

Applied Sea Level Rise Science for Road Realignment and Design in San Juan County; Putting Science into Action

Oct. 2017

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Coastal Geologic Services, Inc.

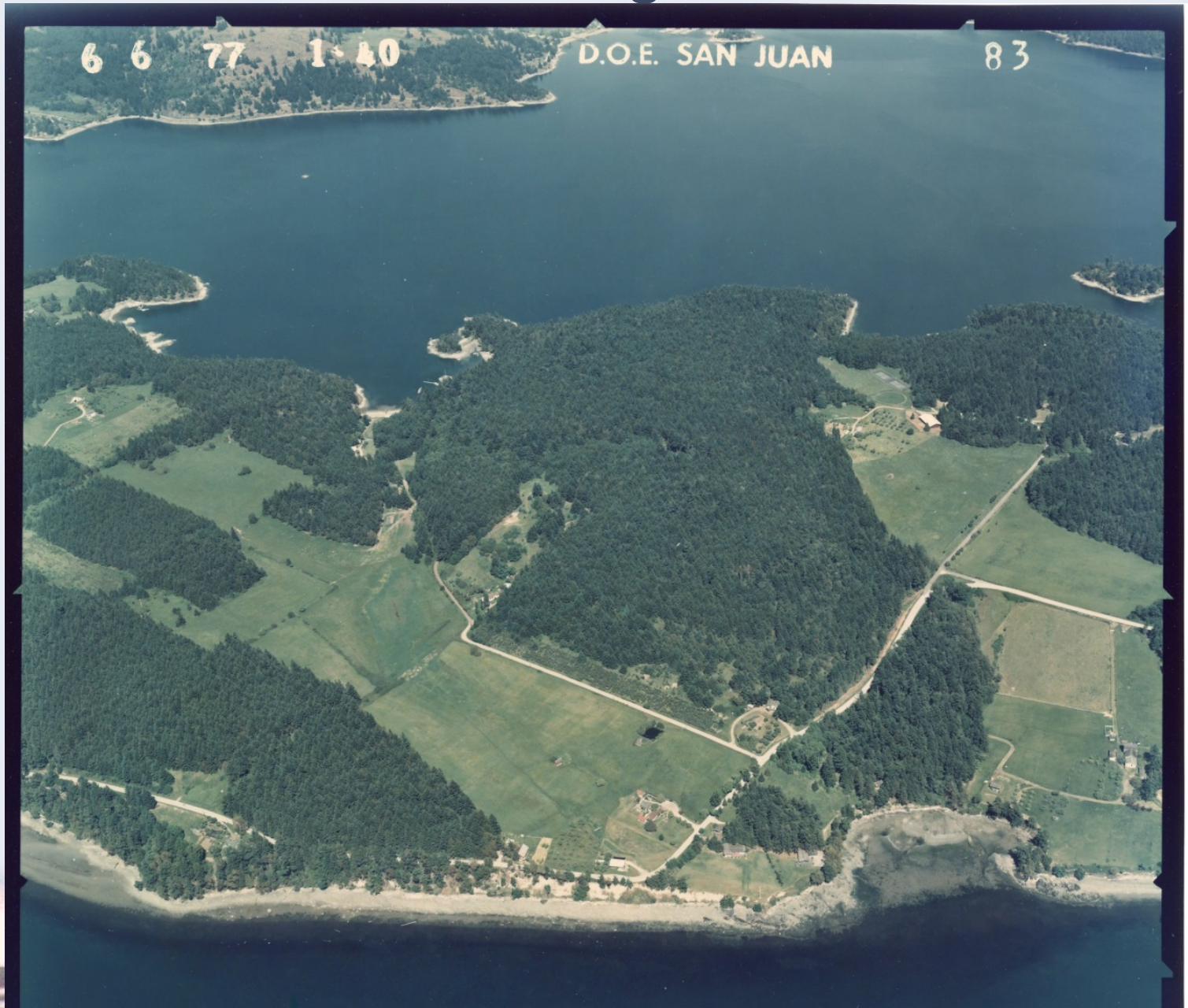
Bellingham, WA

www.coastalgeo.com



Realignment Studies – Past

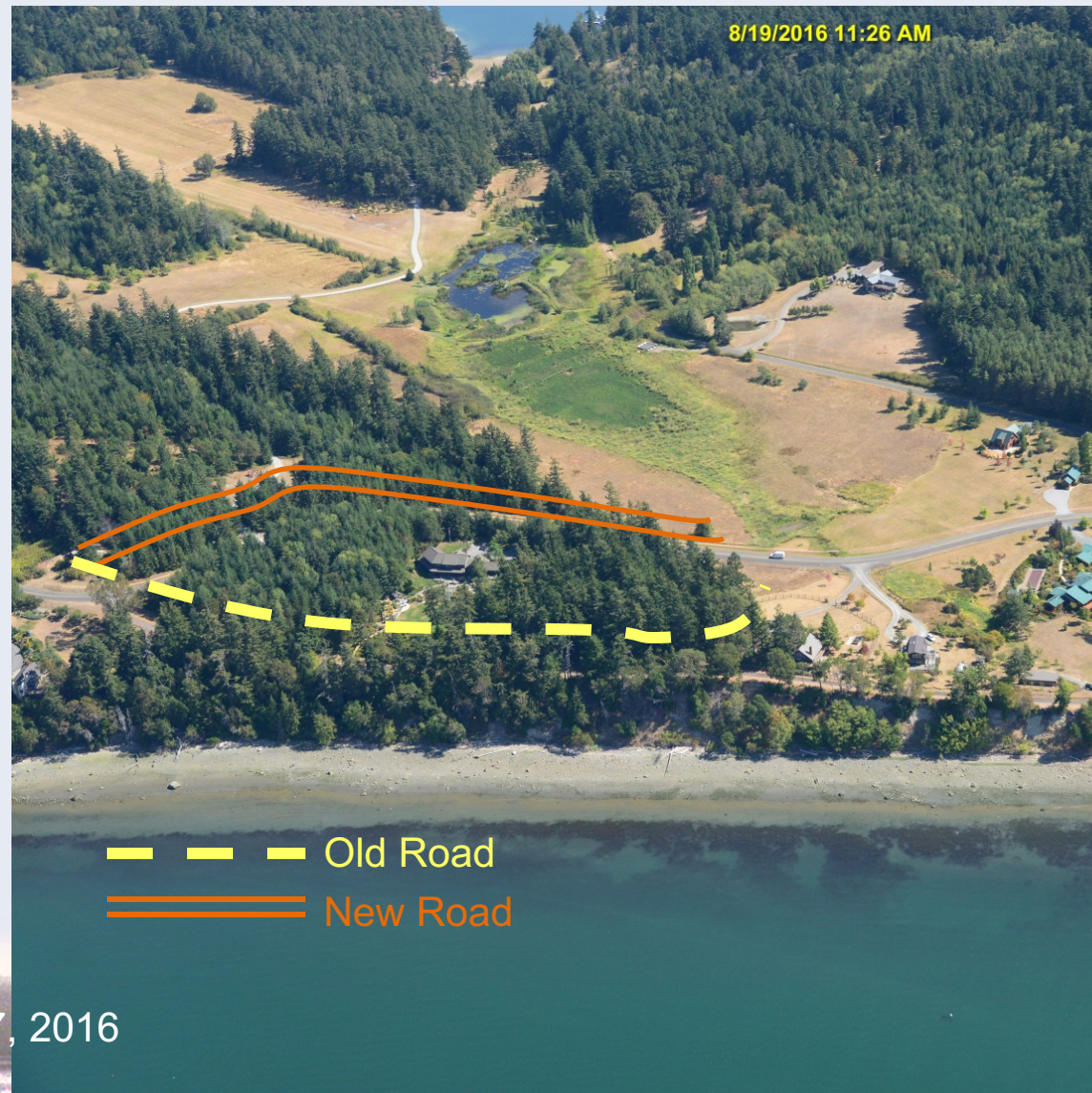
Orcas Island –
Deer Harbor Road
Realigned



WA DOE Coastal
Zone Atlas -1977

Realignment Studies – Past

Orcas Island –
Deer Harbor Road



WA DOE Coastal Zone Atlas -1977, 2016

Sea Level Rise Vulnerability Assessment of San Juan County

By Coastal Geologic Services Inc, 2013 – 2015

For Friends of the San Juans

Making Informed Decisions

**Shoreform
Response**

Different shoreforms will respond differently

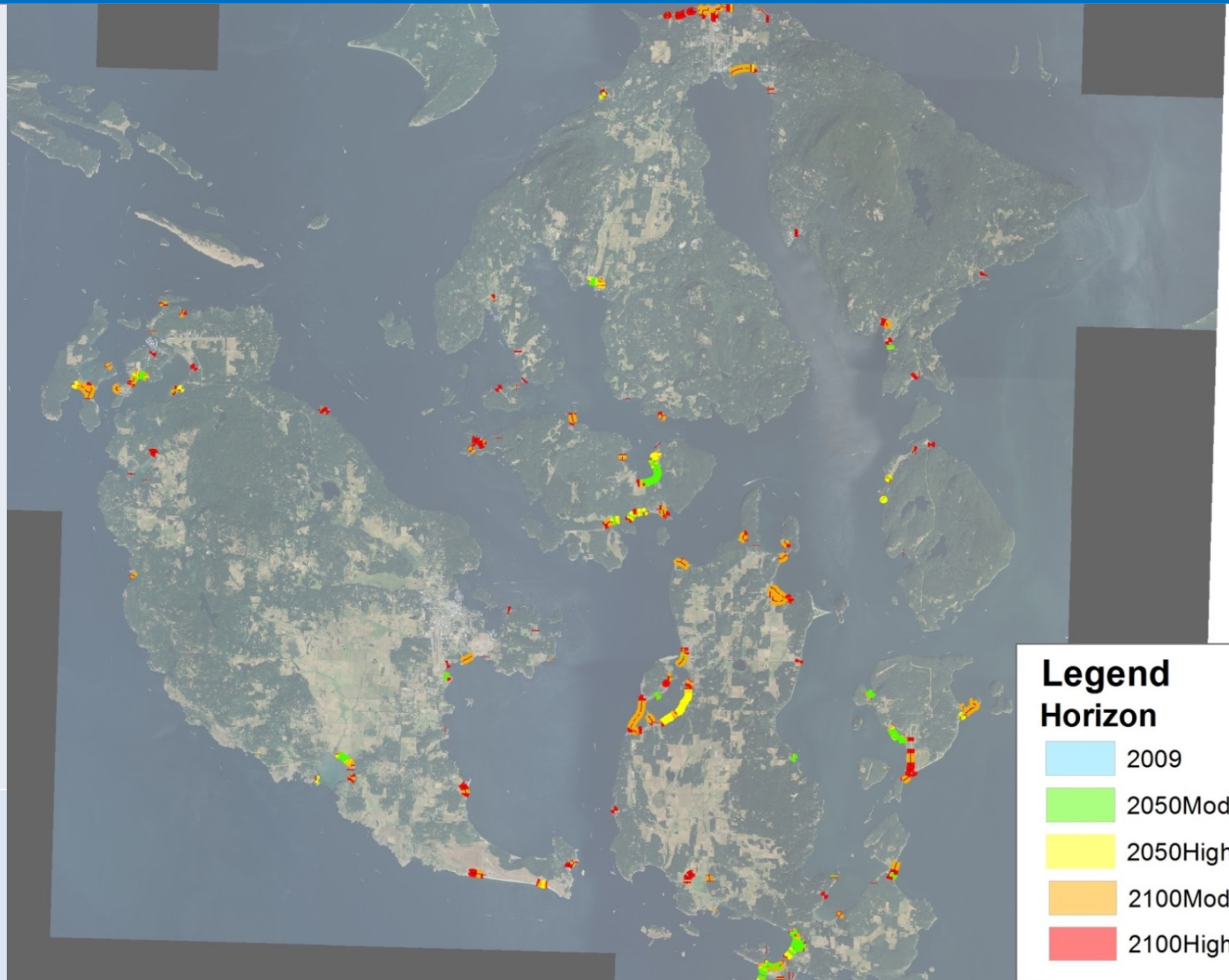
**San Juan County
Vulnerability
Assessment**

