representative transect per reach
- Focus on reaches susceptible to coastal flooding with potential for moderate or greater wind-wave energy:
  - Fetch > 1 mile (MSDG guideline)
  - Use beach strategies fetch/erosion potential database
  - Depending on number of locations add directional component to narrow number of sites
- Low bank shoreline (<5 feet)





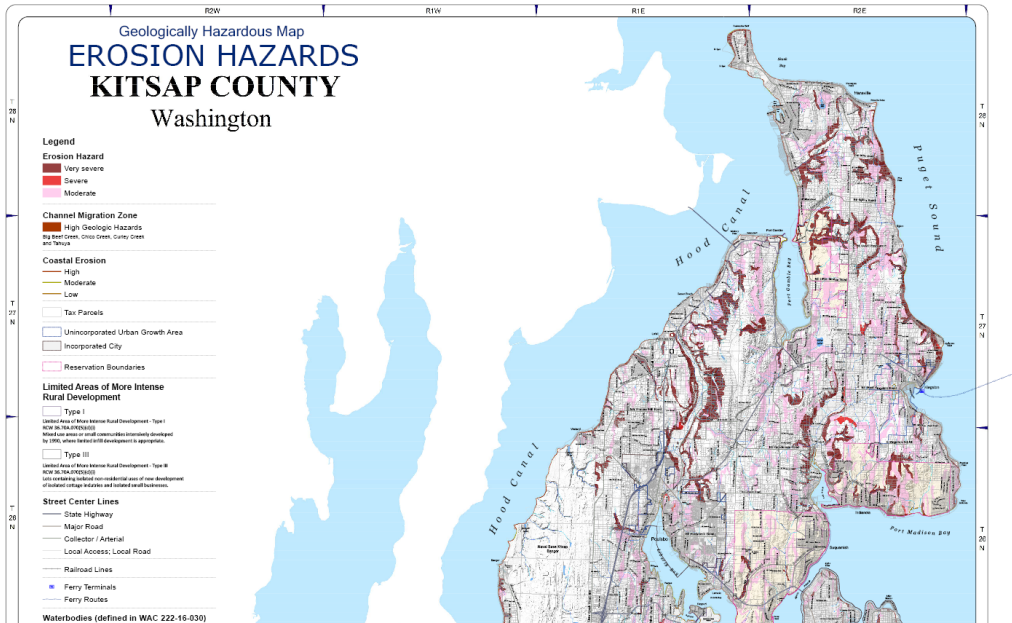


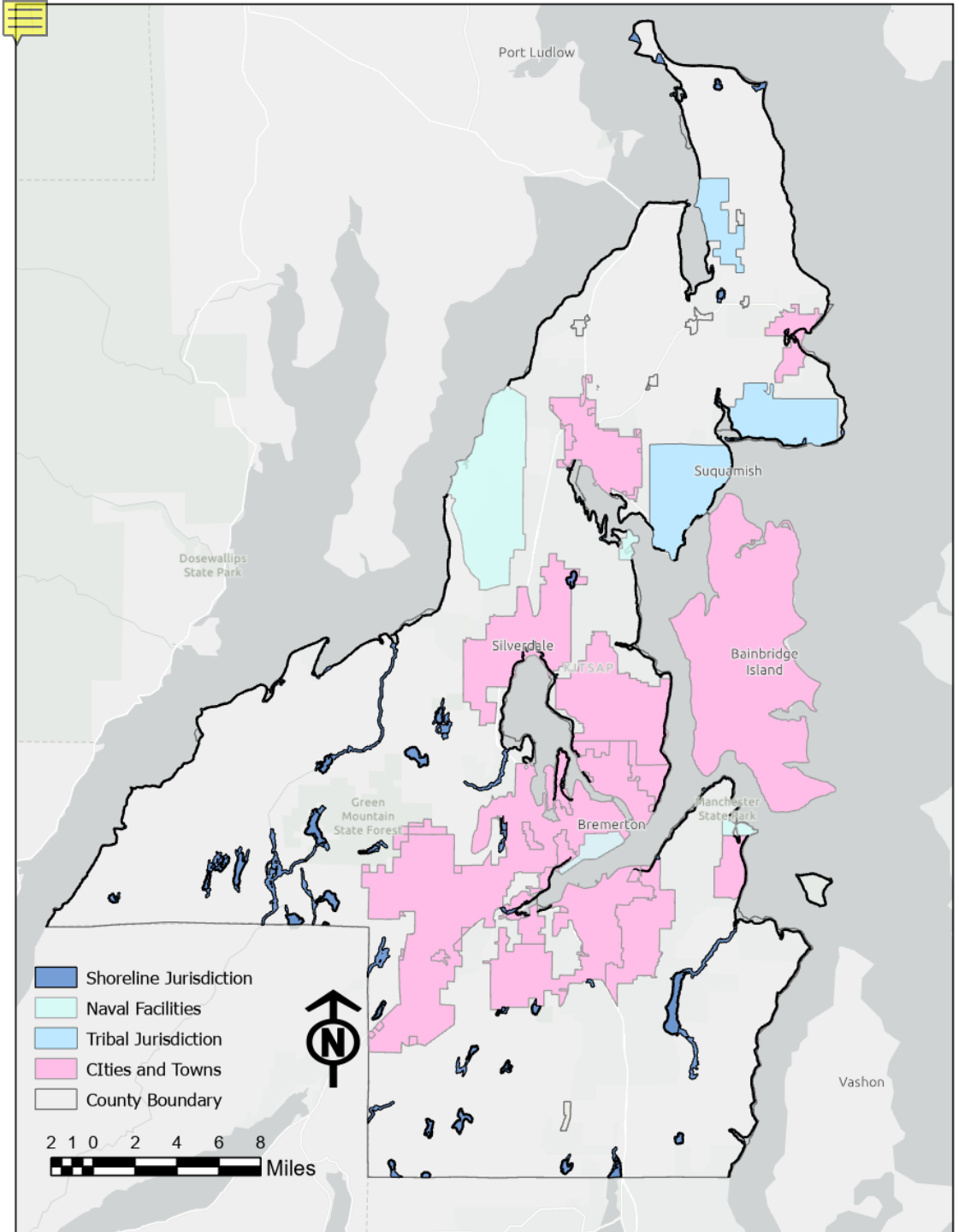
BLUE COAST ENGINEERING

Bluff recession rates - SLR

Description:

- SLR could increase bluff recession rates through increased precipitation along and wave energy acting higher on the toe of the bluff. Estimate bluff recession rate to include predictions for SLR using empirical method.
- Need to know historical recession rate either based on published data or through an analysis using topographic (LiDAR) data and aerial photos
- Selection criteria
- Coastlines with high coastal erosion (Kitsap County Erosion Hazards Map)
- Limit to shorelines with at-risk infrastructure upland





