El Dorado Hydroelectric Project No. 184

Oyster Creek Stabilization Project: Final Geomorphic Monitoring Report

El Dorado County

Prepared for:

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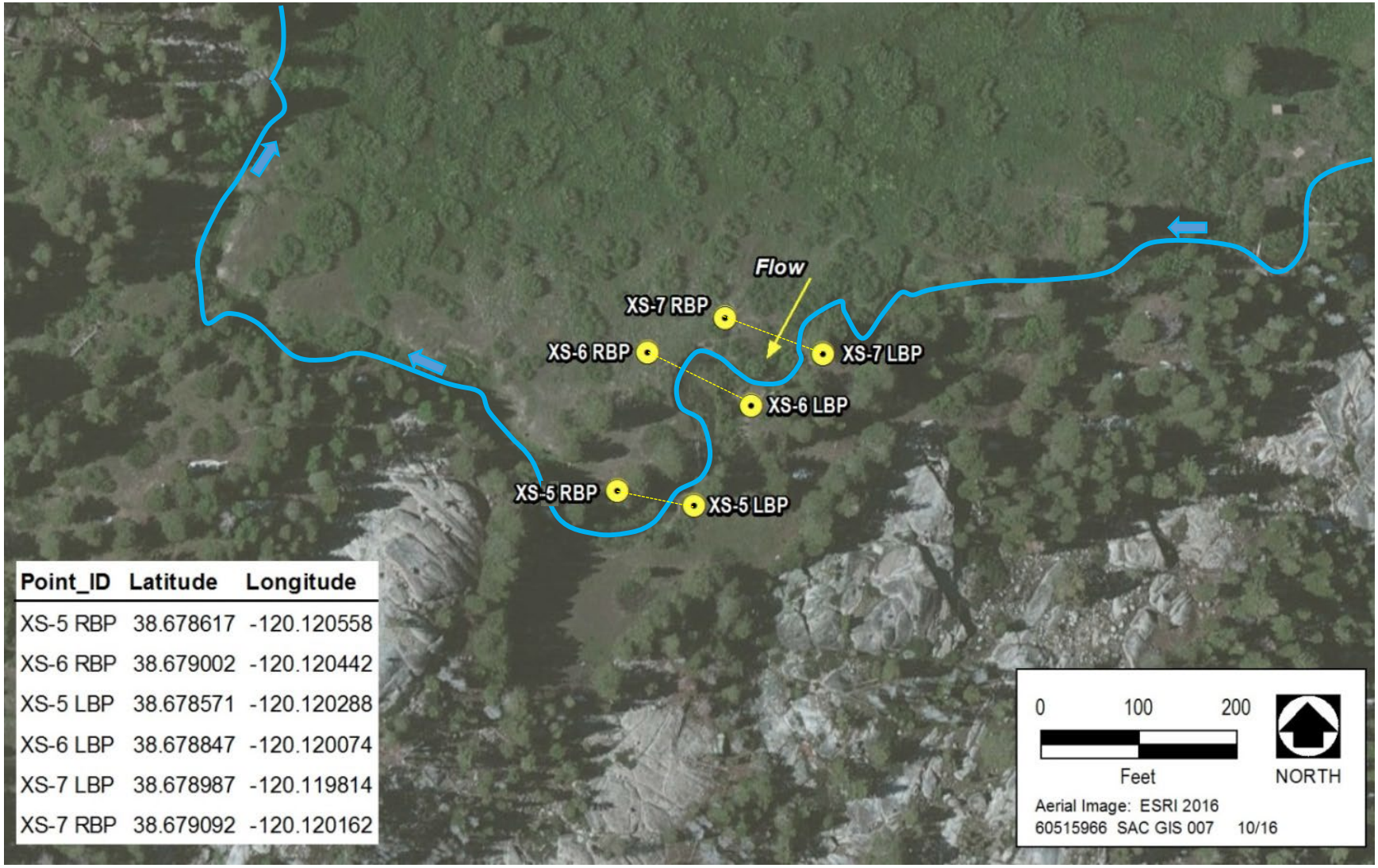
1. INTRODUCTION