What type of hazards? (erosion or floods? both?)
When? 2050/2100?

**Appropriate
Adaptation
Approaches**

What are long-term vs short term solutions?
Costs?

Sea Level Rise Vulnerability Assessment of San Juan County

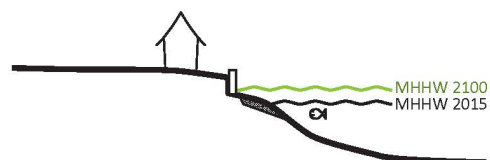
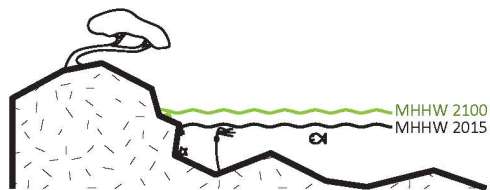
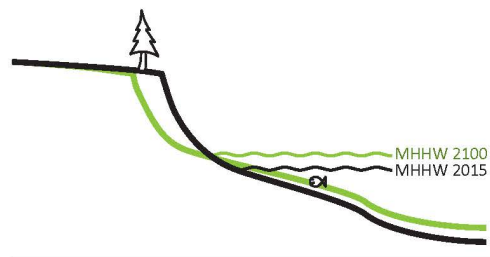


Sea Level Rise Vulnerability Assessment of San Juan County

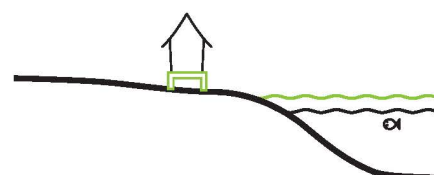
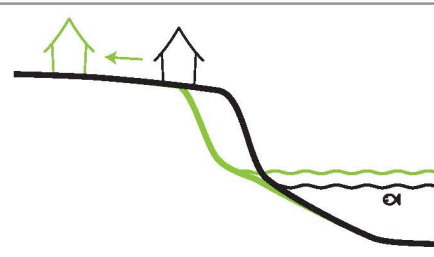
By CGS, 2013 – 2015, For Friends of the San Juans

Geomorphic Response & Adaptation Approaches

Geomorphic Responses



Adaptation Approaches

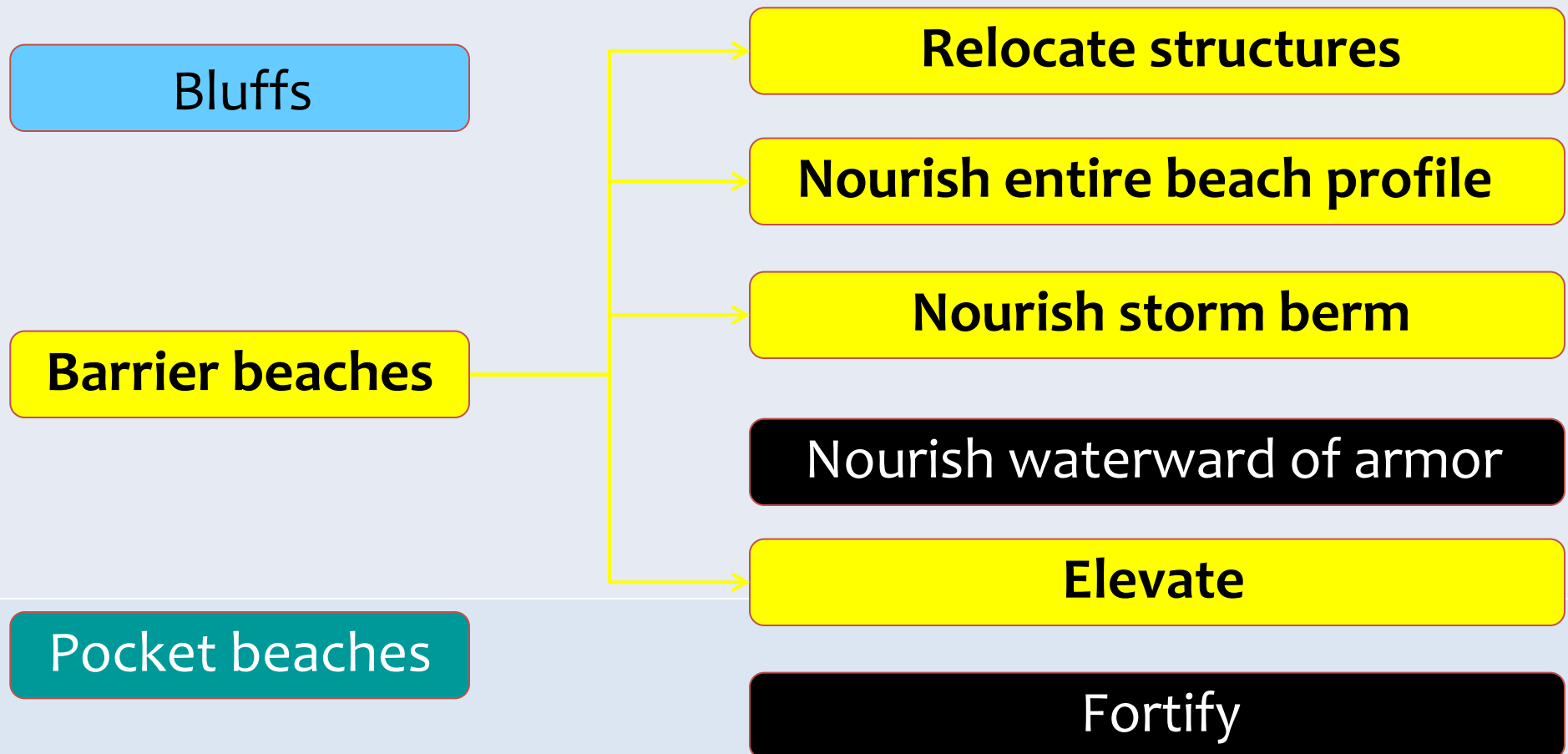


Sea Level Rise Vulnerability Assessment of San Juan County

By Coastal Geologic Services Inc, 2013 – 2015

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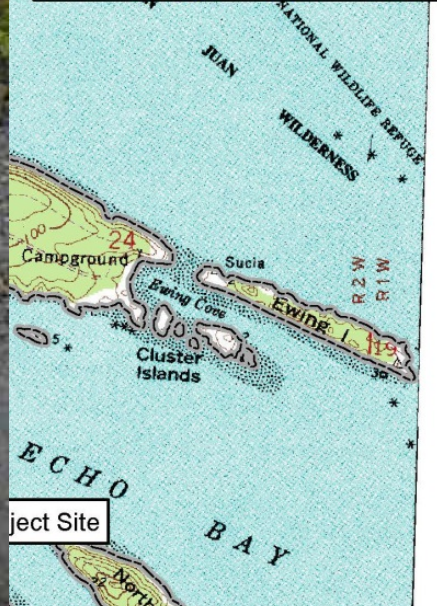
Appropriate Adaptation Approaches



The most appropriate approach depends on site-specific conditions

Sucia Island-Road on Barrier Beach

Realignment Studies – Present



Client/ Funding:



NW Climate Cor



Road Realignment and Design



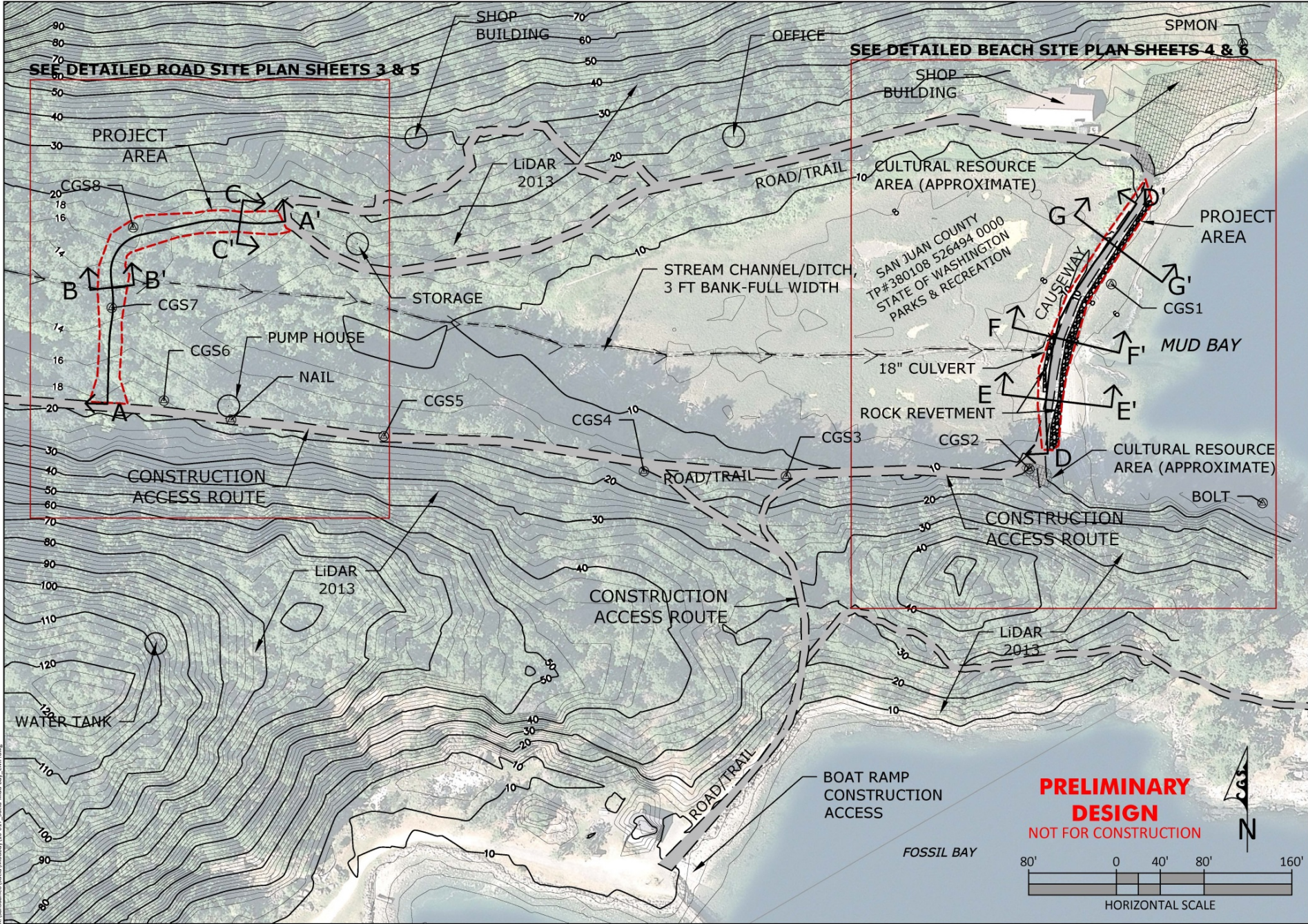
Sucia Island-Road on Barrier Beach

Realignment Studies – Present



Sucia Island-Road on Barrier Beach

Realignment Studies – Present



SEE DETAILED ROAD SITE PLAN SHEETS 3 & 5

SEE DETAILED BEACH SITE PLAN SHEETS 4 & 6

CGS
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REVISIONS	

SUCIA ISLAND - MUD BAY RESTORATION
 EXISTING CONDITIONS
 SITE PLAN
 FRIENDS OF THE SAN JUAN

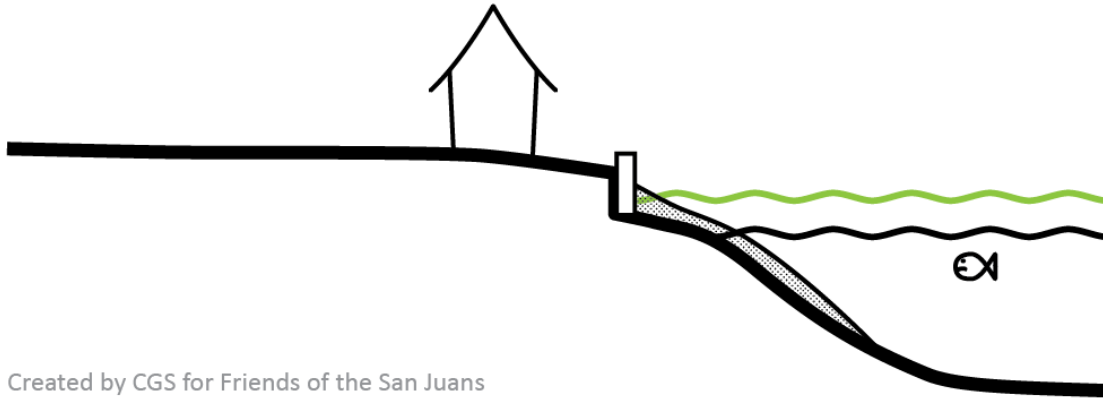
DRAFT

PRELIMINARY DESIGN
 NOT FOR CONSTRUCTION

MILLW= 0.00 FT
 MINW= 8.65 FT
 SCALE: AS SHOWN
 DATE: 5/18/2017
 SHEET: 2
 OF: 7



Appropriate Adaptation Approaches – Nourish Waterward of Armor



- Effective only in short-term



Enhancement Studies

Shaw Island - Smuggler's Cove Road
Pre-project, Sep. 2011



Client/ Funding:



Shaw Island - Smuggler's Cove Road
Construction, Sept. 2011



Enhancement Studies

Shaw Island - Smuggler's Cove Road
Post-project, Sep. 2011



Enhancement Studies

Shaw Island - Smuggler's Cove Road
Post-project, Oct. 2017



Shaw Island – Blind Bay Pre-project, Oct. 2014



Client/ Funding:





Shaw Island – Neck Point Rd.
Pre-project, Oct. 2017

Adaptation Design - Starting



Realignment Studies – Future

Orcas Island – Crescent Beach Road



WA DOE - 2002

NW Climate Conference, 2017



SLR Science for Road Realignment and Design

Realignment Study – Mackaye Harbor Rd.

Mackaye Harbor Road Relocation Feasibility Study Coastal Analysis Report – Final

Prepared for: Skillings Connolly Inc.
Prepared by: Coastal Geologic Services Inc.
March 24, 2017

Main cover photo from WA Dept of Ecology, 2006
Insets from Coastal Geologic Services, 2016



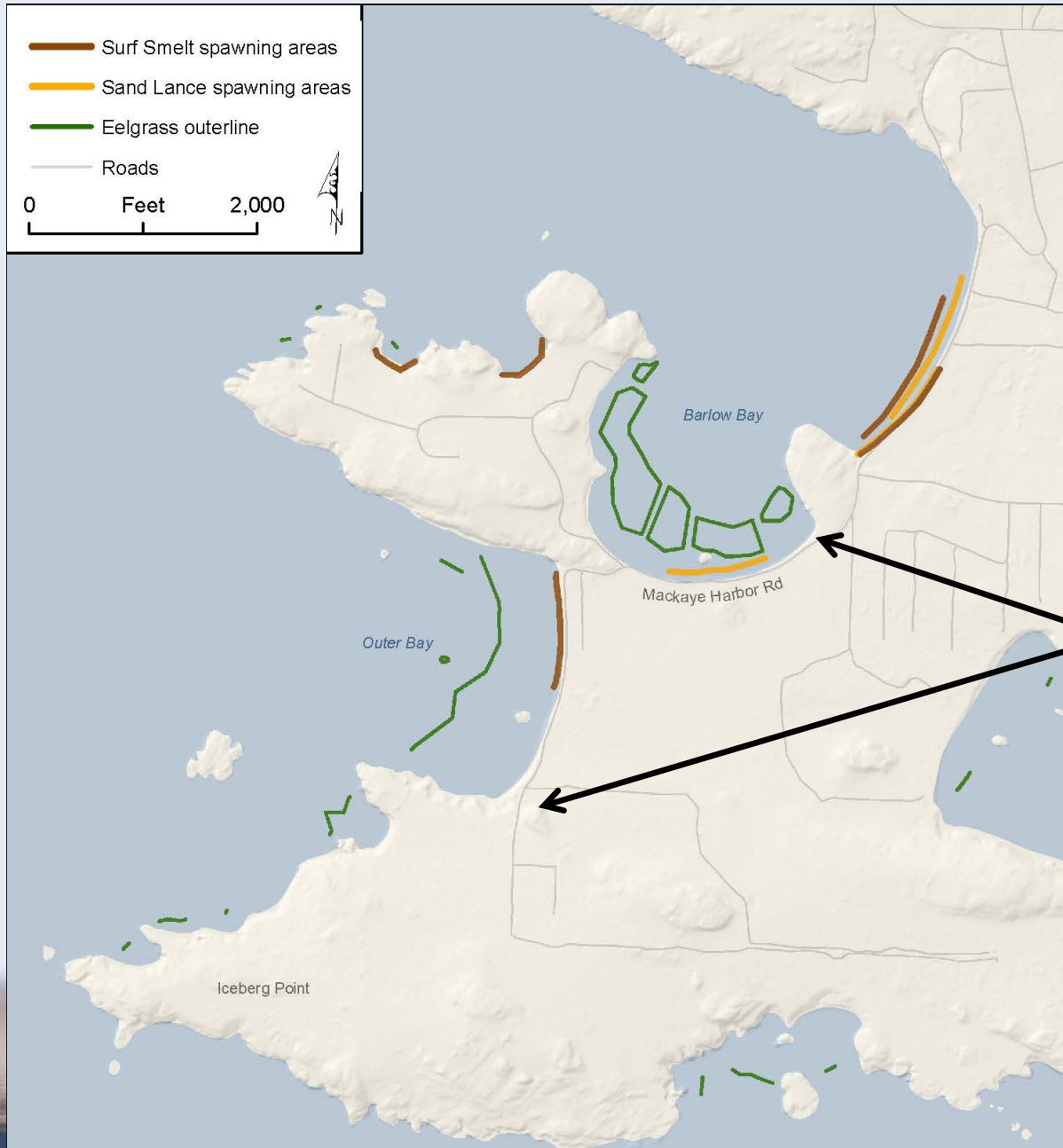
Client/ Funding:



With:



Realignment Study – Mackaye Harbor Rd.



South Lopez Island

Habitats;
Mackaye Harbor Rd study area

Realignment Study – Mackaye Harbor Rd.

2006



2016, at West facing shore



Realignment Study – Mackaye Harbor Rd.

High water, Jan. 10, 2017,
North facing shore



Realignment Study – Mackaye Harbor Rd.



Beach Erosion Rates Realignment Study – Mackaye Harbor Rd.