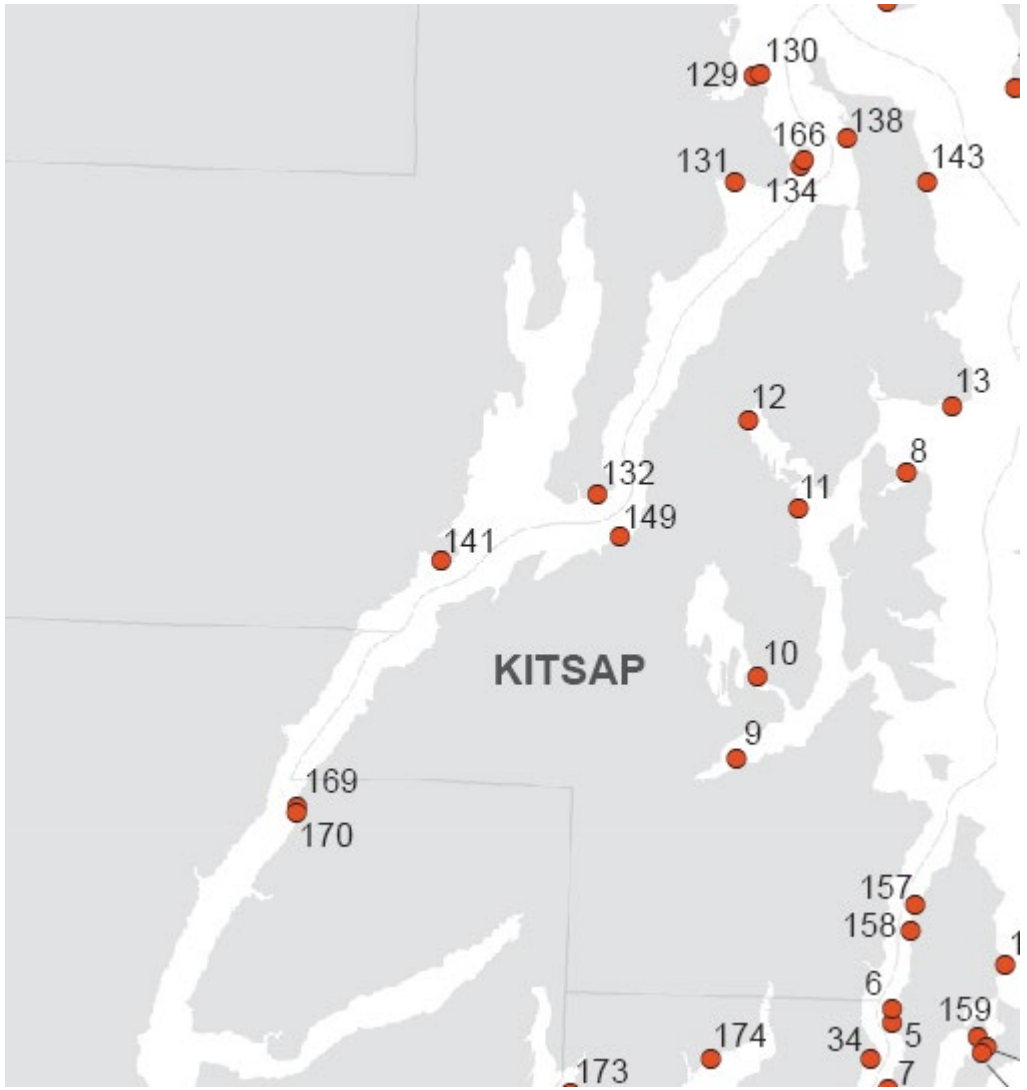
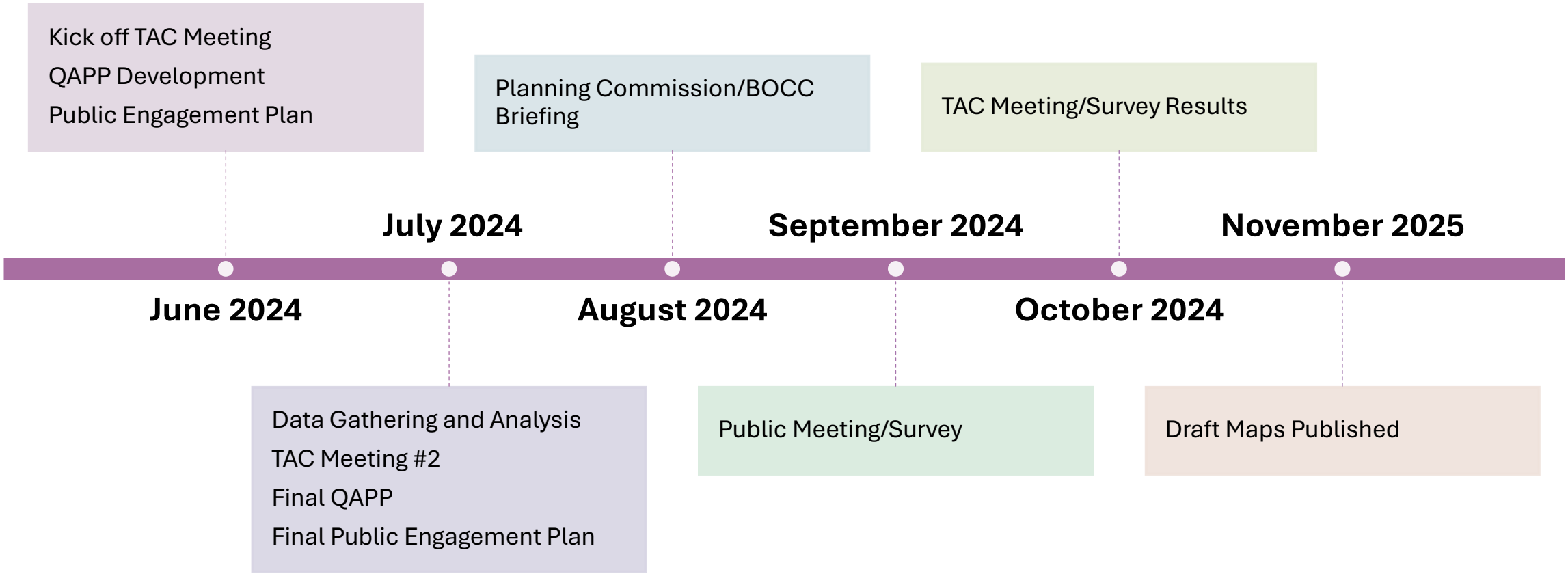


