FEASIBILITY OF A BARRIER ISLAND RESTORATION FOR STORM DAMAGE REDUCTION AT A LARGE NATURAL INLET: WILLAPA BAY, WASHINGTON, USA

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The Shoalwater Bay Indian Reservation is located on the northern shore of Willapa Bay, a large natural estuary located on the southwest coast of Washington State, USA. With a diurnal tidal prism of more than 7.1 x 10^9 m^3, Willapa Bay is one of the largest inlets on the coast of the continental United States, (Jarrett 1976). The northern shoreline of Willapa Bay has changed substantially since the Shoalwater Reservation was established in 1866, (Terich and Levensellar 1986). Over the last century, portions of the Cape Shoalwater shoreline have receded more than 4.5 km. By the 1990's, the Shoalwater Reservation's only remaining protection from storm wave attack was a series of barrier islands fronting Tokeland Peninsula (see Figure 1). Tidal currents and storm waves have severely eroded the barrier island, which culminated with a series of breaches beginning in 1994, exposing the Shoalwater Bay Indian Reservation to increasing levels of flooding due to storm overwash during extreme water levels. The erosion and storm overwash has in-filled North Cove with sand and significantly degraded and altered habitat of the once protected embayment. As a result, North Cove's capacity to sustain tribal subsistence shellfish beds and native plant populations has diminished. The increased wave energy in North Cove has, in turn, led to an increase in the severity and frequency of flooding and erosion of Reservation uplands during storm events. In 2000, the Assistant Secretary of the Army for Civil Works authorized the Corps of Engineers to construct and maintain a project at Federal expense provided the project is a cost-effective, environmentally acceptable, technically feasible, and will improve the economic and social conditions of the Shoalwater Bay Indian Tribe. A series of alternatives including both hard and soft engineering solutions was evaluated by a multi agency technical team. The analysis determined barrier island restoration with periodic nourishment was the most appropriate solution to mitigate further consequences (USACE 2009).

Flooding risk to Shoalwater Reservation is investigated using a detailed structure inventory and inundation maps generated from overland wave propagation data generated from the numerical wave model CMS-WAVE (Lin et. al 2008). The without-project conditions were evaluated over the 50-year life cycle using scenarios generated from the joint distribution of astronomical tide, storm surge, and offshore wave height. Wave runup is computed using the relationship defined by Komar (1998) at the land-water interface and averaged with the local depth to determine if the water can flood the proceeding dry cell. If wave runup is higher than the adjacent land cell elevation, CMS-Wave floods the dry cells to simulate storm overwash. In areas which have been flooded to allow overland wave propagation, the maximum water level is computed as the wave amplitude plus the wave setup, or, $\eta + 0.5H_{1/3}$, where $H_{1/3}$ is wave height. In low-lying regions removed from overland wave propagation, flooding strictly due to water level increases from tide is also represented. This analysis determined 63% of the inventoried structures were at moderate to high flooding risk for a 2% annual storm event. This framework shows potential for other coastal flood elevation studies which typically apply the one-dimensional WHAFIS model to investigate overland wave propagation (FEMA 2005).

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The current project schedule plans to nourish the barrier island in late 2010. Approximately 5 x 10^5 m^3 of dredged sediment would be transported hydraulically to the site from an offshore borrow area located approximately 1 km offshore. Design of the borrow sites depth, length, and width incorporate recent guidelines to minimize adverse impacts to the local wave environment (Michalsen and Haller 2008). Given the dynamic environment, periodic nourishment has been incorporated into the operation and maintenance plan. It is estimated the barrier island will be re-nourished at a rate of 2 x 10^5 m^3 every five years to maintain adequate storm damage protection. A monitoring program will collect pre/post storm data to steer the adaptive management plan and serve as a validation dataset for next generation morphological model application on the West Coast. This paper will present the restoration plan and associated wave and hydrodynamic calculations.

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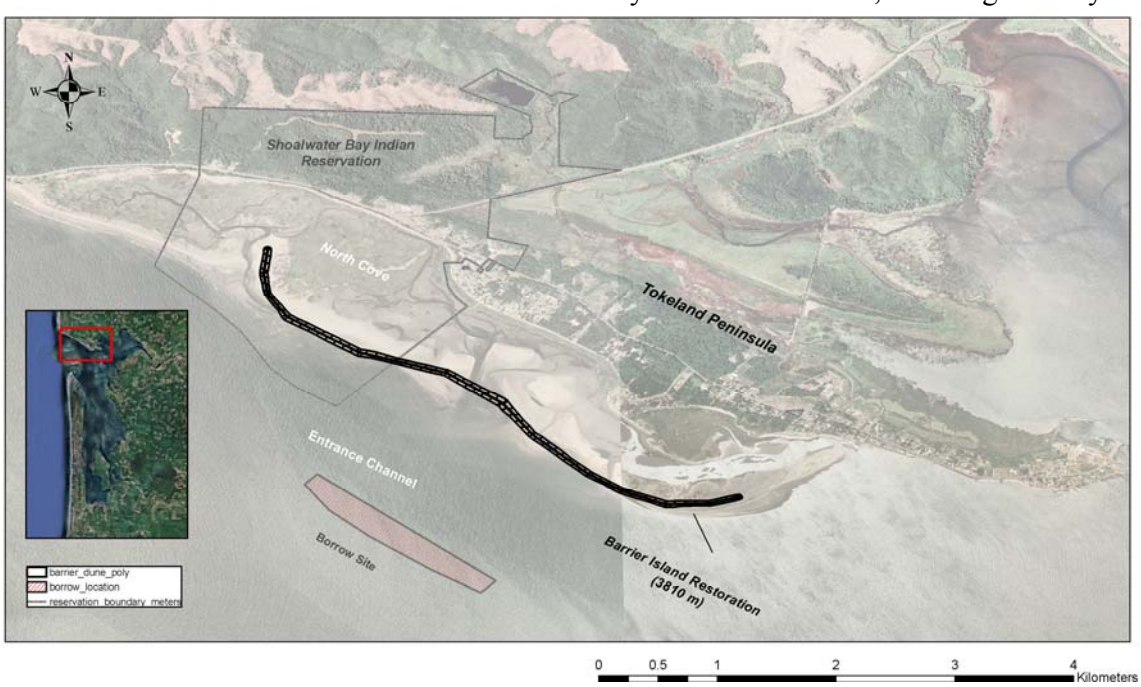

Figure 1. Barrier Island Restoration at Willapa Bay, Washington, USA