Figure 10. A comparison of drift log lines in Outer Bay from 1932–2016.

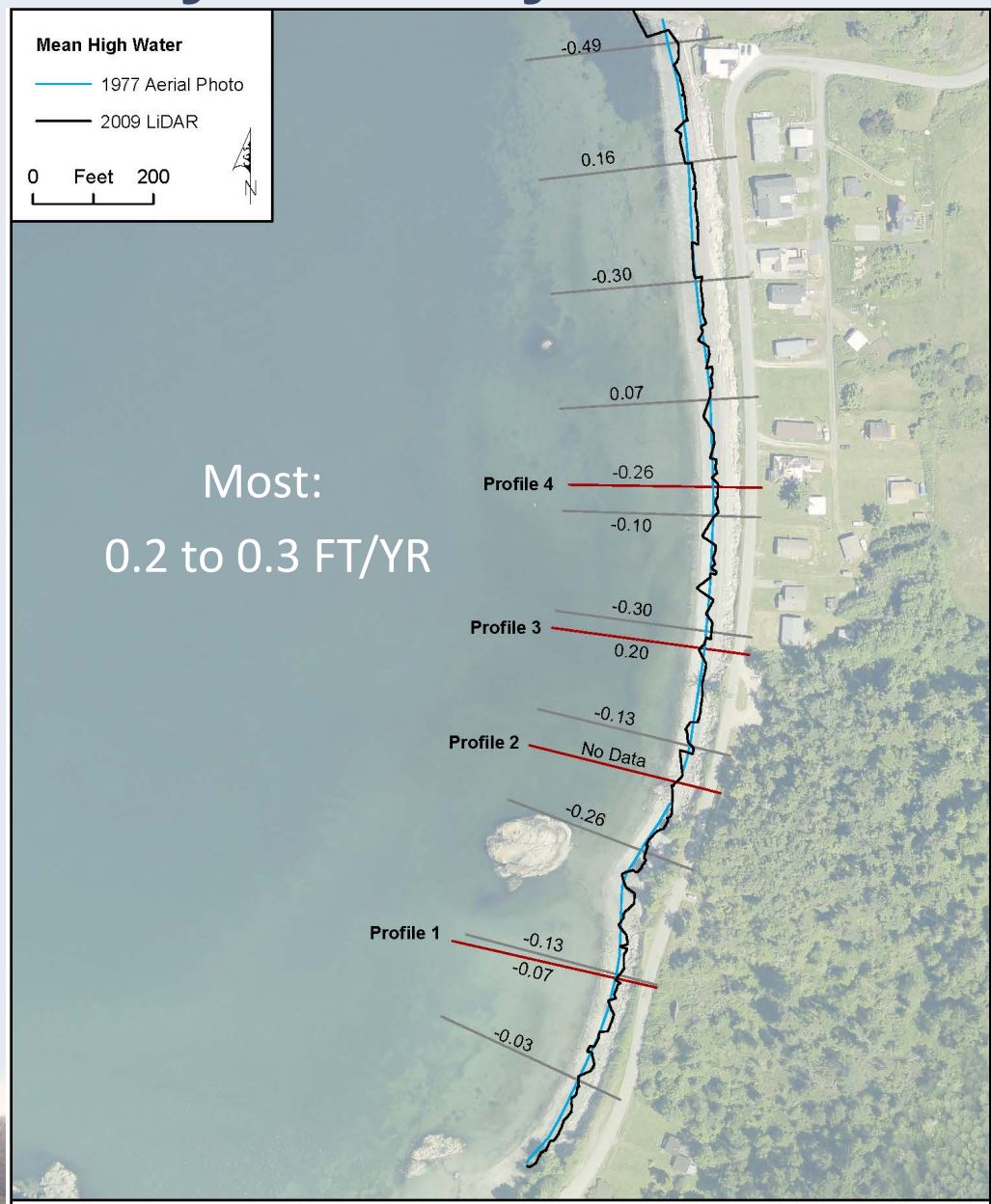


Figure 6. Mean High Water (MHW) lines from 1977–2009 in Outer Bay. Erosion rates are in FT/YR and are displayed along DSAS transects (grey) and field transects (red).
Mackaye Harbor Road Relocation Feasibility Study



Max recession: 15.5 ft in 32 years, 0.49 ft/yr

Shoreline Proxy	Outer Bay ft/yr	Barlow Bay ft/yr
Vegetation line	-0.18	-0.06
Bluff crest	-0.09	n/a
Mean high water line	-0.13	-0.16

Figure 11. Bluff crest erosion along the southern stretch of Outer Bay beach from 1977–2016. Erosion rates are given in FT/YR.
Mackaye Harbor Road Relocation Feasibility Study



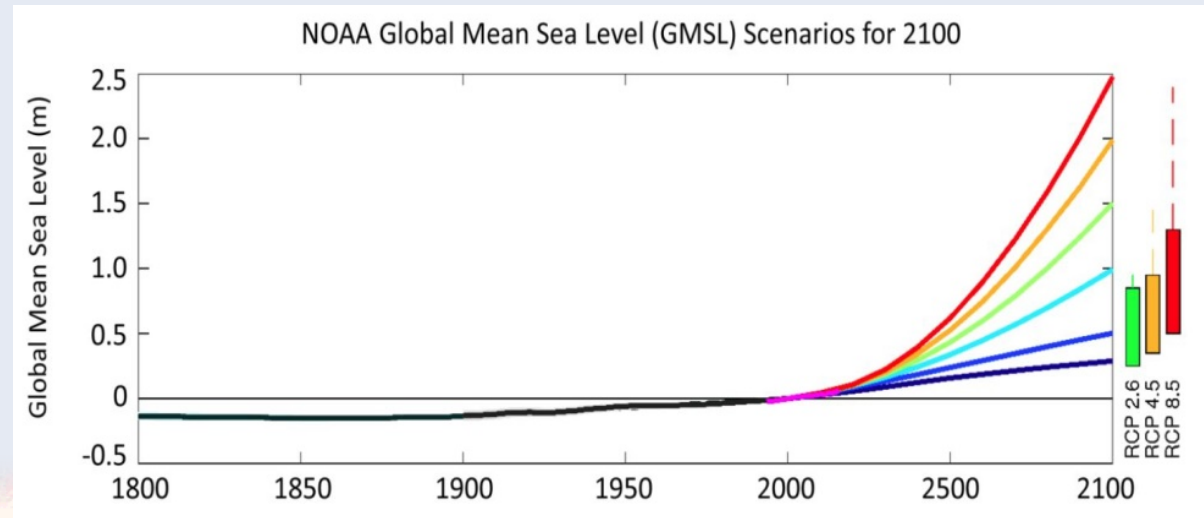
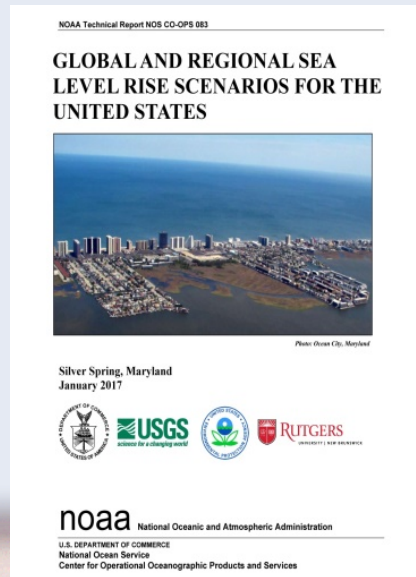
Realignment Study – Mackaye Harbor Rd.

Study used National Research Council (2012)

High Scenario SLR of
1.87 ft for year 2050
4.69 ft for year 2100

Local MHHW was 7.17 ft MLLW

Highest observed water level: 3.13 ft above MHHW
=10.3 ft MLLW



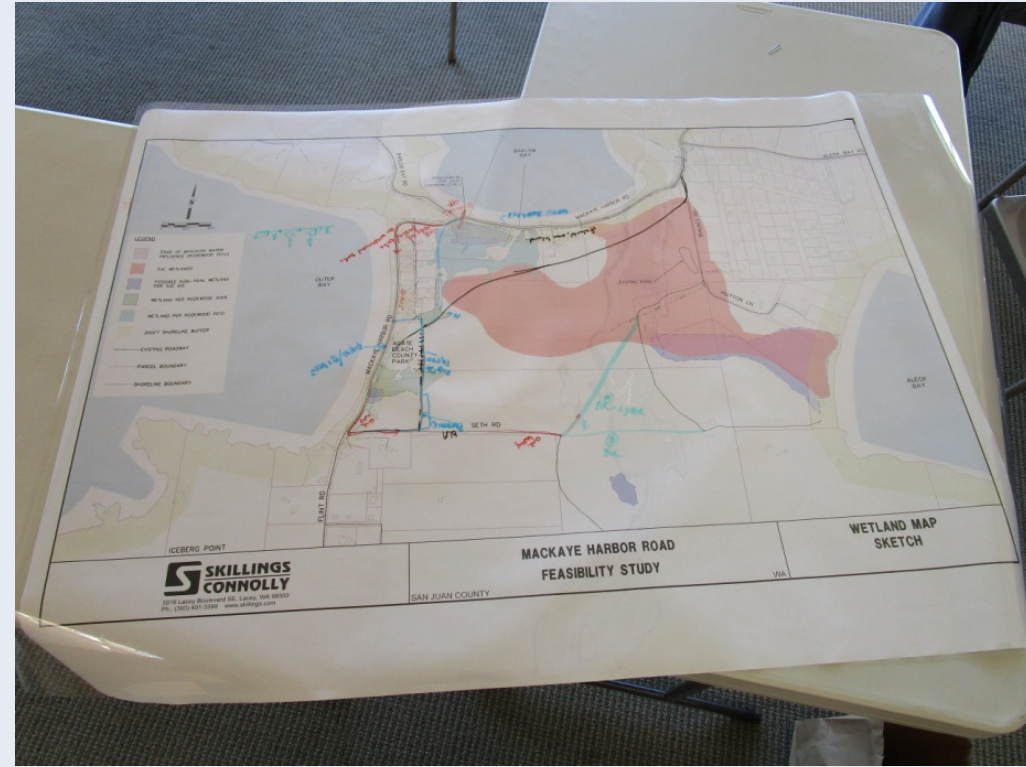
Feasibility Study Process

Representatives

- Public Works
- Planning
- Parks
- Natural Resources
- Coastal Engineers
- Transportation Engineers
- Biologists
- Archaeologist
- Geotechnical Engineers
- Community Representatives
- Local environmental groups
- Utility Commission