This report presents the results of a follow-up geomorphic assessment at the Oyster Creek site conducted by Horizon Water and Environment (Horizon) in October 2019, immediately following implementation of the Oyster Creek Stabilization Project (Project). The Project included installation of willow poles and alder container plants along the right bank of Oyster Creek, and as well as a 12-inch diameter coconut coir roll at the toe of the right bank as prescribed by the Oyster Creek Stabilization Plan (Stabilization Plan, EID 2012). The survey effort described in this report is a requirement specified in the Monitoring Maintenance and Reporting Plan (EID 2014) for the Project and followed the geomorphic monitoring protocols defined in the Project No. 184 Geomorphology Continuing Evaluation of Representative Channel Areas Monitoring Plan (Continuing Evaluation Plan, EID 2011). This report documents conditions following implementation of the Project and compares those conditions to previous conditions observed during monitoring efforts in 2011 and 2016 associated with the Continuing Evaluation Plan.

Figure 1. Oyster Creek below Highway 88, Survey Area



Point_ID	Latitude	Longitude
XS-5 RBP	38.678617	-120.120558
XS-6 RBP	38.679002	-120.120442
XS-5 LBP	38.678571	-120.120288
XS-6 LBP	38.678847	-120.120074
XS-7 LBP	38.678987	-120.119814
XS-7 RBP	38.679092	-120.120162

2. GENERAL SITE DESCRIPTION

The Oyster Creek watershed includes the lands immediately surrounding and draining to Oyster Lake and tributaries that join Oyster Creek downstream of the lake. Approximately 0.5 miles downstream of Oyster Lake, a small tributary, Thunder Mountain tributary, joins Oyster Creek. Oyster Creek continues to flow for another 0.9 miles before joining the Silver Fork American River. In total length, Oyster creek is approximately 1.4 miles long between Oyster Lake and the confluence with the Silver Fork American River.

The study site for this geomorphic report is a 500 ft. long reach of Oyster Creek located approximately 1,000 feet downstream (southwest) of where Highway 88 crosses over the creek (Figure 1). At the downstream end of the study site, the contributing Oyster Creek watershed is approximately 1.1 mi^2 in area. Oyster Creek at the study site flows along the southern border of an adjacent low gradient alpine meadow. The creek has a low degree of entrenchment, the thalweg (low point) of the creek bed is approximately seven feet below the adjacent top of bank and meadow surface. The creek is sinuous with a sinuosity measure of 1.8 (river length/straight line distance) (Entrix 2002). The creek bed is typically comprised of alternating riffles and runs, with typical bed sediment comprised of sand and gravel. The cross-sectional channel shape includes a point bar and floodplain bench (Appendix A, Photo 4) approximately two feet above the thalweg.

Instream flows to the Oyster Creek study site are influenced by watershed runoff including snowmelt via Oyster Lake and contributing tributaries. Local road drainage contributes to Oyster Creek as well. There is also contributing groundwater inflow from the Silver Lake, only 350 feet south of Oyster Lake (Entrix 2002). Hydraulic head in Silver Lake creates seepage rates ranging from a base flow of two cubic feet per second (cfs), to a high of 17 cfs when Silver Lake is at the normal maximum lake level (Hydrologics 2002, as cited in Entrix 2002).

3. DATA COLLECTION AND ANALYSIS METHODS

The 2019 geomorphic evaluation includes comparing channel cross sectional surveys, comparing longitudinal profiles, assessing channel bed sediment textures, and identifying the bank erosion potential since the previous monitoring was conducted. These methods are further described below and followed the initial Monitoring Plan (Entrix 2011) and previous monitoring conducted by Stillwater Sciences in 2011 and 2012 (Stillwater Sciences 2012a, Stillwater Sciences 2012b) and AECOM in 2016 (AECOM 2016).

