Process-Based Approach to Understanding and Mitigating Erosion at Ecola Creek Study Site

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Introduction

The north bank is disappearing, and previous fixes have not worked.

Ecola Creek's north bank has experienced episodic erosion averaging 3 to 4 ft per year, and past mitigation efforts have repeatedly failed because the underlying processes were never fully characterized. The north side of Ecola Creek in Cannon Beach, Oregon, is an erosion hot spot shaped by compound coastal forcing including seasonal river flows, king tides, and large offshore waves. Infragravity waves and wave reflection off a seawall located on the other side of the river further increase vulnerability at the site. This ongoing erosion puts nearby homes, infrastructure, and recreational beach access at risk. Numerous prior stabilization attempts at the site have failed. This study takes a different approach, building a process-based understanding of what is actually driving erosion before proposing any design solution.

Figure 1. *Project area (green oval) with key site features*

Study Objective

To design an effective solution, we first had to know what was causing the erosion.

Among waves, tides, and river flooding, which process is actually responsible, and by how much? The study objective was to characterize the relative contributions of waves, tides, and riverine flooding to ongoing bank erosion at the site, and to use that process-based understanding to develop mitigation alternatives that are effective, permittable under Oregon coastal regulations, and protective of the site's recreational and habitat values.

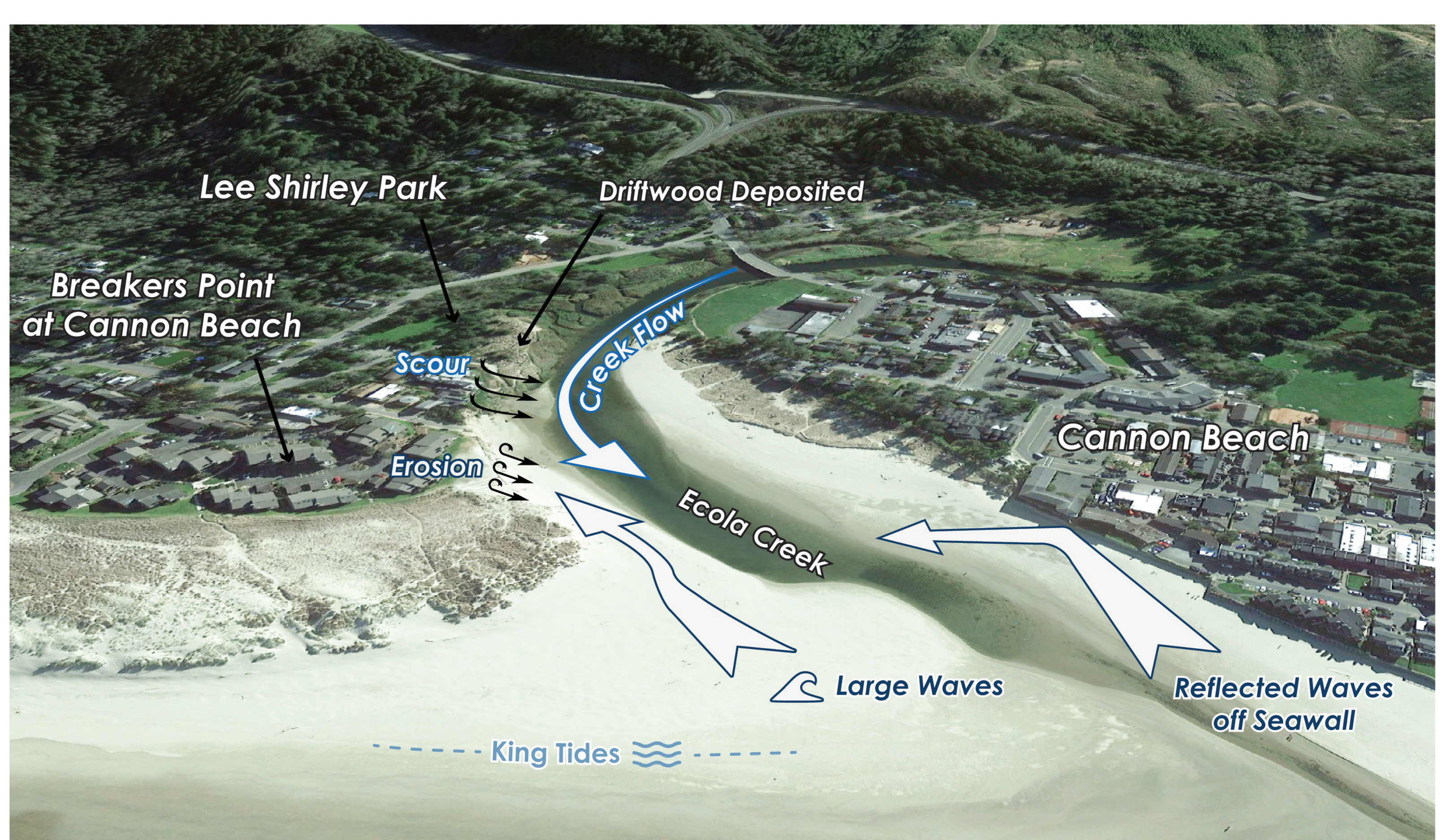

Figure 2. *Conceptual site diagram of erosive processes*

Methods

Two models, one goal: untangle the drivers of persistent bank erosion.