Stakeholders Group, Public Meeting, Brainstorming

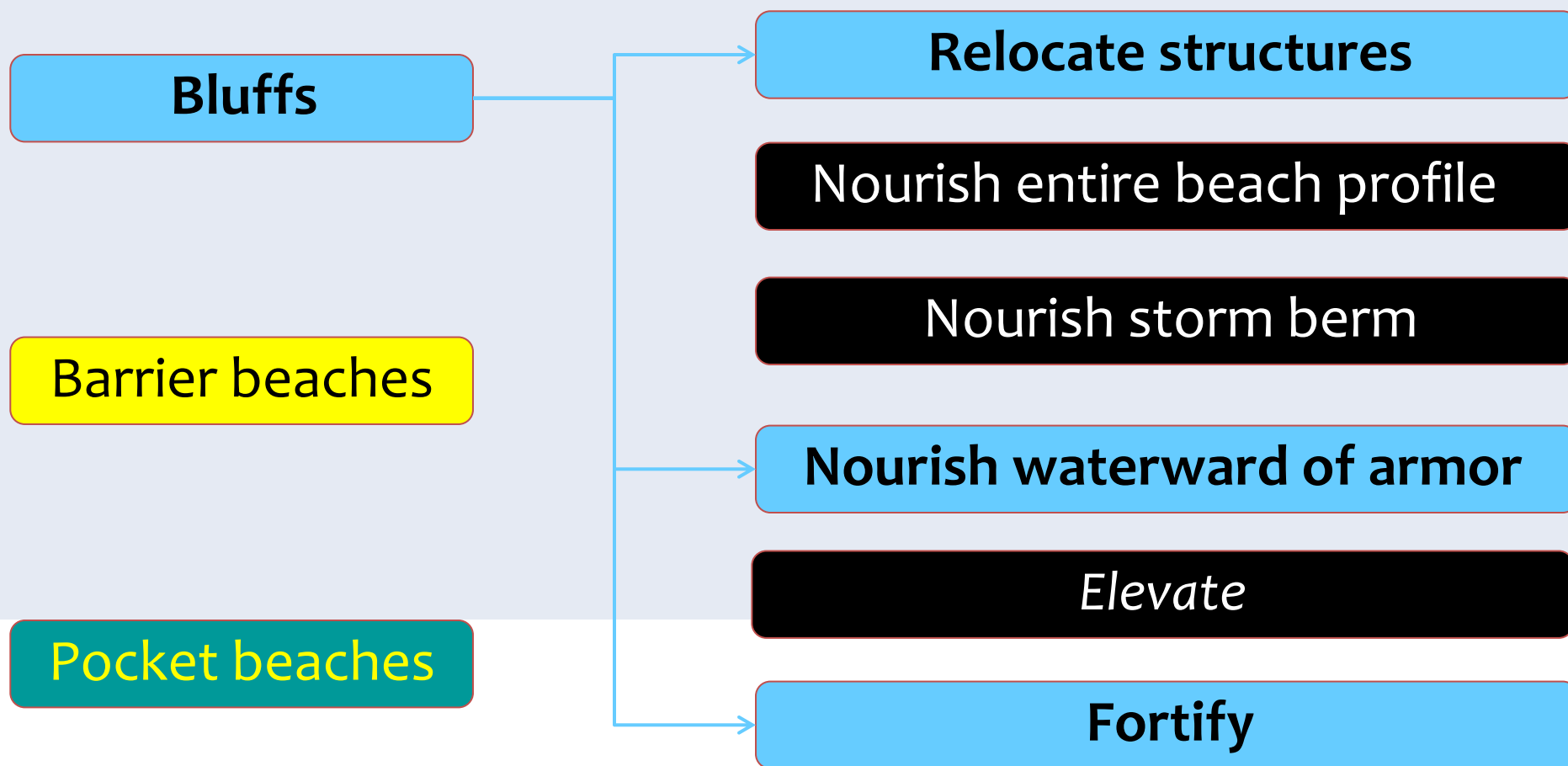


Sea Level Rise Vulnerability Assessment of San Juan County

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Appropriate Adaptation Approaches



The most appropriate approach depends on site-specific conditions

Realignment Study – Mackaye Harbor Rd.

Feasibility of alternatives – Quantitative & qualitative analysis

Inputs:

Current topography

Historical erosion rate

Shore protection extents; conditions assessment

NRC High SLR for 2050, 2100

Road infrastructure planning for 75 years out (2100)

Accelerated future erosion rates

Site-specific options for soft and hard shore protection

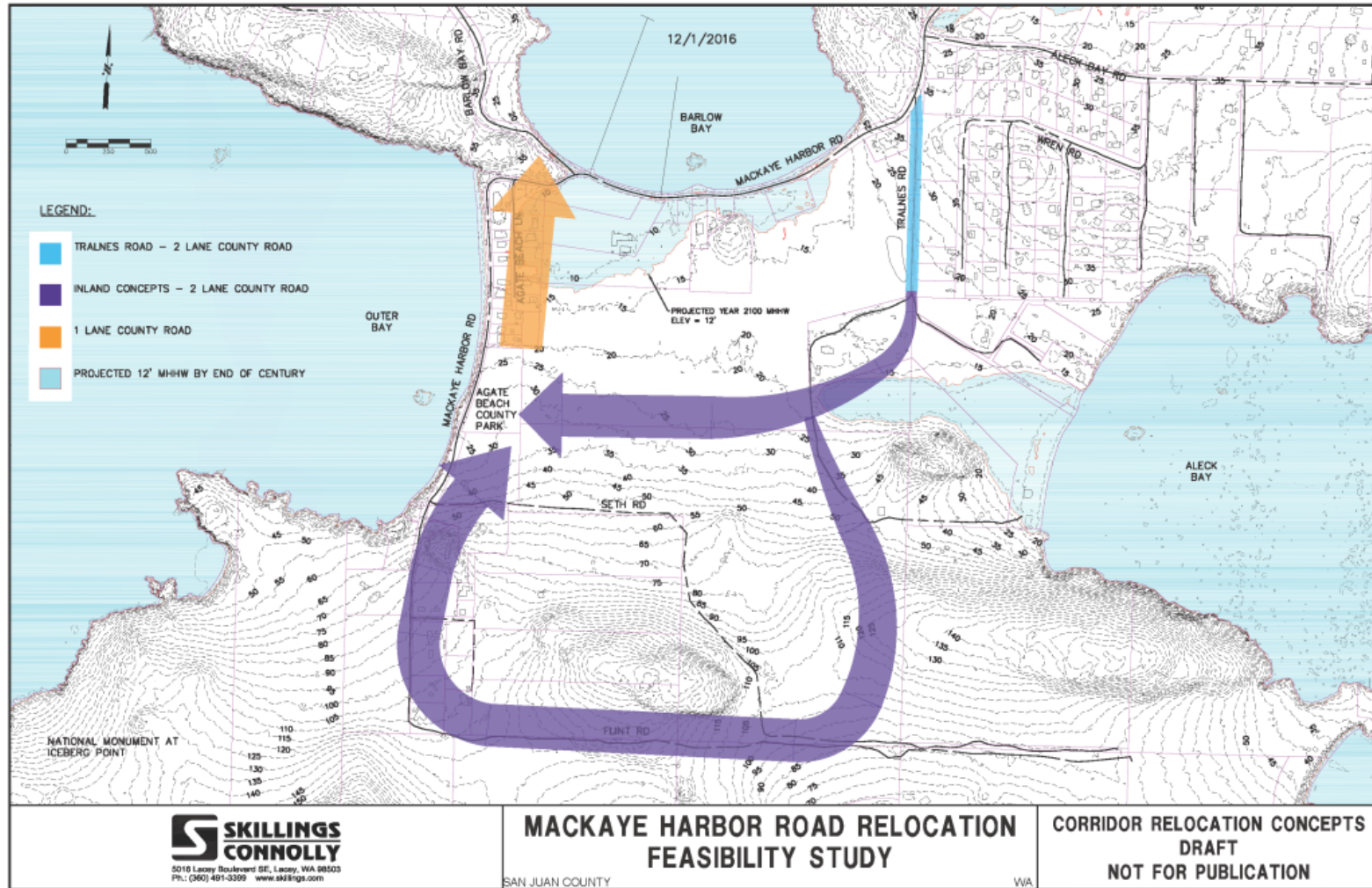
Regulatory constraints, including:

- Forage fish spawning
- Cultural resources
- Wetlands
- New shore armor restrictions

