# SR 105 MP 20 Washaway Beach

# 2019 Dynamic Revetment Monitoring Report

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2018 Dynamic Revetment Monitoring Report

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# 1.0 Introduction and Purpose

In the fall of 2017 WSDOT constructed a dynamic revetment to protect SR 105 near Milepost (MP) 20, on a low segment of highway that runs along the north side of the Willapa Bay entrance channel near Tokeland (Figure 1). Dynamic revetments are a relatively new method of shoreline protection that mimics the natural energy dissipation provided by coarse beach deposits. WSDOT worked with the Department of Ecology to develop a monitoring plan for the project to help with adaptive management and the design of future projects. This report describes the results of the second season of monitoring (October 2018-May 2019).

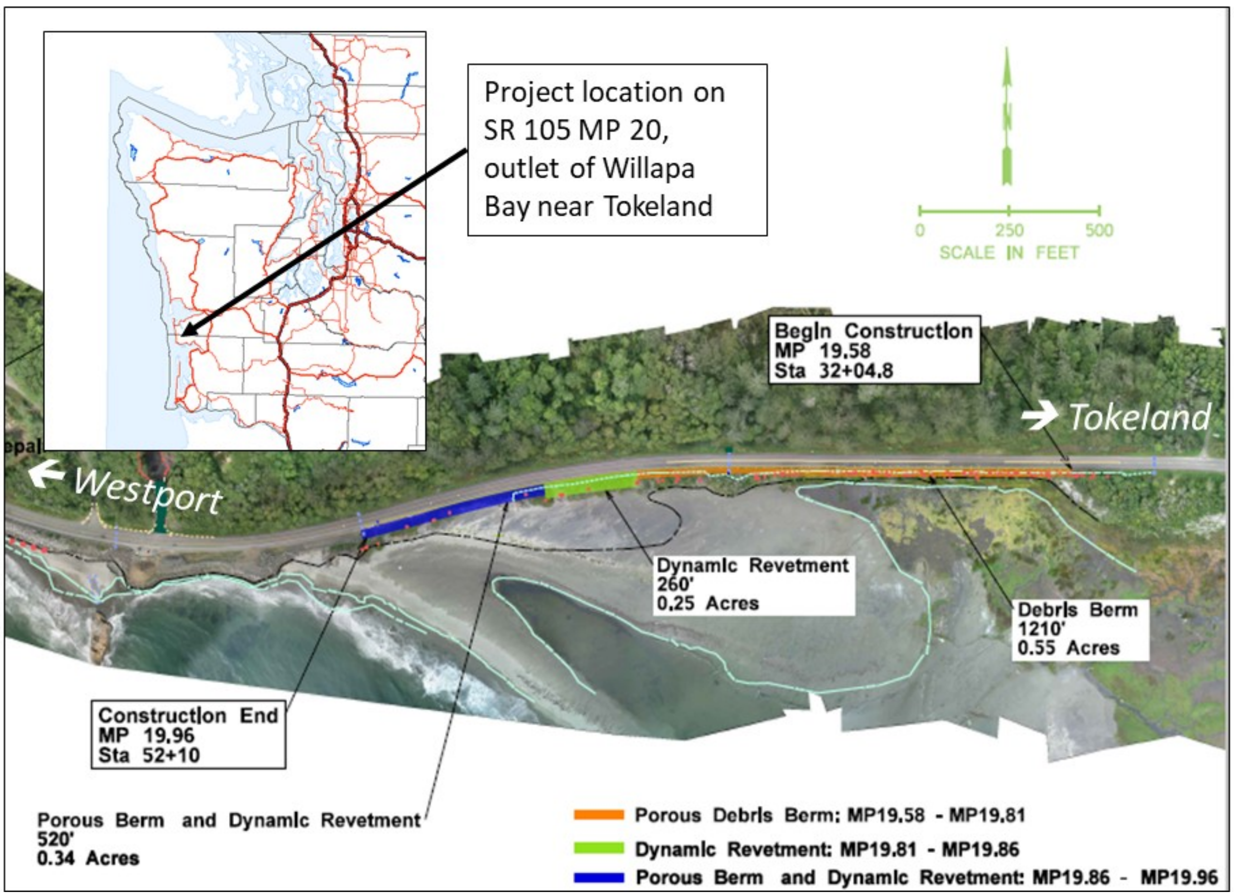



**Figure 1. Vicinity map and project plan view.**

# 2.0 Description of the Constructed Project

The dynamic revetments were constructed in the fall of 2017. Figure 1 shows the locations of the dynamic revetments, and Figures 2 and 3 show typical as-built conditions. The revetments were constructed as trapezoidal berms with flat tops and 1.5 to 2:1 (Horizontal:Vertical) side slopes. The berms were built of rounded cobbles with a size distribution designed for local wave energy conditions. The berms are intended to deform into a sloping beach as they are exposed to wave action.