3.1 CHANNEL CROSS SECTIONS

Three cross sections were surveyed at the Oyster Creek site in 2011 and 2016. During the 2019 survey, surveyors successfully located the headpins marking the endpoints of previously established cross sections and repeat surveys of the 2011 and 2016 cross sections were conducted. The cross-sectional surveys were performed consistent with the standard survey procedures established by the US Department of Agriculture (USDA) Forest Service (Harrelson et al. 1994), including surveying the left and right water surface, thalweg, top of bank, and ground elevations at both headpins. Elevations were recorded at all grade changes across the cross sections. Ground surface elevation data was collected using an automatic optical level.

The Monitoring Plan describes two indices that should be calculated to compare channel morphology changes over time: net percent change in area (ΔA%) and absolute percent change in area (|ΔA%|) (Entrix 2011). Net percent change in cross-sectional area quantifies the extent to which the channel at the cross section may have widened, narrowed, deepened, or incised since the last monitoring period. Absolute change in cross-sectional area indicates that total amount of streambed or bank material movement since the last monitoring period. The cross sections surveyed in both 2016 and 2019 were plotted and measured to compare net and absolute percent changes in cross-sectional areas for each cross section.

3.2 LONGITUDINAL PROFILES

A longitudinal profile of the channel thalweg was surveyed. Survey extents for the 2019 survey matched 2011 and 2016 survey limits. Bed elevation measurements were referenced to the local datum used for the cross-sectional survey. The longitudinal profile survey consisted of sufficient numbers of points to capture the topography of pools, riffles, substantial changes in channel gradient, and other habitat features of the channel. Survey procedures were consistent with standards established by the USDA Forest Service (Harrelson et al. 1994). Ground surface elevation data was collected using an automatic optical level.

Longitudinal profile data were plotted with data from the 2016 monitoring effort (AECOM 2016). The average slope of the reach was compared to 2016 data in order to assess changes in slope and identify areas of local channel aggradation or incision.

3.3 BED PARTICLE SIZE DISTRIBUTIONS

Along each cross section, a pebble count was performed consistent with the methods described in Wolman (1954) to characterize bed particle size distribution. One-hundred particles were randomly selected using the "first blind touch" method across the bankfull channel width. The particles were measured on the intermediate axis (b-axis) using a gravelometer and all silt- and sand-sized particles were classified as "less than 2 millimeters."

Pebble count data was plotted as a cumulative percentage distribution. The D16 (particle size for which 16 percent of the distribution is finer), D50 (median particle size), and D84 (particle size for which 84 percent of the distribution is finer) were calculated and compared to 2011 values to assess any recent trends in stream bed coarsening or fining.

3.4 BANK EROSION POTENTIAL ASSESSMENTS

At each cross section monitoring site, a bank erosion potential assessment was conducted for both left and right banks according to Rosgen (1996). The bank erosion rating (very low, low, moderate, high, very high, or extreme) was based on the following five parameters: the ratio of bank height to bankfull height, the ratio of root depth to bank height, root density, bank angle, and an assessment of surface protection. Additional secondary characteristics were also recorded, including bank material and degree of stratification.

Following the field data collection effort, these scores were summed and used to determine bank erosion potential for each cross section, which ranged from very low (total bank erosion potential score of <9.5) to extreme (total bank erosion potential score of >45). Erosion potential scores are presented for both left and right banks at each of the three cross sections.