Figure 2. Bluff recession point locations. Labels correspond to the unique identifiers in Appendix A.

ESRP Learning Project - Long-Term Bluff Recession Rates in Puget Sound

9 locations within Kitsap County

Draft Timeline



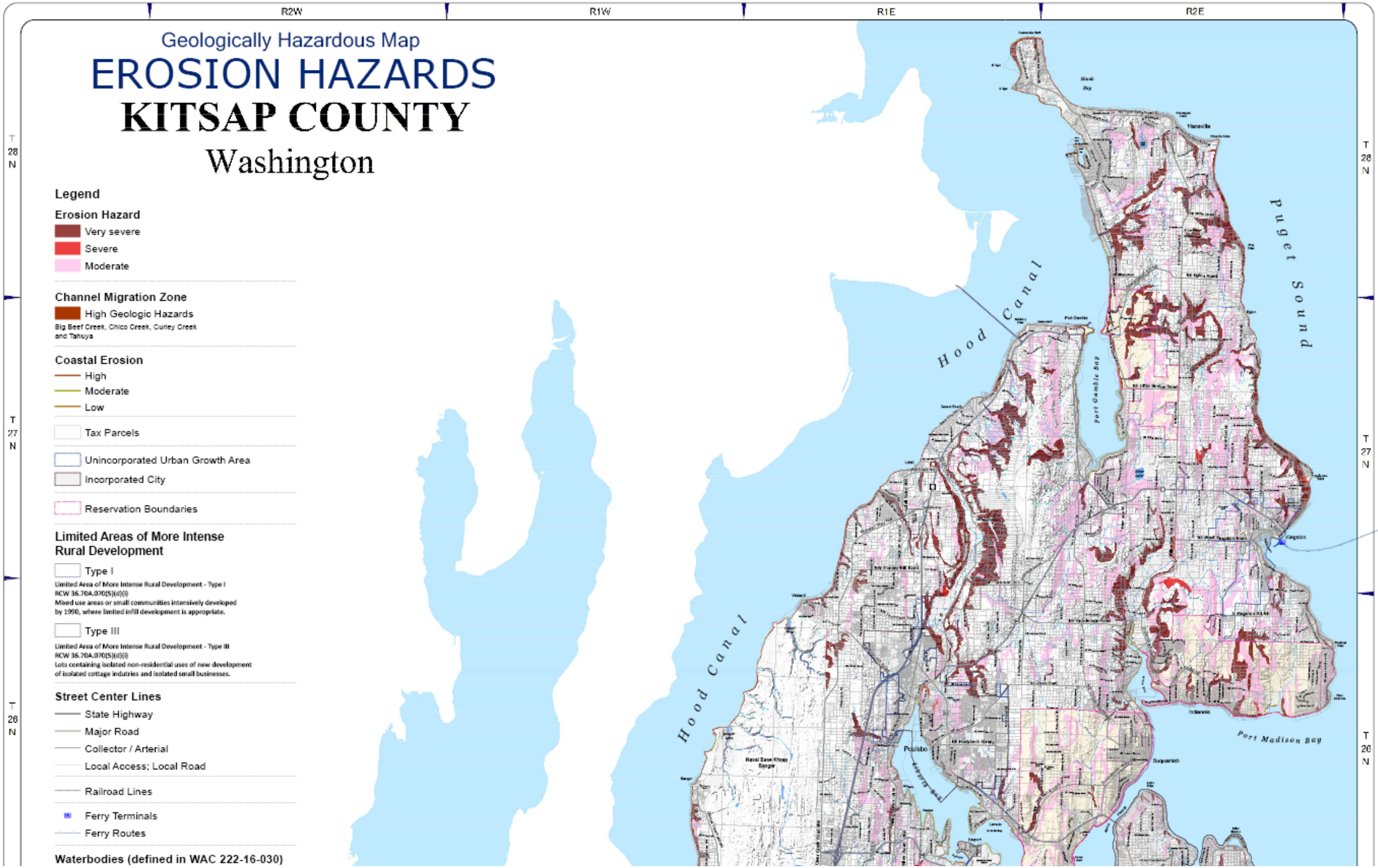
Questions

Geologically Hazardous Map

EROSION HAZARDS

KITSAP COUNTY

Washington



Legend

Erosion Hazard
- Very severe
- Severe
- Moderate

Channel Migration Zone
- High Geologic Hazards

Big Beef Creek, Chico Creek, Curley Creek and Tahuya

Coastal Erosion
- High
- Moderate
- Low

- Tax Parcels
- Unincorporated Urban Growth Area
- Incorporated City
- Reservation Boundaries

Limited Areas of More Intense Rural Development
- Type I

Limited Area of More Intense Rural Development - Type I
RCW 36.70A.070(5)(d)(i)
Mixed use areas or small communities intensively developed by 1990, where limited infill development is appropriate.

- Type III

Limited Area of More Intense Rural Development - Type III
RCW 36.70A.070(5)(d)(ii)
Lots containing isolated non-residential uses of new development of isolated cottage industries and isolated small businesses.

Street Center Lines
- State Highway
- Major Road
- Collector / Arterial
- Local Access; Local Road
- Railroad Lines
- Ferry Terminals
- Ferry Routes

Waterbodies (defined in WAC 222-16-030)

Finding 2: Bluff Erosion

Coastal bluffs are important features of Kitsap County, serving as a sediment source and contributing to sediment transport. Although past trends between bluff erosion rates and climate change are not clearly established, many of the physical factors affecting bluff erosion will likely be impacted by future climate change, with implications for habitat, sedimentation, and infrastructure.

Coastal bluffs are important features of Kitsap County, and they serve as a sediment source and contribute to sediment transport. Coastal bluffs are prominent features of Puget Sound's shoreline, including Kitsap County, covering approximately 17.7 miles of Kitsap County's shorelines, with 8.5 miles of coastal bluffs being armored (Figure 46).[670] Bluff erosion is a natural geologic process that provides sediment to shores and nearshore systems and habitats.