The eastern 260 feet of dynamic revetment was constructed with a 26-foot top width (Figure 2). The back side of the berm sloped at about 2:1 to meet the edge of the roadway a few feet behind the guardrail. The berm was constructed of 10-inch minus streambed cobbles.

The western 520 feet of dynamic revetment was constructed in front of a smaller berm of angular rock that functions as a barrier to floating debris (Figure 3). The dynamic revetment here has a narrower top width of about 11 feet because it was designed as a revision to an original angular rock revetment, and therefore was constrained by previously-defined permitting limits on the footprint. The dynamic revetment transitions at the west end to an angular rock revetment constructed as an emergency repair in 2016.

The project also included a stockpile of dynamic revetment cobbles, to be used as needed by WSDOT maintenance to repair small pockets of erosion.

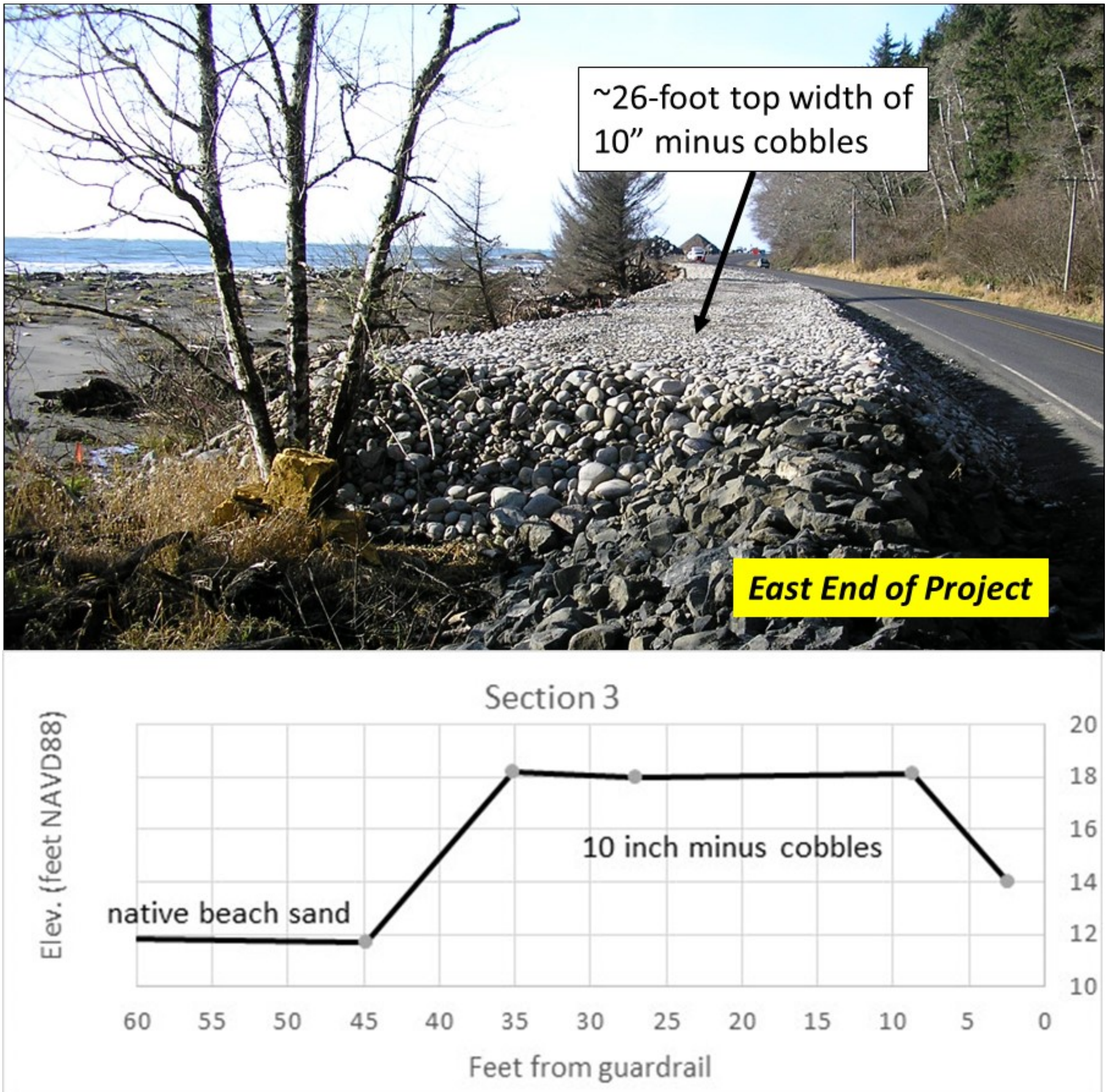
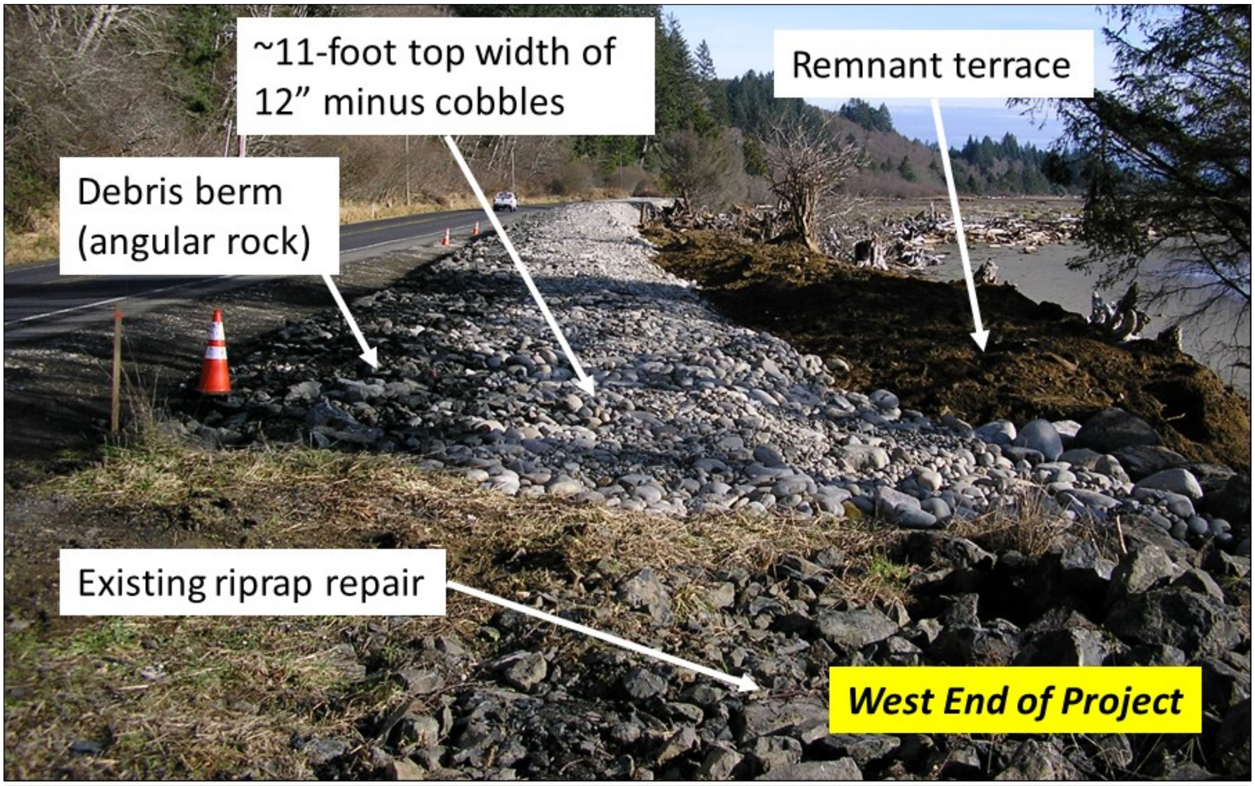