A multi-model approach moved from identifying the dominant erosion mechanism to quantifying its magnitude, the information needed for effective design. A large-scale hydrodynamic model (**Delft Flow + SWAN**) was first used to simulate both major riverine flood events (20- and 50-year return periods) and wave conditions across a range of high water elevations. This model identified the dominant forcing mechanisms driving erosion at the site. Once the primary driver was identified, a small-scale storm erosion model (**XBeach**) was applied to quantify erosion magnitude and evaluate the geomorphic response to wave events—information needed to design an effective alternative.

Large-scale model
Delta Flow + SWAN
Identifies dominant forcing mechanism

Small-scale model
XBeach
Quantifies erosion magnitude and response

Informs design alternatives

Results

It is not the river. It is the waves.

Even during major flood events, river velocities at the project area are too low to cause bank scour. During 20- and 50-year flood events, the creek widens and redirects upstream of the site, dissipating riverine energy before it reaches the eroding bank. Modeled river velocities at the project area remain below 1 ft/s, insufficient to cause scour at the bank toe.

Instead, wave energy propagating into the estuary during winter storms and periods of elevated water levels is the key mechanism. Modeled wave heights at the site ranged from 0.5 to 3 ft, consistent with video observations from king tide events. A seawall to the south further amplifies wave energy through reflection. The channel configuration of Ecola Creek also plays a role: a larger channel prism allows greater wave energy to reach the project area.