4. RESULTS

4.1 Channel Cross Sections

The Monitoring Plan called for surveying cross sections in places that would facilitate comparison with historical geomorphic data. All previous cross sections were successfully located and resurveyed during the 2019 monitoring effort. The study site cross sections for 2016 and 2019 are shown in **Figure 2, Figure 3,** and **Figure 4**. Representative photographs were taken and are included in **Appendix A.**

Figure 2. Oyster Creek below Highway 88, Cross Section 7 Survey Data

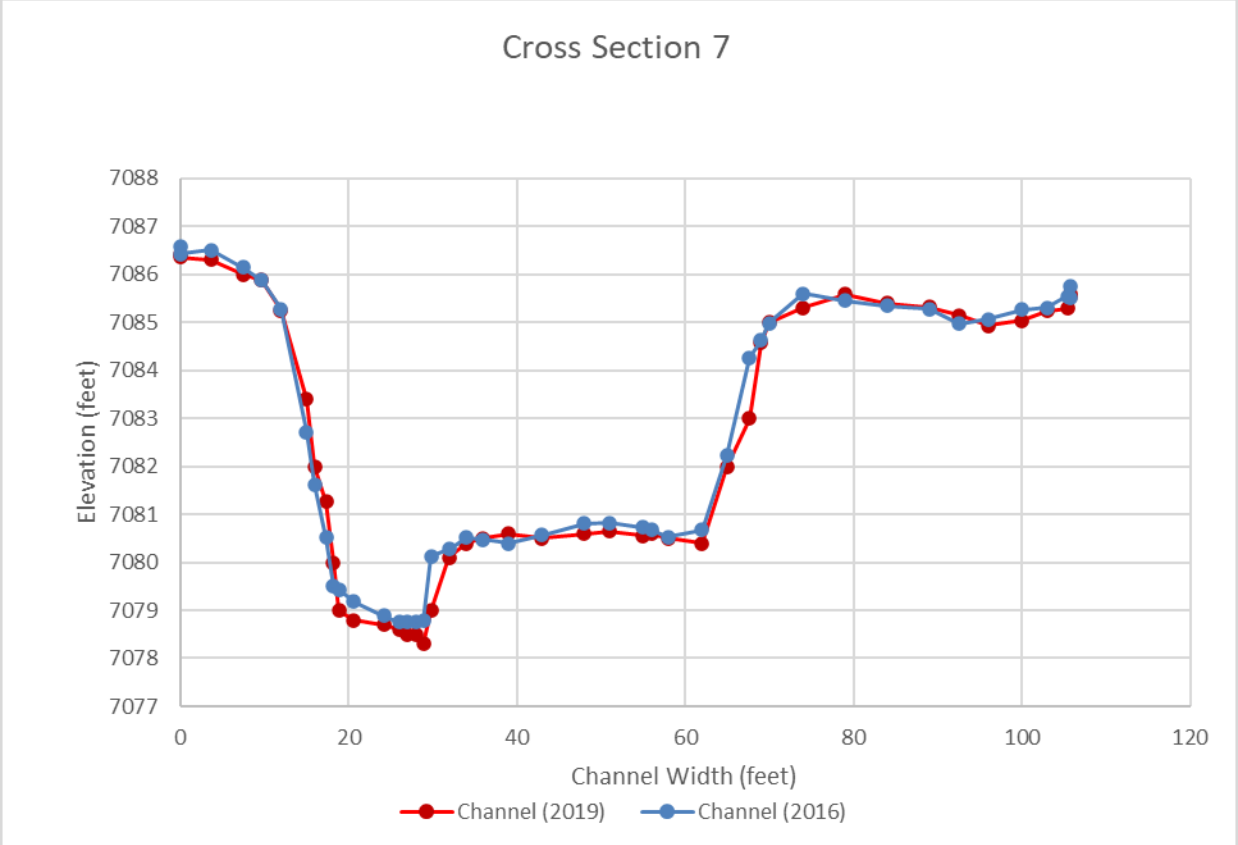


Figure 3. Oyster Creek below Highway 88, Cross Section 6 Survey Data

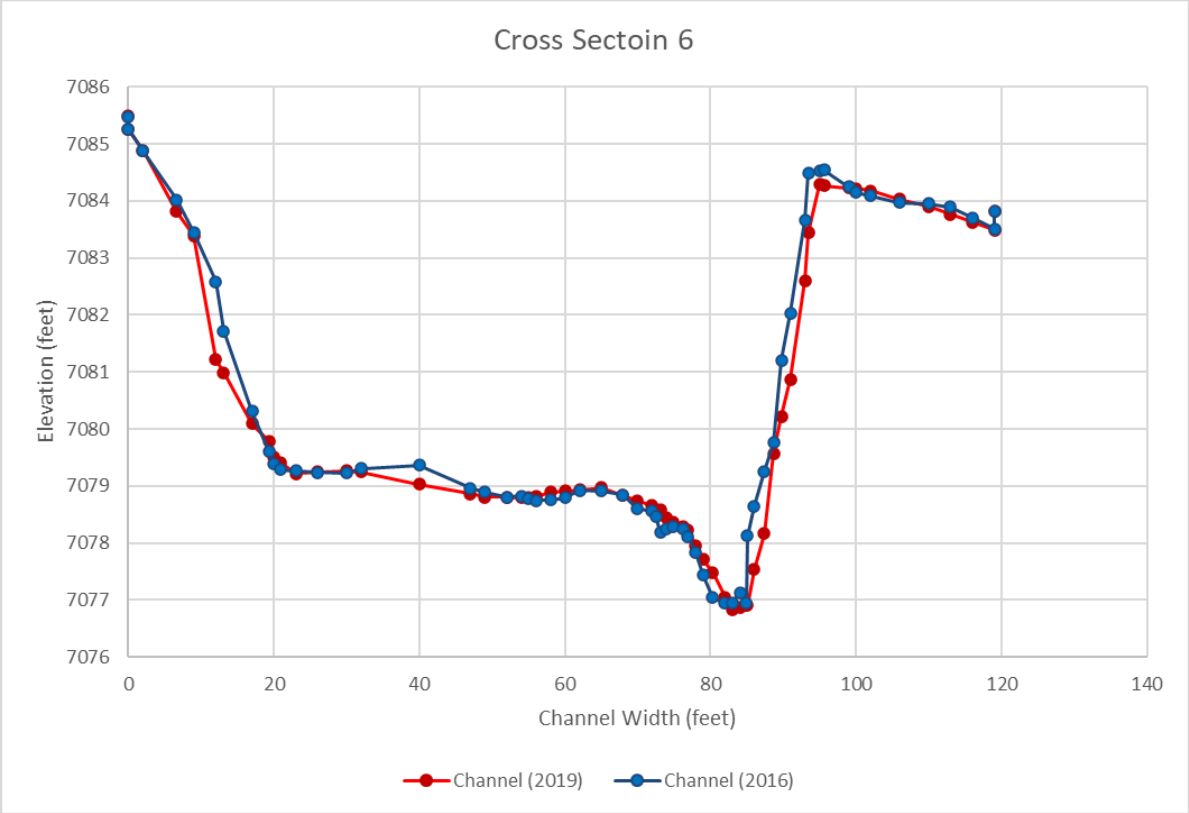
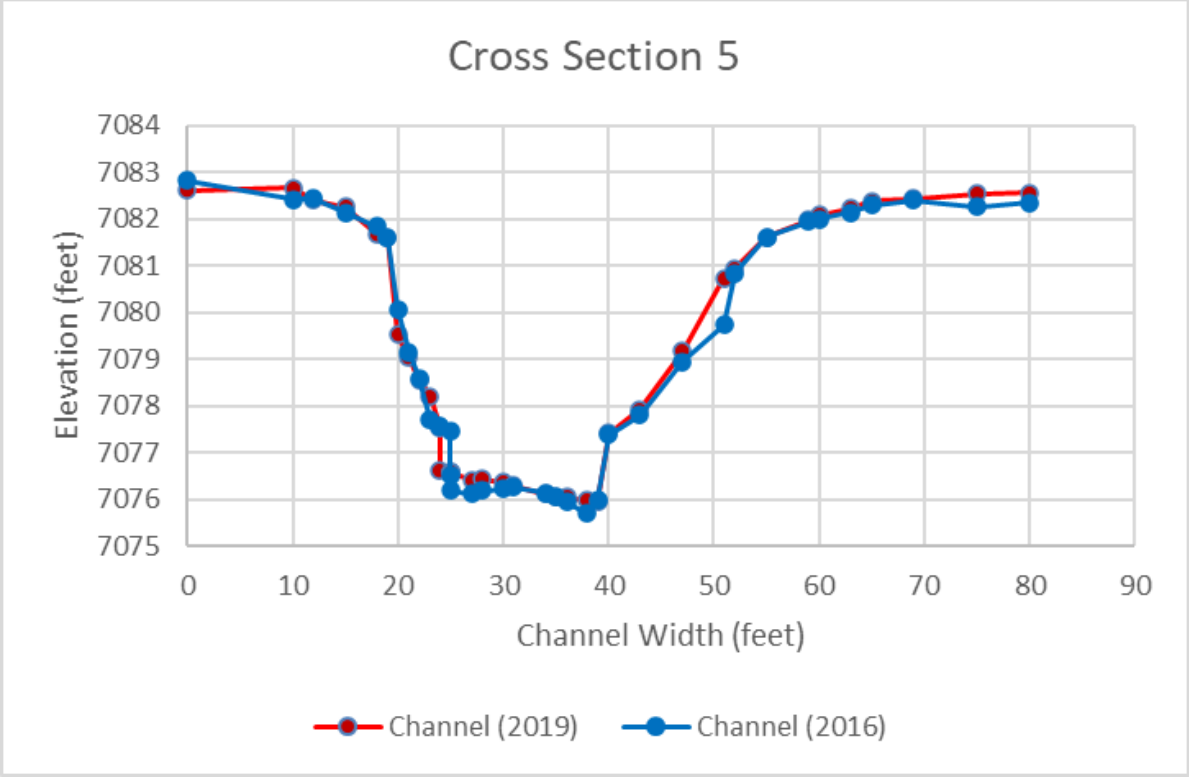