**Figure 2. As-built condition of the eastern dynamic revetment (looking west).**



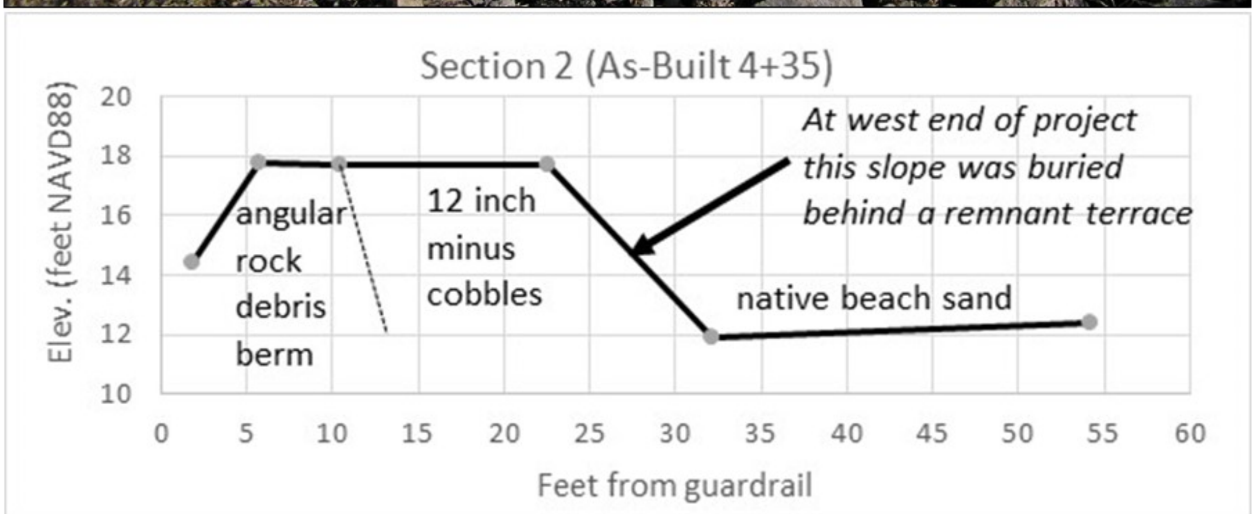




**Figure 3. As-built condition of the western dynamic revetment (looking east).**

# 3.0 Monitoring Methods

The performance of the project was monitored by WSDOT following procedures and criteria outlined in the Monitoring and Adaptive Management Plan finalized with the Department of Ecology's input on August 17, 2017 (Appendix A). The sections below describe specific methods used to meet the objectives of the plan.

## 3.1 Routine Inspection by Maintenance

WSDOT maintenance personnel inspected the site weekly beginning in October 2018 and ending in the last week of March 2019.

WSDOT installed lines of markers spaced every five feet along the top of the dynamic revetment at four monitoring transects (Figures 4 and 5). During the weekly inspections WSDOT personnel recorded changes in the top width of the dynamic revetment based on visual observation of the transect markers. These observations as well as any other significant changes in the condition of the revetment were entered into a tablet-based form that ties into WSDOT's HATS database for maintenance activities. Photos were also taken as needed to document observations. The form includes a box for "no change" for instances when no significant change has occurred since the last observation.

## 3.2 Dynamic Revetment and Beach Surveys

WSDOT Hydrology Program staff performs more detailed surveys of the condition of the revetment twice each season:

- Within a few days after the first storm when sustained wind gusts above 35 knots (40 mph) occur at tides greater than 8 feet MLLW. Wind data at the NOAA Toke Point buoy (Station TOKW1 – 9440910, http://www.ndbc.noaa.gov/station_page.php?station=TOKW1) and tide data at the Toke Point tide gage (Station ID: 9440910, https://tidesandcurrents.noaa.gov/stationhome.html?id=9440910) are used to characterize storm conditions for the site.
- At the end of the storm season (April - May).

During each survey a total station level is used to survey elevations along the four transect lines shown in Figure 4, beginning on the pavement on the seaward side of the guardrail and ending far enough out on the beach to record changes in the beach profile (typically 150- to 200-feet out from the toe of the dynamic revetment). Additional transects are surveyed as needed to characterize areas of concern. The surveys are tied into a hub stake installed on the north side of SR 105 between Transects 2 and 3. At each transect survey points are taken to define break points in the profile of the dynamic revetment. The beach is surveyed at less detail, with only enough points to define major breaks in the beach profile shape. Photo points were also established and repeated each survey at the points shown in Table 1.