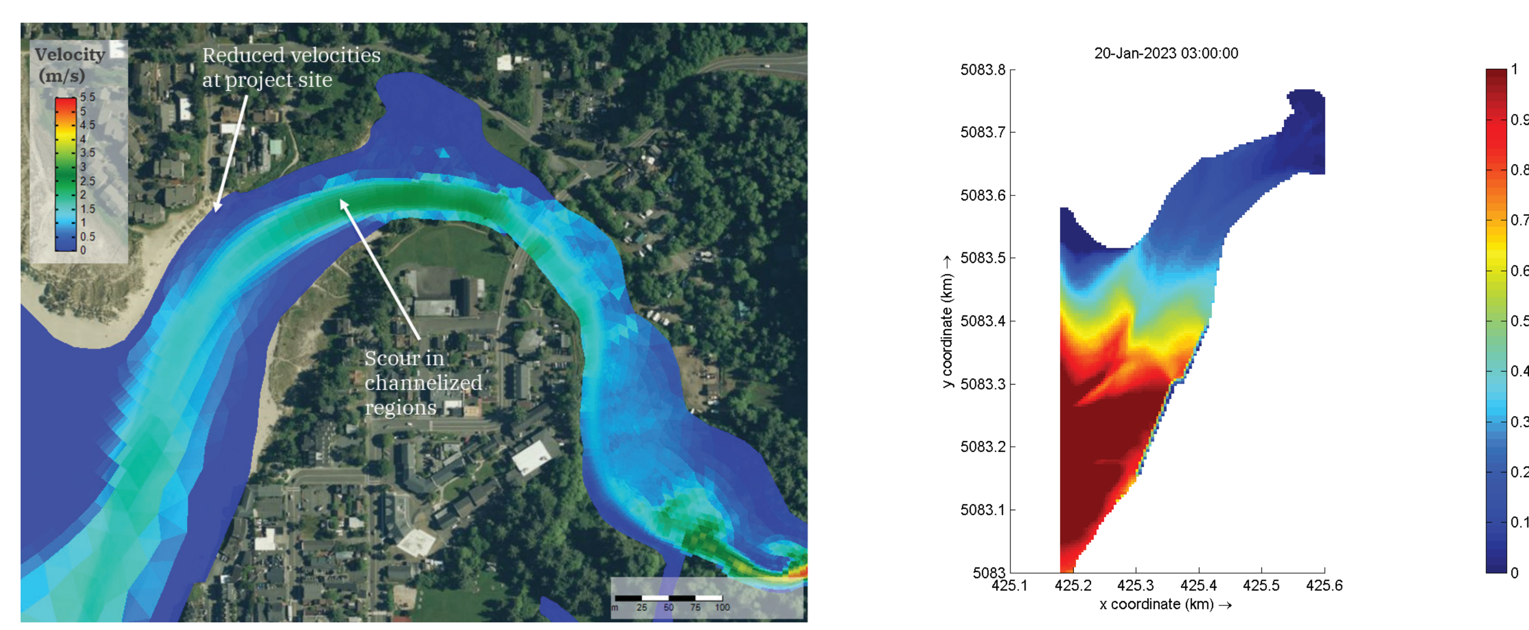

Figure 3. *Wave modeling map showing wave refraction into the estuary, project area, and seawall reflection*

A few winter storms are responsible for nearly all the damage.

Toe erosion during episodic high water/wave events destabilizes the entire bank. Just a handful of events per year account for the full 3 to 4 ft of annual loss. Cross-shore erosion modeling (XBeach) shows that even moderate wave events at high water levels are sufficient to erode the bank toe, triggering destabilization and subsequent slumping of the bank face. This mechanism was confirmed by direct site observation.

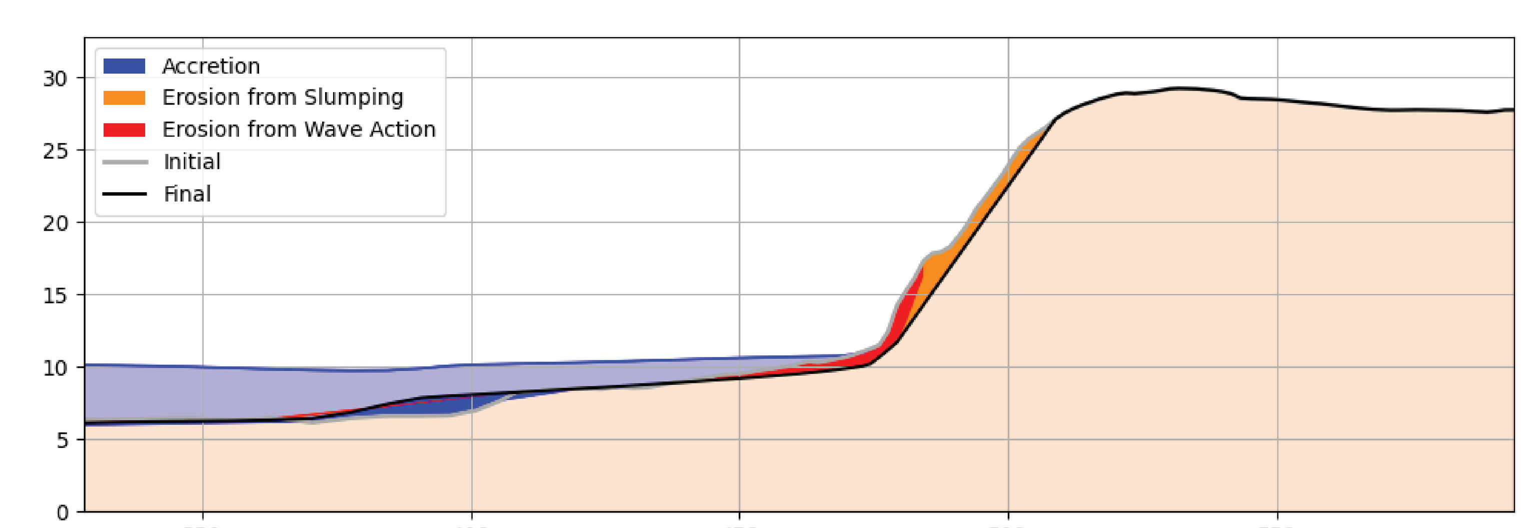

Figure 4. *XBeach modeling of toe erosion and bank slumping*

Discussion

A proposed hybrid design is directly informed by naturally occurring woody/cobble shoreline structures.

Knowing that wave energy at the bank toe is the primary driver pointed directly to the design approach. Any permittable alternative must comply with Oregon's Goal 18, which prohibits structural beachfront protection such as riprap or other hardened armoring, and must minimize impacts to the beach and estuary. Maintaining Larch Road access for recreation and emergency use is also a requirement.

The proposed design uses large, interlocking woody material cross-braced both horizontally and vertically within a pocket of cobble to dissipate wave energy at the bank toe. Root wads and log ends are buried deeply in cobble to prevent undermining and mobilization. This configuration provides effective toe reinforcement within a smaller horizontal footprint than alternatives such as dynamic revetments, a critical advantage for preserving beach access. Native vegetation and sand placed over the wood and cobble provide additional stabilization, discourage foot traffic, and help limit anthropogenic erosion.