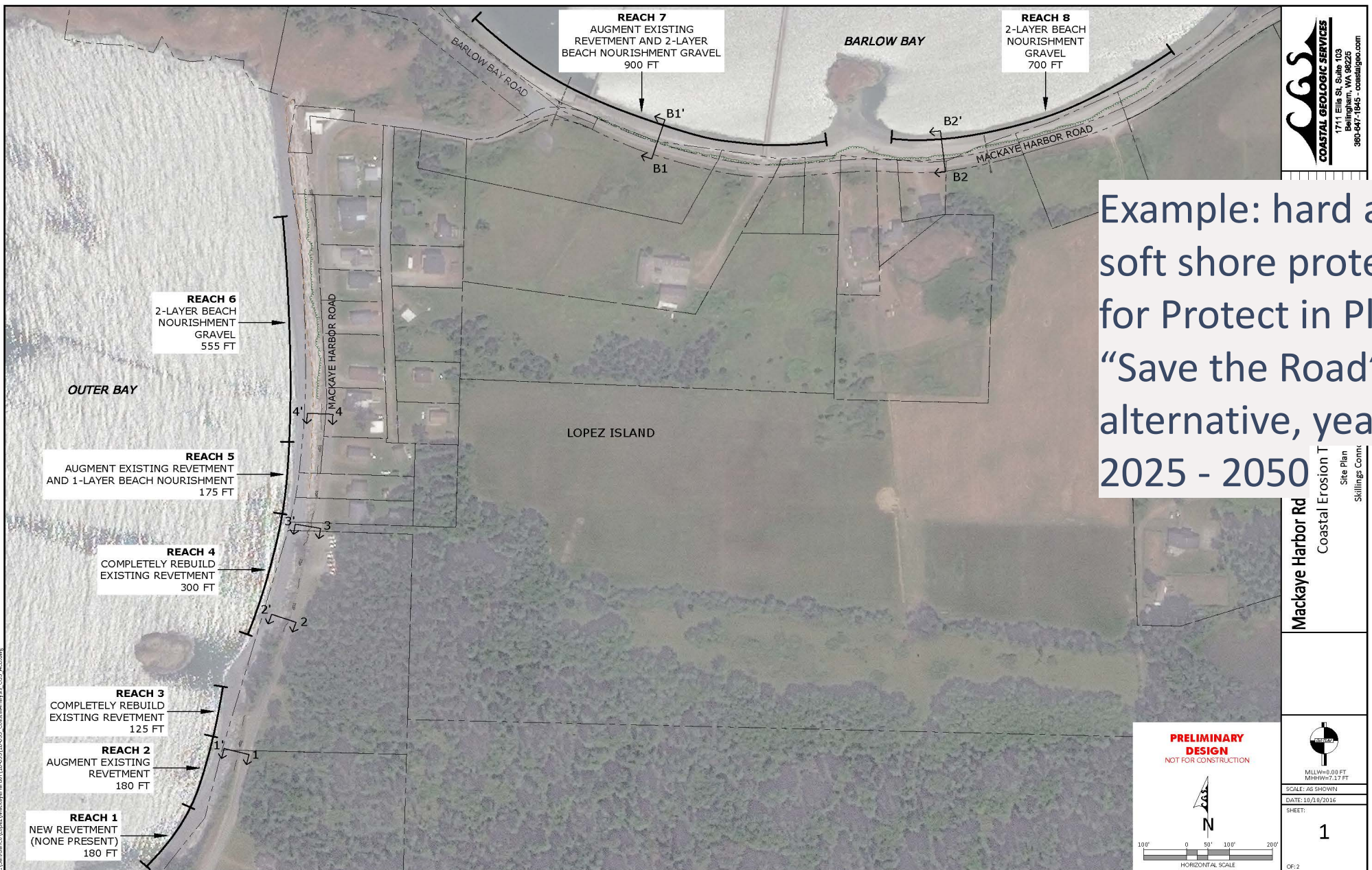
Cost estimates going forward , funding needs

Concepts

- AS-IS Maintenance
- Save the Road
- Inland Relocation
- Flint Road Relocation



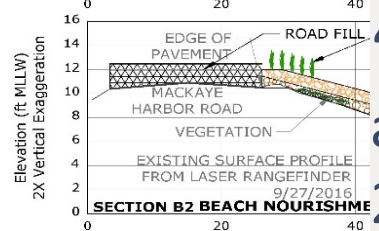
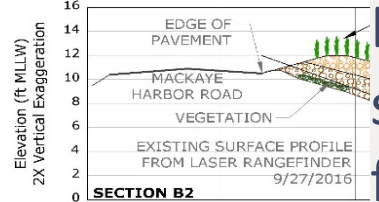
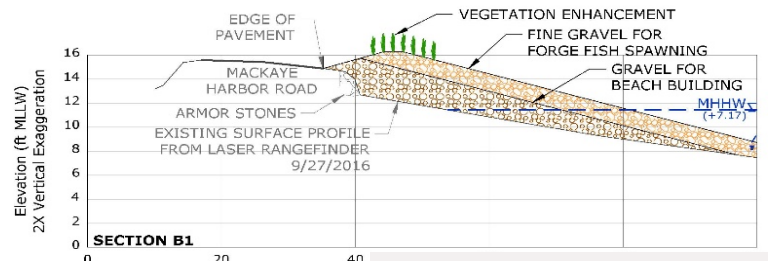
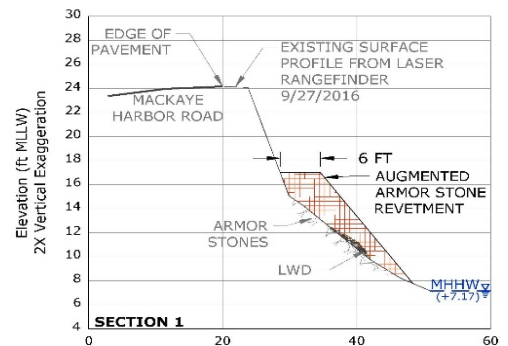
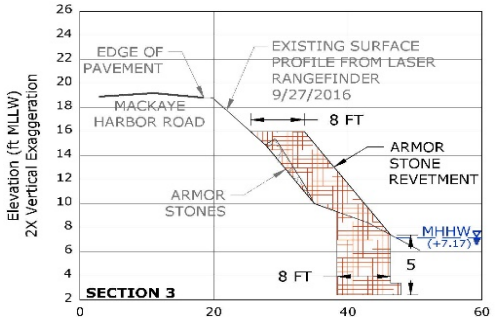
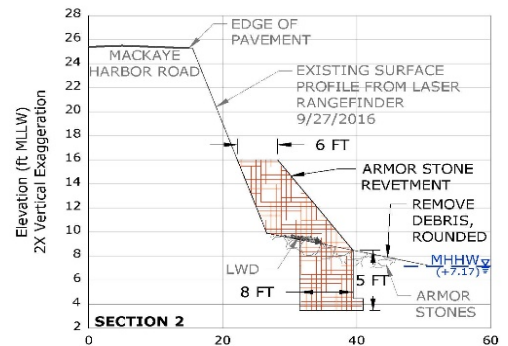
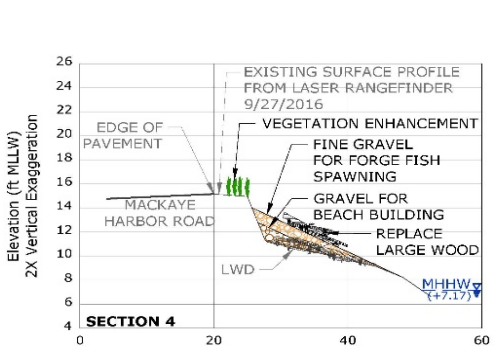
Realignment Study – Mackaye Harbor Rd.



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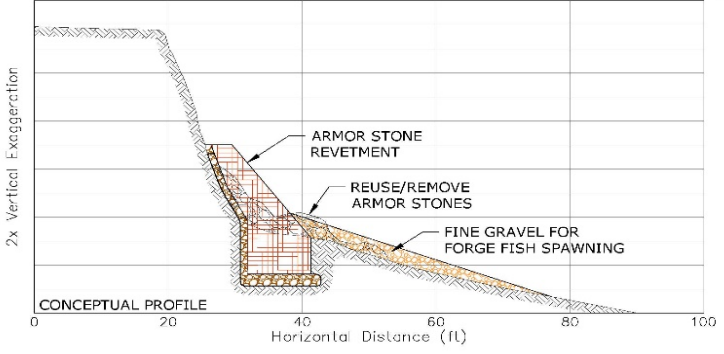
Example: hard and soft shore protection for Protect in Place/ "Save the Road" alternative, years 2025 - 2050

Realignment Study – Mackaye Harbor Rd.

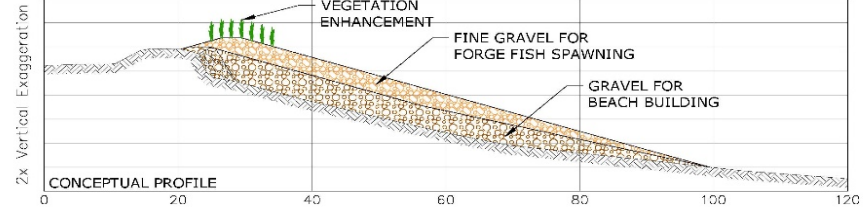


Example: hard and soft shore protection for Protect in Place/ "Save the Road" alternative, years 2025 - 2050

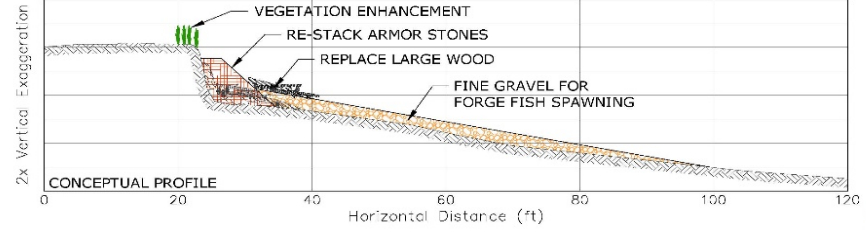
TYPICAL ARMOR STONE REVETMENT WITH MINOR BEACH NOURISHMENT



TYPICAL BEACH NOURISHMENT



TYPICAL ROCK RE-STACK WITH MINOR BEACH NOURISHMENT



Mackaye Harbor Rd. Relocation
Coastal Erosion Techniques
Cross Sections and Technique Typicals
Skills: Connolly

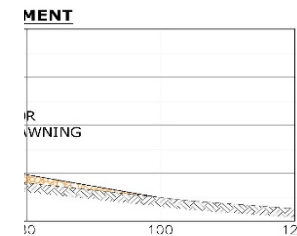
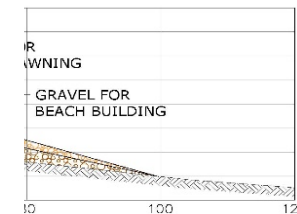
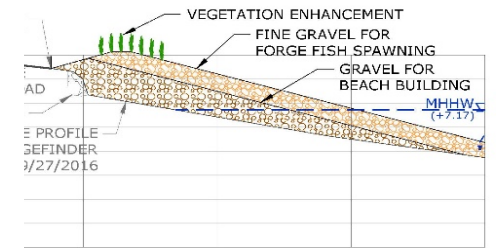
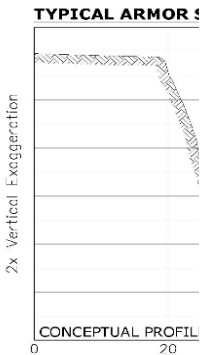
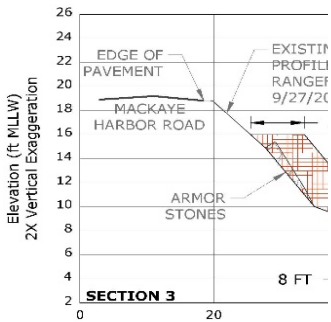
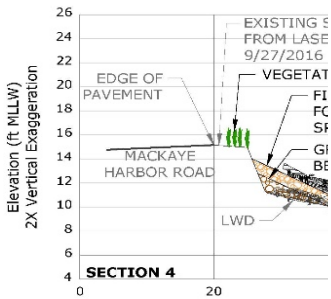
MLLW = 0.00 FT
MHHW = 7.17 FT
SCALE: AS SHOWN
DATE: 10/18/2016
SHEET: **2**
OF: 2

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

Cost Estimates

Table 5. Estimated construction cost for **Outer Bay 2050** within the project area assuming no mitigation costs for eelgrass impact. Approximately 20% of imported beach nourishment material needed during maintenance cycle. Inflation assumed at 2.5% for maintenance.