**Figure 4. Location of monitoring transects.**

**Figure 5. Photo of stakes at monitoring transects.**

| Location | Description |
|---|---|
| At each transect | Top of berm at first stake, looking east and west |
| | Looking out towards the beach from the top of the berm |
| | Top of the berm at the last stake, looking east and west |
| | Looking back towards the berm from about 100 feet out on the beach |
| 50 feet west of west end of berm | Looking east along the top of the berm |
| From the beach at the west end | Looking at the face of the berm at the west transition to older riprap maintenance repairs |

**Table 1. List of photo points for detailed monitoring surveys.**

# 4.0 Monitoring Results

## 4.1 Winter 2018-19 Wind Conditions

Table 2 and Figure 6 summarize wind conditions for the 2018-19 storm season. The project faced a series of high-wind events from late November through early January that overlapped with a period of king tides in late December. The remainder of the season saw no high wind events at high tide. Winter storm monitoring was conducted after the November 26 and December 20 storms. Storms on December 18 and 20 led to cobble supplementation on December 21 and a rock revetment repair on January 1. These storms corresponded to a series of king tides where the maximum water levels reached 12.6 MLLW on December 20 and continued above 11 feet MLLW on December 22, 23, and 24.

| Date | Time Range tide >8 (GMT) | Peak gust (knots) | Direction (degrees) |
|---|---|---|---|
| November 26, 2018 | 21:12 – 23:12 | 41 | 190 |
| December 11, 2018 | brief | 39 | 190 |
| December 15, 2018 | brief | 48 | 180 |
| December 18, 2018 | 3:54 – 6:06 | 51 | 190 |
| December 20, 2018 | 15:30 – 19:36 | 55 | 190 |
| January 4, 2019 | brief | 47 | 185 |
| January 6, 2019 | brief | 47 | 285 |