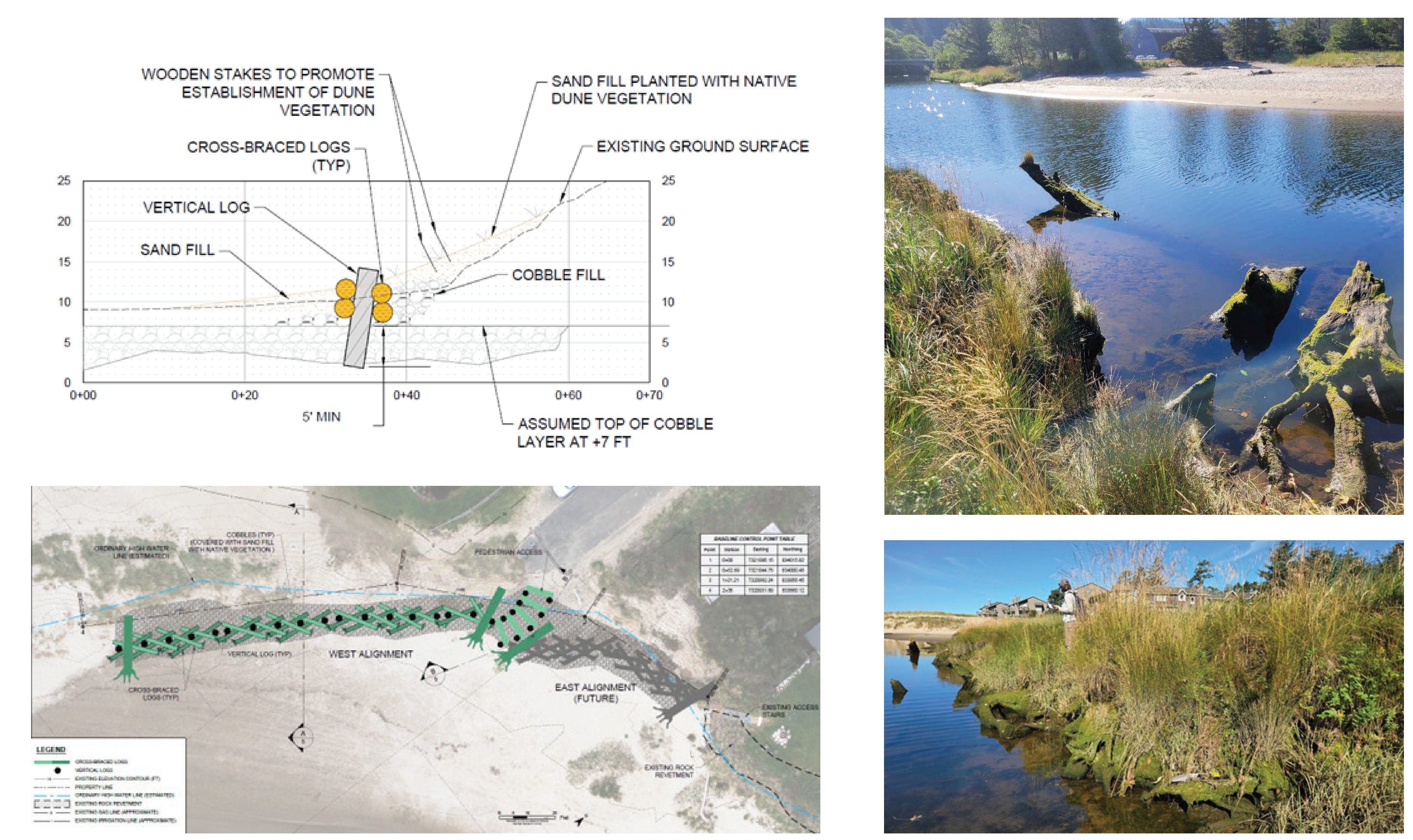

Figure 5. *Cross-section of proposed project plan (top left), plan view of the proposed bank stabilization system (bottom left), natural analog "ghost forest" integrated with cobbles found upstream of project site (top right), woody mesh and vegetation just upstream of project site (bottom right)*

Conclusion

Understanding the "why" made the solution possible.

Process-based analysis identified what previous efforts had missed: wave erosion during extreme high water events, not river flooding, is the primary cause of bank failure at this site. By leveraging available site data and multiple models, this study developed a robust understanding of the dynamics driving ongoing bank loss at Ecola Creek. That understanding directly enabled the design of an innovative nature-based erosion mitigation concept suited to both the physical setting and Oregon's regulatory environment. The proposed erosion mitigation is anticipated to receive permits in 2026.

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