Reach	Quantity	Unit & Description	Unit Cost	Cost	Reach Total	Price per foot
Reach 1	180	LF; Labor (New)	\$250	\$45,000	\$105,000	\$583
	1200	Tons (Rock)	\$50	\$60,000		
Reach 2	180	LF; Labor (Augment)	\$175	\$31,500	\$50,250	\$279
	375	Tons (Rock)	\$50	\$18,750		
Reach 3	125	LF; Labor (Rebuild)	\$300	\$37,500	\$78,750	\$630
	825	Tons (Rock)	\$50	\$41,250		
Reach 4	300	LF; Labor (Rebuild)	\$300	\$90,000	\$187,500	\$625
	1950	Tons (Rock)	\$50	\$97,500		
Reach 5	175	LF; Labor (Rebuild)	\$175	\$30,625	\$64,675	\$370
	375	Tons (Rock)	\$50	\$18,750		
	255	Tons (BN)	\$60	\$15,300		
Reach 6	555	LF; Labor (BN only)	\$ -	\$ -	\$45,000	\$81
	750	Tons (BN)	\$60	\$45,000		
Total Reaches				\$531,175		
Rock removal	870	CY	\$25	\$21,750		
Mobilization		%	20	\$110,585		
Contingency		%	25	\$165,878		
Total Project Construction				\$829,388		
Maintenance - Approximately 20 year cycle						
	300	Tons (BN) inc. 2.5% inflation	100	\$30,000		
	150	LF (Rock Repair)	300	\$45,000		
Mobilization		%	20	\$15,000		
Contingency		%	25	\$22,500		
Total Maintenance				\$112,500		



Example: hard and soft shore protection for Protect in Place/ "Save the Road" alternative, years 2025 - 2050



Mackaye Harbor Rd. Relocation
 Coastal Erosion Techniques
 Cross Sections and Technique Typical
 Skills: Connolly

PRELIMINARY DESIGN
 NOT FOR CONSTRUCTION

SCALE: AS SHOWN
 DATE: 10/18/2016
 SHEET: 2
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Realignment Study – Mackaye Harbor Rd.

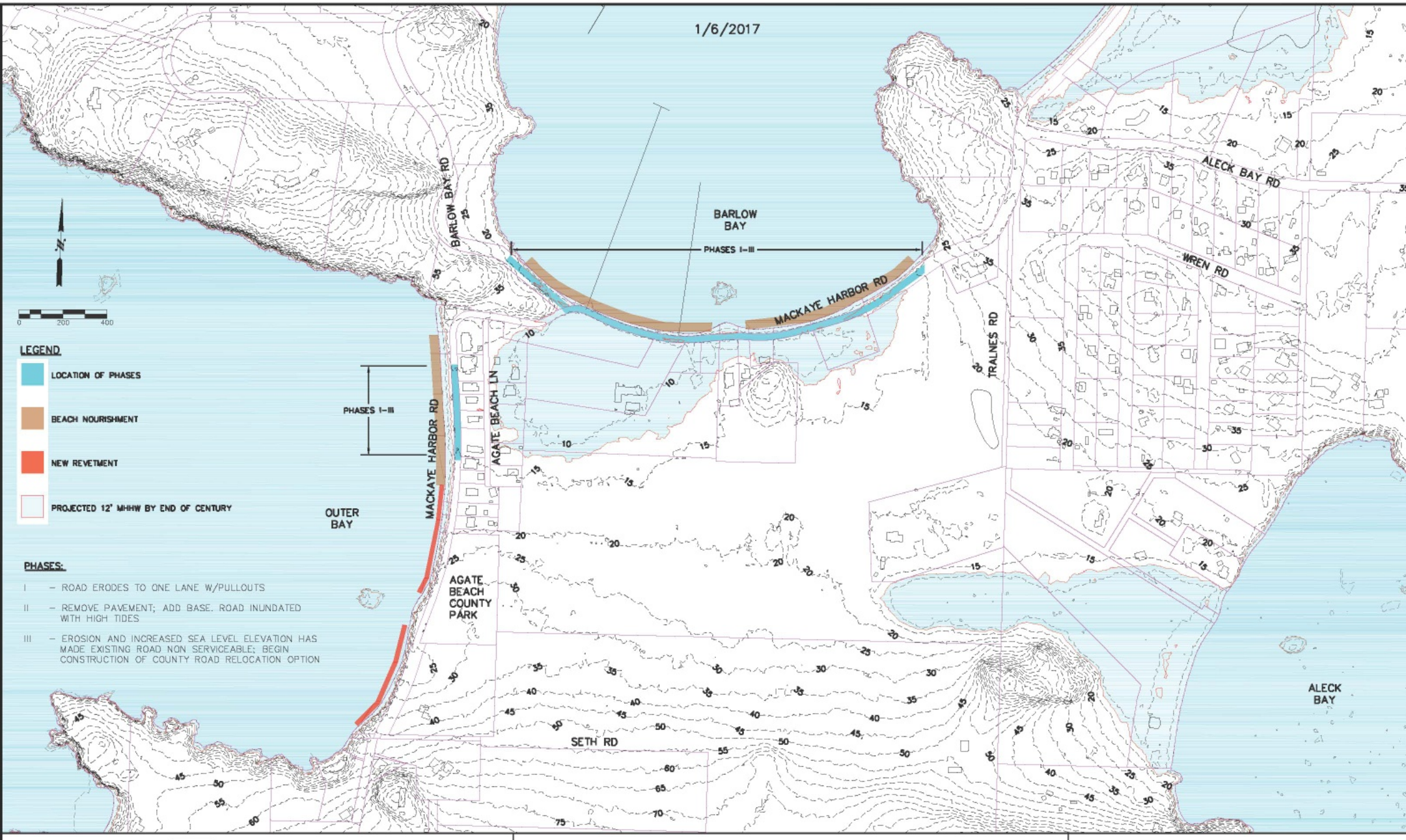


MacKaye Harbor Road Relocation Feasibility Study

CONCEPT	Advantage	Disadvantage	Notes
1: As-Is Maintenance/Inland Relocation	<p>INITIALLY: As-Is Maintenance</p> <ul style="list-style-type: none"> • Can be phased over time to react to erosion and sea level rise conditions • Minimal immediate impact to natural environment other than addition of beach nourishment and revetment 	<p>As-Is Maintenance</p> <ul style="list-style-type: none"> • May not be feasible beyond mid-century due to continual shoreline erosion and sea level rise • Coastal improvements \$2.6M plus \$0.8M every 20 years and permitting • High level of road repairs and maintenance until relocation (costs not estimated) • Does not mitigate for sea level rise • Limits access to Agate Beach, Iceberg Point, Flint Road, and Salmon Point eventually until Road Relocation • Relocation must start before road becomes one-lane 	
	<p>EVENTUALLY: Inland Relocation</p> <ul style="list-style-type: none"> • Permanent solution, relocation planning could start now • Low tree impact • Moderate wetland impact • Local access/non-motorized would continue on existing road until no longer feasible 	<p>Inland Relocation</p> <ul style="list-style-type: none"> • Eliminates access to properties at Barlow Bay unless accessed from south • Eliminates access to docks on Barlow Bay • Converts private roads to public roads • Some unsuitable soils for construction • With no beach nourishment or revetment added, coastline may erode and gradually approach 	