**Table 2. Periods with wind gusts greater than 35 knots and tides greater than 8 feet MLLW.**

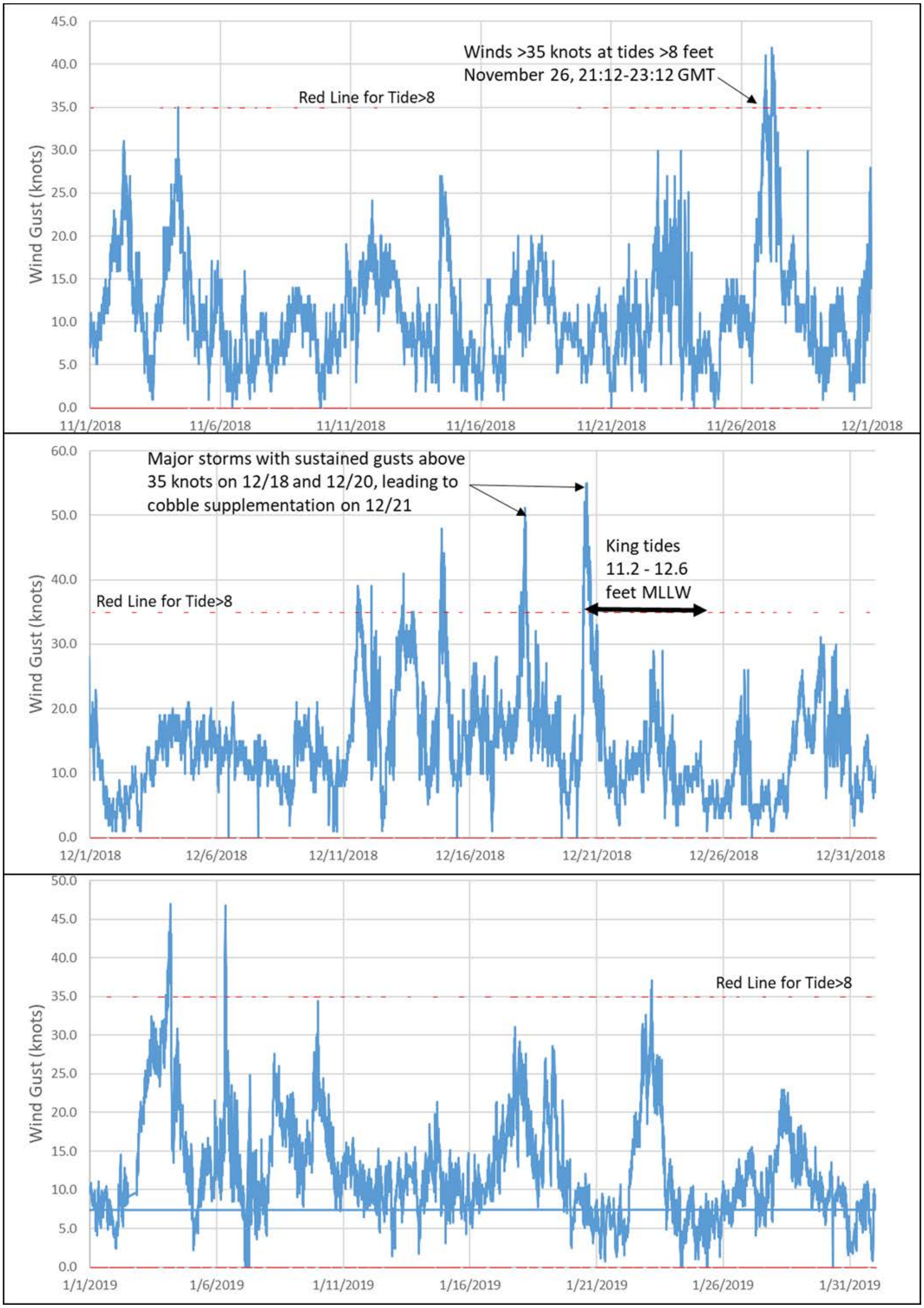



**Figure 6. Observed gusts at the Toke Point wind buoy, winter 2018-19.**

## 4.2 Routine Monitoring and Repairs by Maintenance

In addition to routine inspections, WSDOT Maintenance proactively monitored and repaired the site during a series of storms in November and December. Much of this work occurred during the Thanksgiving, Christmas, and New Year holidays.

Figure 7 shows the locations of repairs constructed in the 2018-2019 storm season, and Figure 8 compares cross sections before and after repairs in the western transition area. On September 11 WSDOT supplemented cobbles in the west transition area based on the recommendation from the 2018 monitoring report to add material where observed wave energy was highest. The main repair area covered about 35 feet of shoreline beginning at the west end of the project. Material was placed using a 12 cubic yard dump truck, end dumping cobbles at the edge of the existing cobble berm. A small excavator then bladed and pushed the material outward to extend the top of the berm. The outer slope was allowed to stabilize at the natural angle of repose without compaction (estimated in the field to be steeper than 1.5:1). The main repair required ten 12 cubic yard loads. Since material was available, WSDOT also used 3 loads (36 cubic yards) to fill a scallop developing on the east side of the planned repair, covering about 30 feet of shoreline.

Maintenance observed major loss of material in this area after two large storms with king tides on December 18 and 20. On December 21 WSDOT placed 220 cubic yards of cobble in a 107-foot length of shore at the west end of the project. This reconstructed a berm top width of 15 feet at the west end, transitioning to tie in to un-supplemented areas to the east at 9 feet wide.

King tides combined with moderate winds on December 22, 23, and 24 continued to erode the new berm material at the west end. By December 25 the berm width in the west transition area had eroded to as narrow as 7 feet. Because of the rapid rate of cobble loss, the observed instability of the berm, and forecasted storms and king tides in early January, WSDOT decided to abandon the cobble berm concept in the west end of the project where storm energy is too high for the narrow berm footprint. An emergency contract was therefore used to replace the cobble with an angular rock revetment on January 1, 2019 (Figure 9). This revetment covered 140 feet of the western end of the original dynamic revetment (Figure 7). Large cobbles pushed to the seaward edge of the rock revetment were used to soften the toe of the treatment, and additional cobbles salvaged from the riprap repair area were used to supplement the transition from the new riprap to the remaining cobble berm sections.