Figure 4. Oyster Creek below Highway 88, Cross Section 5 Survey Data



The repeated cross-sectional surveys show that Oyster Creek at the study site has remained relatively stable between 2011, 2016, and 2019. The changes in channel cross-sectional area from 2016 to 2019 is shown in **Table 1.**

Table 1. Summary of Cross-Section Change Metrics for Oyster Creek below Highway 88

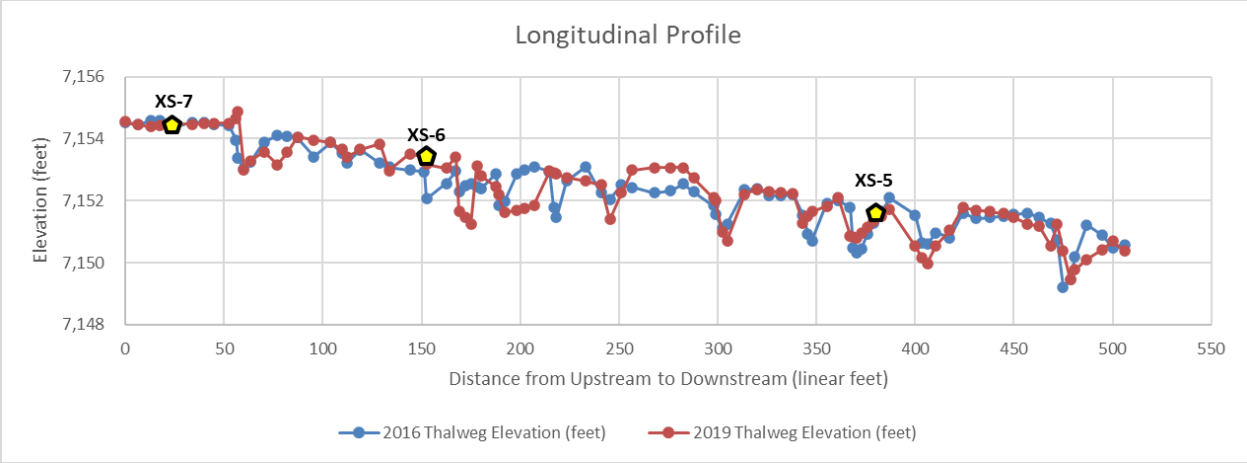
Channel Cross-Section Change Metric	XS-7 (Upper)	XS-6 (Middle)	XS-5 (Lower)
Net percent change in channel area from 2016 to 2019	2%	10%	-1%
Absolute percent change in channel area from 2016 to 2019	2%	10%	1%