Concept 1. As-Is Maintenance

1/6/2017

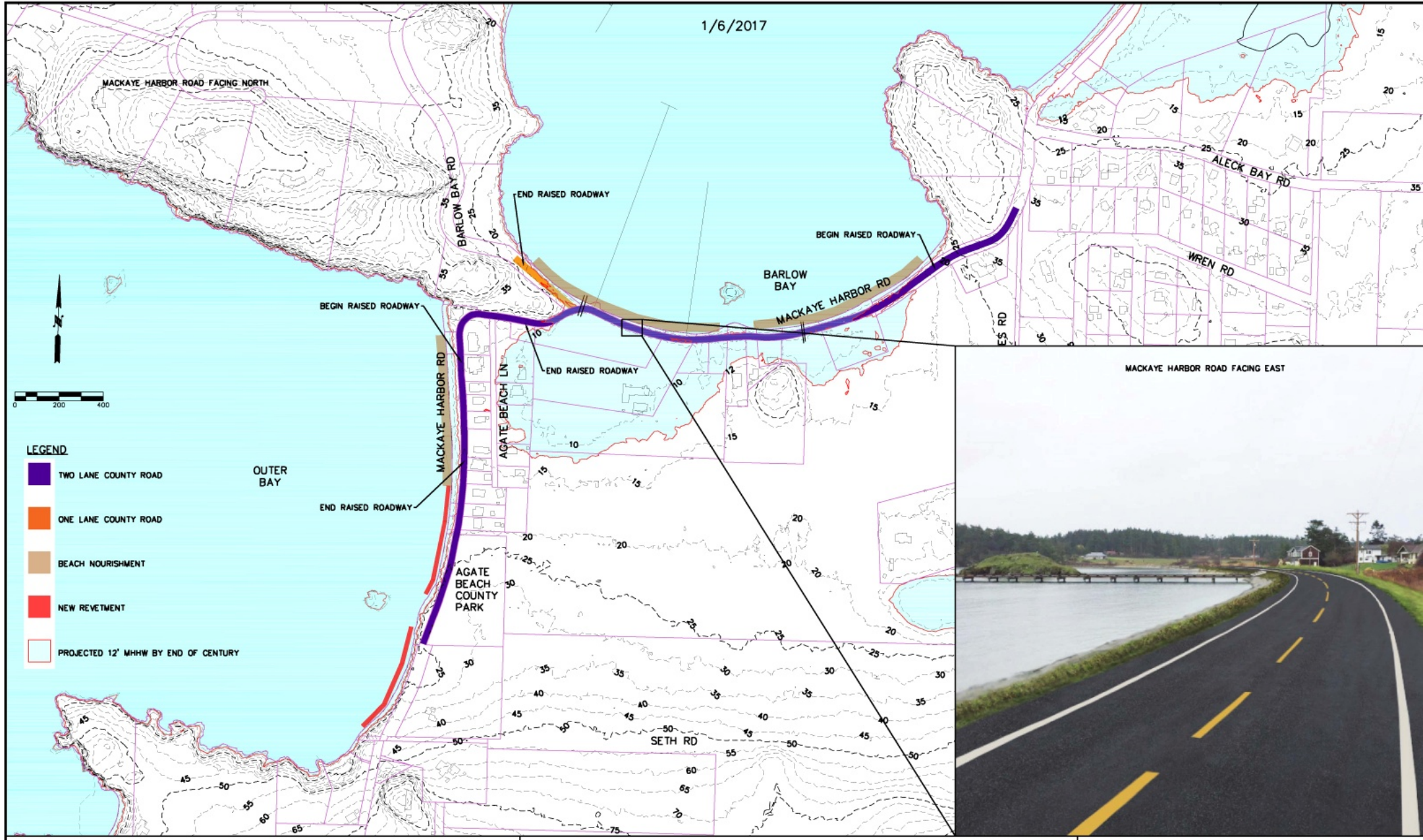


LEGEND

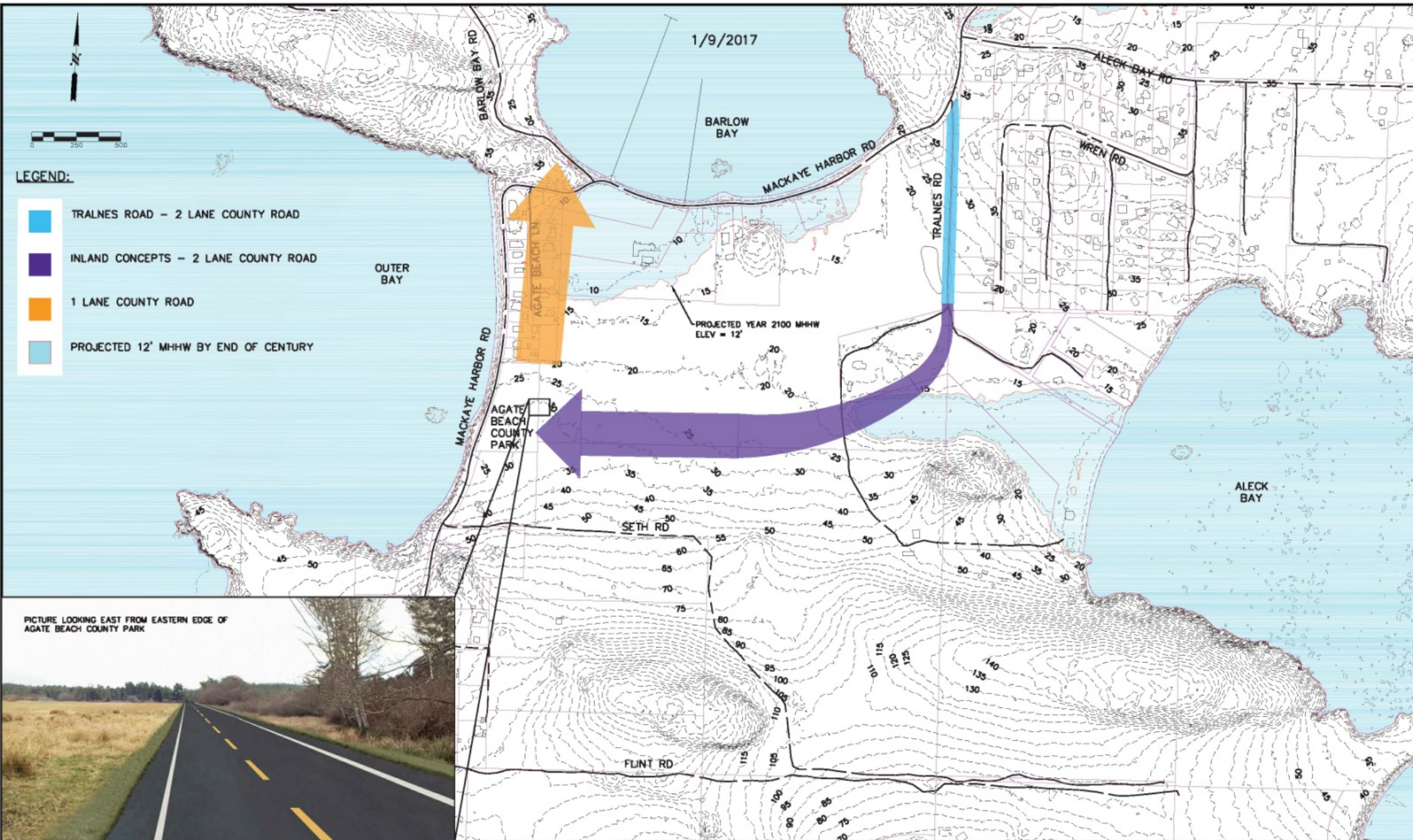
- LOCATION OF PHASES
- BEACH NOURISHMENT
- NEW REVETMENT
- PROJECTED 12' MHHW BY END OF CENTURY

- PHASES:**
- I - ROAD ERODES TO ONE LANE W/PULLOUTS
 - II - REMOVE PAVEMENT; ADD BASE. ROAD INUNDATED WITH HIGH TIDES
 - III - EROSION AND INCREASED SEA LEVEL ELEVATION HAS MADE EXISTING ROAD NON SERVICEABLE; BEGIN CONSTRUCTION OF COUNTY ROAD RELOCATION OPTION

Concept 2. Raise The Road



Concept 3. Inland Relocation



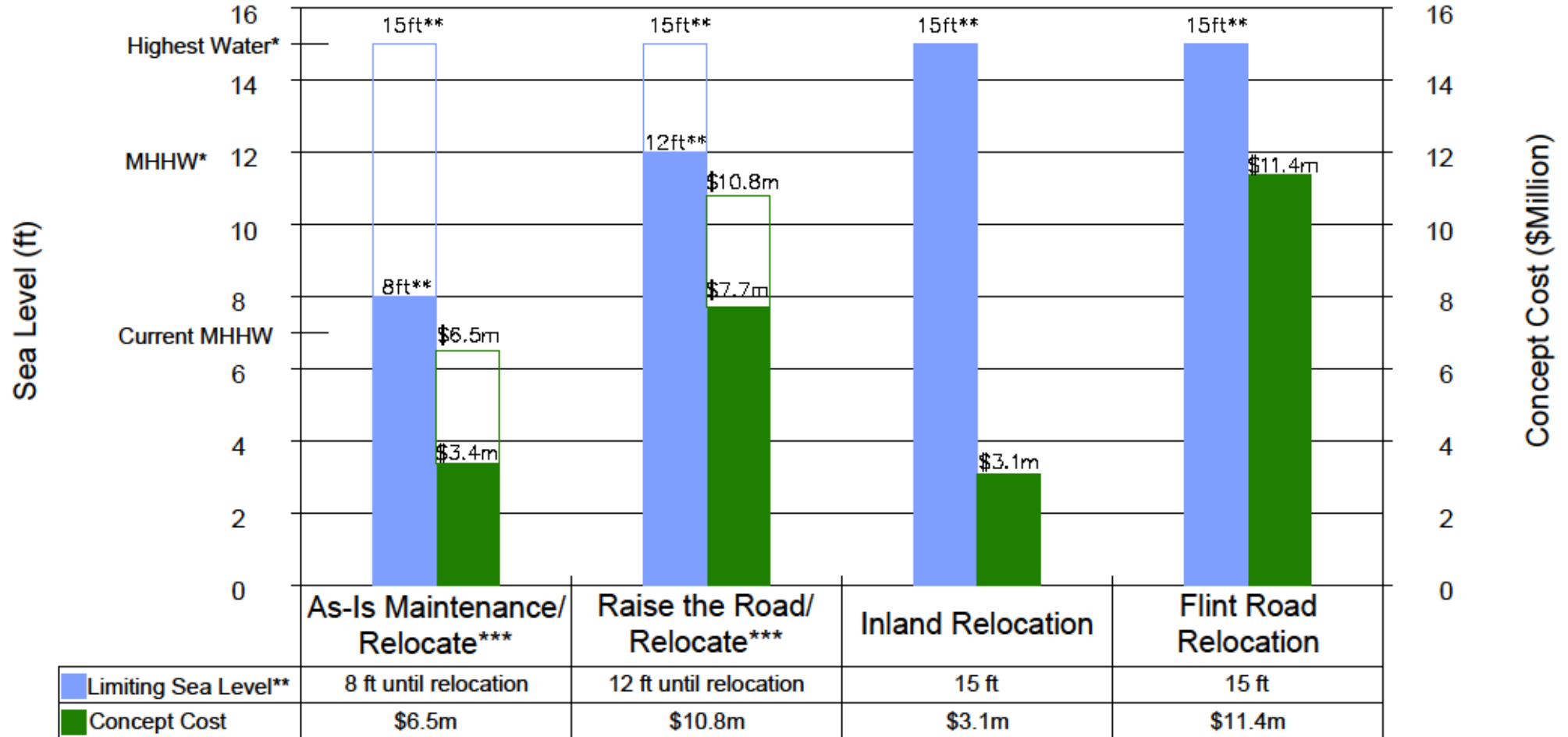
Concept 4. Flint Rd. Relocation



Mackaye Harbor Rd. – Relocation Study

Mackaye Harbor Road Feasibility Study

Concept vs Sea level and Cost



* Projected sea level at end of century

** Limiting Sea level corresponds to the MHHW elevation which necessitates additional action to combat sea level rise. At the limiting sea level, high tides and wave action will make driving through the project location unsafe.

*** The concept does not provide safe passage to Island features through year 2100. Relocation must happen for the concept to be viable through year 2100. Chart shows cost and limiting sea level for both initial phase and relocation phase

Sea Level Rise Vulnerability Assessment of San Juan County