**Figure 7. Map of the 2018-19 repairs and May 2019 survey.**

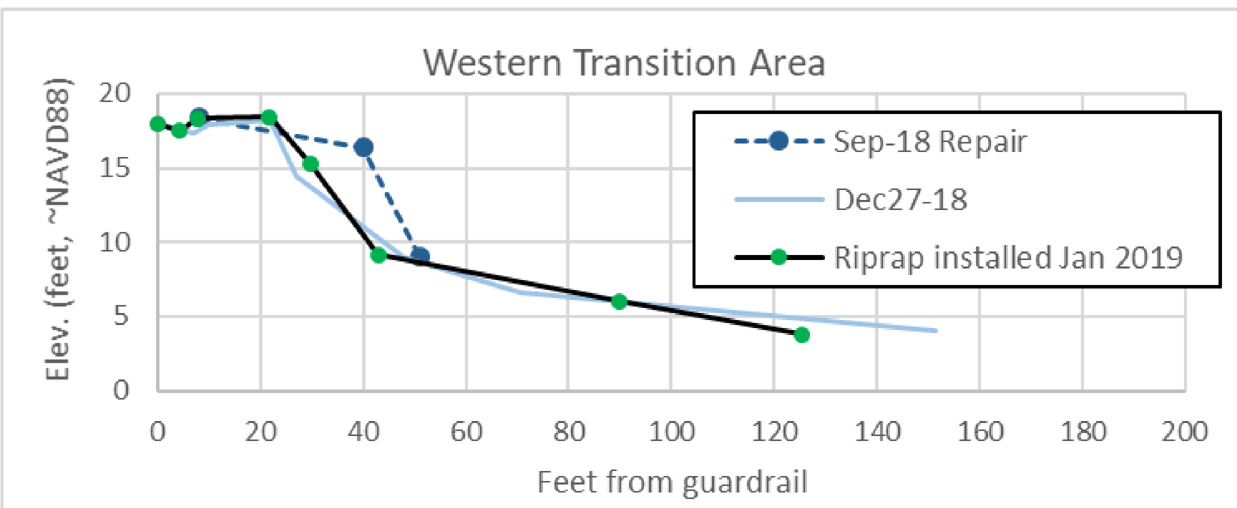



**Figure 8. Typical sections of the September 2018 and January 2019 repairs.**

**Figure 9. Photo of the completed January 2019 riprap repair.**

## 4.3 Dynamic Revetment and Beach Surveys

Detailed site surveys were performed on December 3, 2018, December 27, 2018, and May 30, 2019. Appendix B compares representative photos from each monitoring season, and Figure 10 compares the transect survey data. Figure 7 shows the transect locations. Most of the dynamic revetment east of Section 2 saw little wave action and has not significantly deformed relative to the As-built condition. Changes in this area are subtle and are likely caused by settlement and shifting of the loose cobble material.

Section 1 is at the west end of the remaining dynamic revetment, near the transition to the January 2019 riprap. The dynamic revetment here was eroded by storms in December 2018 and then supplemented with cobbles as part of the riprap repair. The berm top width is now similar to the original constructed project, but the beach at the toe dropped about two feet after the December storms. The transition slope between the original dynamic revetment toe and the eroded beach is covered by cobbles transported from the west, including cobbles eroded before the riprap placement and cobbles that were left on the face of the riprap repair in January 2019. An arc of transported cobbles continues along the upper edge of the beach to Section 2 where cobbles front a bench of wracked wood (Figure 11). Figure 7 maps the eastward extent of the transported cobbles and Figure 10 shows their location on Sections 1 and 2.