The survey data appears to indicate that the upstream-most cross section (XS-7) and the downstream most cross section (XS-5) experienced very little change since the 2016 survey. The middle cross section (XS-6) indicates that the channel experienced a 10 percent increase in area since the 2016 survey. The cross-section comparison of Figure 3 shows erosion along both banks and some minor erosion at one point along the channel inset bench. Some of the difference in the cross section data between 2011, 2016, and 2019 may be due to differences in conditions during the monitoring efforts and data collection variances. That the erosion observed in the middle cross section (XS-6) was not observed as a trend in the cross sections upstream and downstream suggests that overall study site is not experiencing an erosive trend throughout the reach, but rather there is some localized erosion at the middle zone.

4.2 LONGITUDINAL PROFILE

Figure 5 shows the longitudinal profile data for Oyster Creek below Highway 88 from the 2016 and 2019 monitoring efforts. Both profiles extend 25 feet upstream from XS-7 and continue downstream to the exposed bedrock at the top of the waterfall. Comparison of the 2016 and 2019 profiles shows that the average reach slope, as measured between XS-7 and XS-6, has remained relatively constant, indicating that the channel has remained stable during the monitoring period. However, it is very difficult to draw conclusions based on comparison of the profiles due to the low gradient and subtleties in elevation within riffles and pools. The local erosion observed in the cross section for XS-6 (as described in Section 3.1 above) does not appear to result in an increase in deposited material along the streambed downstream of XS-6 suggesting that the material that was eroded from the streambanks of XS-6 was passed downstream beyond the study site.

Figure 5. Oyster Creek below Highway 88, Longitudinal Profile Survey Data



4.3 Bed Particle Size Distributions

Representative bed particle sizes for each cross-section for Oyster Creek below Highway 88 collected in 2019 are presented in **Table 2**. Data from the 2011 (Stillwater Sciences 2012a) and 2016 (ESA 2017) sampling effort are also presented in the table for comparison.

The pebble count data from the 2019 survey show that the bed is primarily finer than coarse gravel (<32 mm) with the median particle size ranging from very coarse sand (2 mm) at XS-6 (Middle) to medium gravel (16 mm) at XS-5 (Lower). Particle size distributions were similar at all three cross-sections in both 2011 and 2016. Data collected in 2019 at XS-5 indicates no change in particle size distribution since 2011. However, 2019 data shows the fining of material at XS-7 and XS-6 for the D_{16} and D_{50} particle size classes. It is possible that this difference is due to a different monitoring team in 2019 compared to 2011 and 2016, who may have detected more particles in fine size classes during sampling. Comparing photos of the bed at XS-6 between 2016 and 2019, the particle size of the bed does not appear to have visually changed significantly.

Table 2. Representative Bed Particle Sizes for Oyster Creek below Highway 88

Representative Particle Size (mm)	Monitoring Year	XS-7 (Upper)	XS-6 (Middle)	XS-5 (Lower)
D_{16}	2011	4.0	3.0	3.0
	2016	3.7	6.0	5.4
	2019	0.125	<0.06	4.0
D_{50}	2011	14.0	16.0	10.0
	2016	17.4	14.5	18.8
	2019	8.0	2.0	16.0
D_{84}	2011	25.0	26.0	19.2
	2016	39.2	29.3	34.3
	2019	32.0	16.0	32.0

4.4 BANK EROSION POTENTIAL

Bank erosion potential assessment scores for each cross sections' left and right bank at the study site are presented in **Table 3**. The 2019 bank erosion potential assessment showed that the banks ranged from low to very high erosion potential. Where the erosion potential score was moderate to very high, it was generally due to specific highly erosive conditions along the outer bank of channel bends. At these locations, more prone to shearing and slumping, resulting streambanks are eroded, steep, and exposed. All of the cross sections' bank erosion potential ratings remained static or improved as compared to the 2016 results.

