Integrating Nature-based Engineering Designs and Adaptive Management Strategies for a Resilient Coast in North Cove, WA

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INTRODUCTION

The community of North Cove, WA faced severe, chronic erosion for over a century, often losing tens of meters of upland per year during winter storms that routinely washed away infrastructure. Following small-scale experiments with placement of quarry spalls along erosion scarps from December 2016 to March 2018, a dynamic revetment spanning about two kilometers of coast was initially constructed in November 2018 along the base of the erosion scarp. The dynamic revetment maintenance was coupled with nature-driven adaptive engineering designs and management strategies that incorporate large wood, vegetation, and seaward rock berms.

DESIGN FEATURES

The **dynamic revetment** provides a shallower upper beach slope to dissipate wave energy and enhance sediment deposition. Poorly sorted **quarry spalls were used to mimic natural rock slide material**, and are an economical alternative to sourcing rounded cobble. Over time, the rock is becoming more rounded in the high-energy environment to simulate a backshore cobble berm on a natural composite beach.

Woody debris complements the function of the cobble by building a gentle slope and buffer against storm events. Wood was added above and below the revetment along with **naturally deposited woody debris**.

A **log groin** was constructed primarily to dissipate infragravity wave energy, but also helped **build a sand spit** by trapping sediment and woody debris that would otherwise be washed into a nearby drainage ditch.

Rock berms and rock mounds placed seaward of the revetment toe provide additional wave dissipation. The initial berms were placed along the summer wrack line to enhance the natural summer profile. Later, berms and mounds were added during the winter to stabilize erosion hotspots as they occurred.

Vegetation on the upper beach was introduced to facilitate sediment retention and **dune-building processes**.

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SITE MAP

This map shows approximate location and extents of the design features during fall of 2019, after the log groin and initial rock berms were constructed. Due to the dynamic nature of the shoreline and beach sand levels, the exposed revetment surface and rock berm configuration and extents vary seasonally and can change within one high-energy wave event. Adaptive management enables changes in the design as needed, including preventative maintenance and repair actions. After the spring of 2021, the rock berm linear extent had reduced from 2.06 kilometers to less than 300 meters due to sand accumulation over the top of the berms and rock dispersion and onshore transport to nourish the dynamic revetment.

RESULTS

Observations and photo monitoring results show an increase in both the seasonal and overall vegetation, and topographic surveys have shown a dynamically stable position of the revetment toe. The photo series below shows sand accumulation and vegetation establishment between 2018 and spring of 2021 on a selected monitoring profile (profile 227). In the winter photos, notice the burial of the rock berm after it was introduced in November 2019. In the summer photos, notice the change between predominantly seasonal vegetation in 2019 to well-established dune grass in 2021.

Profile 227, Winter

Profile 227, Summer

KEY CONSIDERATIONS

- These **nature-based designs** have successfully created a resilient and stable coastline.
- Strategies are based on **observations of natural processes** in the project area, for example, transport of sediment, cobble and wood, and corresponding patterns of material sorting, erosion and deposition.
- Structures are **designed to be dynamic** and follow or enhance the **natural contours** of resilient beach morphology.
- Structures are designed to **dissipate wave energy to enhance constructive forces** and **hinder destructive forces**.
- An **adaptive management** approach, including quick implementation of structural modifications and additions has been key to learning and project performance.
- **Small-scale complexity** to address local conditions and **incremental introduction of dissipative structures** to follow the natural response and evolution have proven successful management strategies.

MONITORING METHODS

The Washington State Department of Ecology Coastal Monitoring & Analysis Program (CMAP) has conducted quarterly monitoring of the project site since June 2018. **Monitoring methods include**:

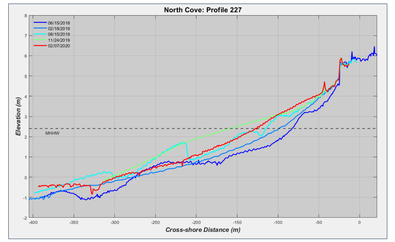
- Topographic surveys
- Revetment mapping
- Rock movement tracking
- Sediment grain size analysis
- Photo monitoring

In the photos above, a surveyor measures the beach elevation along a profile using a GPS backpack (left) and a surveyor measures the location of a tagged rock that was found (right).

Additional topographic surveys were performed during winter to determine response and **recovery from storm events**. The photo to the left shows a surveyor preparing to collect elevation data using a GPS mounted on an ATV.

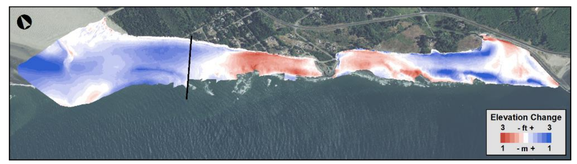
MONITORING RESULTS

The cross-shore profile plot to the right shows beach changes at **profile 227** based on topographic surveys. Between February 2019 (light blue) and 2021 (red), there has been a **net increase** in sediment volume by **122 m³/m**.



Results from storm monitoring, however, show a 97 **m³/m decrease** in sediment volume between November 2020 and February 2021.

The figure below shows annual elevation change between February 2019 and 2020 where blue is accretion and red is erosion. Profile 227 is shown in black.



Middle areas in red receive concentrated wave energy and are still susceptible to erosion. The drainage area to the right routinely fluctuates with little impact. Continued adaptive management will enhance resiliency, and monitoring and analysis will document how a once rapidly eroding shoreline has transitioned to a stable and accreting coast.

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