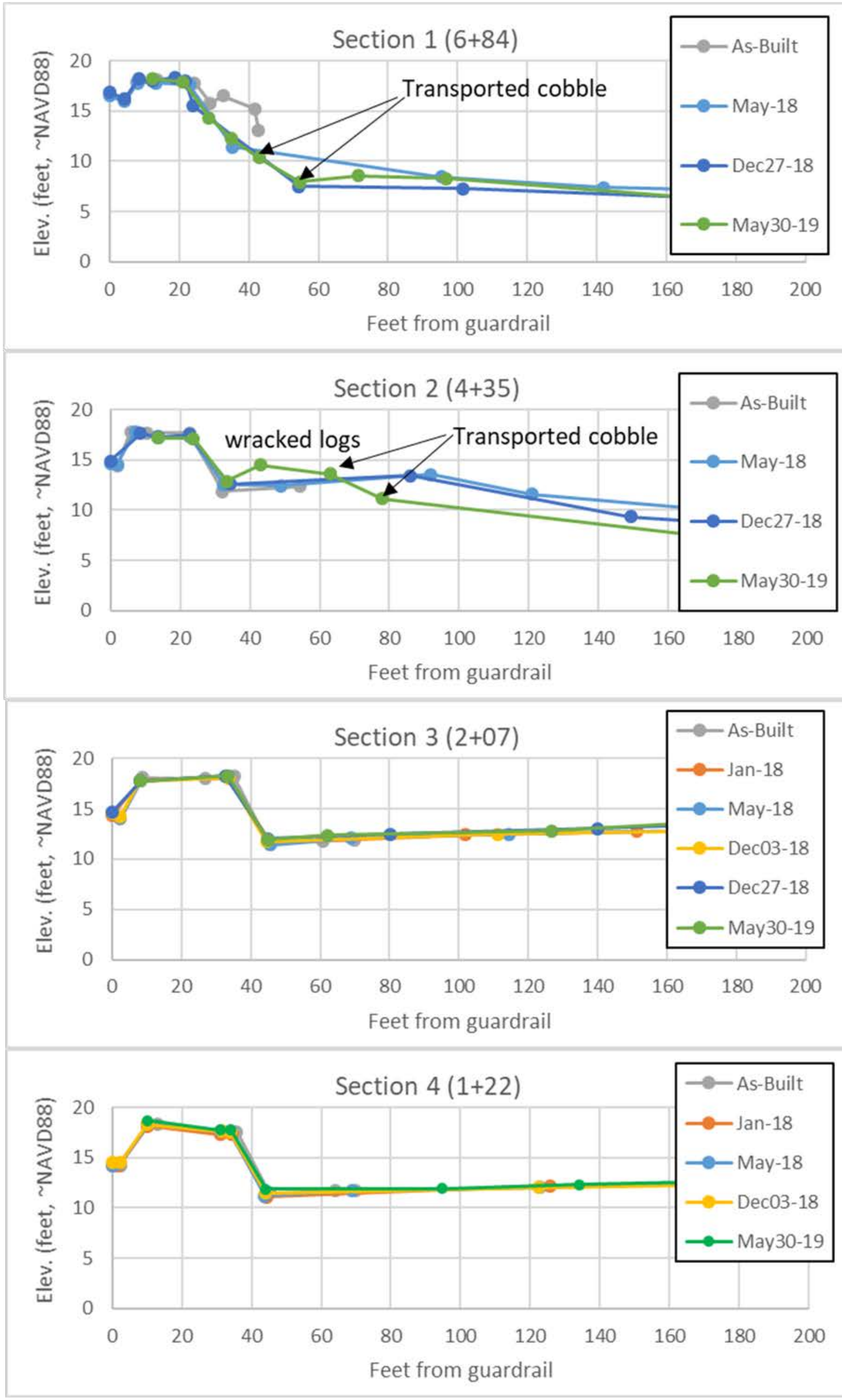



**Figure 10 Comparison of transect surveys**

**Figure 11. Photo from Section 1 of cobbles transported eastward along the toe of the dynamic revetment.**

# 5.0 Conclusions and Recommendations

The dynamic revetment has generally performed as intended, with storm erosion transporting the berm material to the toe where it can buffer and dissipate wave energy. Unfortunately, due to project footprint constraints the cobble berm was constructed with a narrow width at the western end where wave energy is highest. This segment receives the brunt of waves that refract off adjacent revetment at the entrance to the North Cove embayment to impinge directly onto the shore. This generates a long-shore current that erodes material from the toe and transports it eastward into the embayment. During king tides this erosion and transport can occur even under relatively moderate wind conditions.

The rate of erosion required multiple cobble replacement projects at the west end in a single season of fairly typical storm events. This level of replenishment was not viewed as sustainable for WSDOT (and was not specifically funded), so WSDOT replaced the dynamic revetment with an angular rock revetment in the most critical section. A significantly wider dynamic revetment in this location would allow the berm to deform and create a broad slope that could better absorb the excess wave energy and protect the highway. A wider berm would also feed eastward deposition of an arc of cobbles that could eventually create a resistant beach in front of remaining marshlands and log deposition areas. This eastward transport of cobbles supports the concept of building an erosion-resistant beach and dune on Graveyard spit to protect the embayment, and WSDOT is continuing to work with local partners to fund and design a project here.

# Appendices A (Monitoring Plan) and B (Photo Comparisons)