Table 2. Bank Erosion Potential Analysis Scores for Oyster Creek below Highway 88

Bank Erosion Potential Index	Index Value					
	XS-7 (Upper) Left Bank	**XS-7 (Upper) Right Bank**	**XS-6 (Middle) Left Bank**	**XS-6 (Middle) Right Bank**	**XS-5 (Lower) Left Bank**	**XS-5 (Lower) Right Bank**
Bank Height/ Bankfull Height	10	1	1	10	10	10
Root Depth/ Bank Height	7	5	3	7	5	1
Root Bank Density (%)	8.5	3	3	7	5	3
Bank Angle (degrees)	5	5	1	7	3.5	4.5
Surface Protection (%)	7	1	3	8.5	3	1
Bank Material	0	0	0	0	0	0
Stratification	0	0	0	0	0	0
Sum Total	**37.5**	**15**	**11**	**39.5**	**26.5**	**19.5**
Erosion Potential Category	High	Low	Low	Very High	Moderate	Low

4.5 GENERAL GEOMORPHIC ASSESSMENT

Based on the monitoring data collected to date and described above the Oyster Creek site appears to have a relatively stable channel bed with steep banks and higher erosion potential specifically at the outside of channel bends. While the channel at the study site has remained relatively stable during the monitoring period between 2016 and 2019, continued erosion along exposed banks at outer channel bends that have experienced past erosion is a likely possibility during future high flow events.

5. LITERATURE CITED

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Wolman GM. 1954. A method of sampling coarse river-bed material. Transactions of the American Geophysical Union 35: 951–956.

Appendix A.
Oyster Creek Site Photographs

Photo No. 1	Date: 10/24/2019
Location: XS-7	
Description: Right bank at cross section. Dense herbaceous vegetation covers the bank.	

Photo No. 2	Date: 10/24/2019
Location: XS-7	
Description: Left bank at cross section. Vegetation is sparse with mostly exposed soil. Leaf litter and duff provide some erosive resistance.	

Appendix A.
Oyster Creek Site Photographs

Photo No. 3	Date: 10/24/2019
Location: XS-6	
Description: Facing downstream looking at XS-6. The right bank of XS-6 is on the outside bend of the creek resulting in severe erosion and steepening of the bank slope. Recent restoration efforts are visible along the right bank toe, e.g. the coir fiber rolls, and willow stakes.	

Photo No. 4	Date: 10/24/2019
Location: XS-6	
Description: View of XS-6 looking from the right bank to the left bank. A point bar and low gradient floodplain bench are on the left side of the channel (see arrow).	

Appendix A.
Oyster Creek Site Photographs

Photo No. 5	Date: 10/24/2019
Location: XS-6	
Description: View of the right bank at XS-6. Bank erosion potential analysis found this bank as very high erodibility. Erosion control and revegetation efforts were complete to reduce the erosion potential at this location.	

Photo No. 6	Date: 10/24/2019
Location: XS-6	
Description: Measured bed particle size decreased at XS-6 since the last assessment (2016). The median particle size at X-6 was coarse sand, but gravel and larger particles are also present.	

Appendix A.
Oyster Creek Site Photographs

Photo No. 7	Date: 10/24/2019
Location: XS-5	
Description: View of XS-5 looking from the right bank to the left bank.	

Photo No. 8	Date: 10/24/2019
Location: XS-5	
Description: Right bank at XS-5. Dense herbaceous vegetation covered the right bank.