[671] Bluff erosion is often influenced by bluff height, the erosion rate, and bluff composition.[672] Kitsap County's bluff characteristics are naturally variable, though many mapped bluffs are low to medium height.[673] Although it is extremely difficult to measure bluff erosion rates and correlate those rates to climate change, major erosion episodes often occur during storm events or the coincidence of storm events and high tides.[674,675] In Port Gamble Bay, surface water erosion and subsurface sediment seepage has caused slope failures.[676]

Although past trends between bluff erosion rates and climate change are not clearly established, many of the physical factors affecting bluff erosion will likely be impacted by future climate change, with implications for habitat, sedimentation, and infrastructure. Increased winter rain precipitation, higher intensity winter storms, more heavy rainfall events, and sea level rise will very likely accelerate bluff erosion rates, though it is unclear the increase in the magnitude of erosion rates.[677,678,679] Furthermore, future bluff erosion increases and associated risks will vary based on bluff geology and location.[680] One study from San Juan County found that coastal bluffs could recede 75 to 100 feet by the end of the century, doubling current recession rates.[681] Another study in Clallam County projected that erosion rates could increase up to +4 inches per year by 2050.[682]

Increased bluff erosion has multiple implications for habitat, houses, infrastructure, and long-term climate resilience. Future increases of bluff erosion may transport additional sediment to bluff-fed beaches, potentially mitigating sea level rise impacts, although there is still uncertainty about long-term impacts of bluff erosion as a means to mitigate sea level rise as the sediment may be transported off-shore.[683,684] Furthermore, many residences and infrastructure along bluffs face long-term risk from bluff erosion, although they will likely remain safe in the short term.[685,686,687] Potential long-term impacts from bluff erosion include property or residence abandonment, engineered mitigation strategies, managed retreat, and rerouting of roads and transportation routes.[688]