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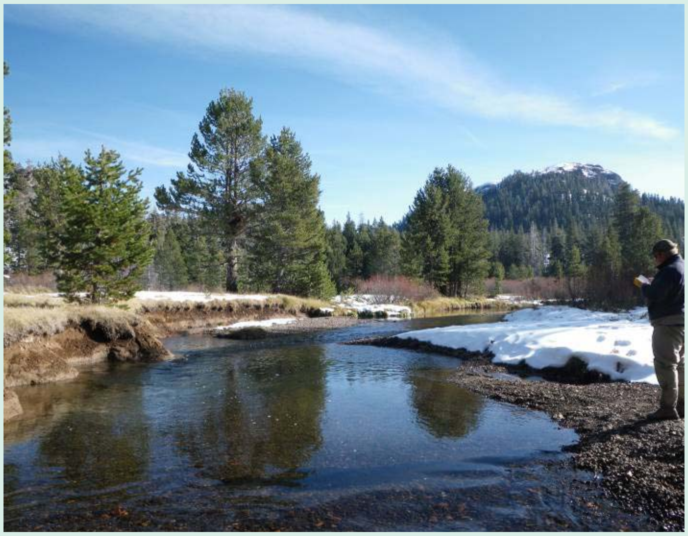
Geomorphic Monitoring of Representative Channel Areas for El Dorado Hydroelectric Project No. 184



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Cover photo: Field photos taken at the Caples Creek Meadow, Jake Schneider Meadow, and Lower Echo Creek monitoring sites.

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1 INTRODUCTION

The El Dorado Irrigation District (District) owns and operates the El Dorado Hydroelectric Project (Project No. 184), which is licensed by the Federal Energy Regulatory Commission (FERC). The Project No. 184 Monitoring Program[1] requires geomorphic monitoring at representative sites throughout the project area on a 5-year interval. The specific geomorphic monitoring requirements are defined in the Project No. 184 Geomorphology Continuing Evaluation of Representative Channel Areas Monitoring Plan (Plan; EID 2011), which was approved by FERC on October 6, 2011. The primary goal of this monitoring effort is to collect the necessary data to determine if the District is meeting geomorphic-specific objectives associated with Project No. 184 operations, which are:

1. To maintain or restore channel integrity; and
2. To maintain, improve, or restore fluvial processes that provide for balanced sediment transport, channel bed material mobilization and distribution, and channel structural stability, thereby contributing to aquatic habitat diversity and healthy riparian habitat.

In the fall of 2011, the District tasked Stillwater Sciences with conducting geomorphic monitoring pursuant with Plan at representative channel sites (Figure 1-1). Per the guidelines outlined in the Plan, geomorphic monitoring includes establishment and monitoring of permanent cross-sections, longitudinal profiles, and bed and bank properties at the following sites:

- Caples Creek Spillway Channel
- Caples Creek at Caples Meadow
- Caples Creek at Girl Scout Access
- Caples Creek at Jake Schneider Meadow
- Oyster Creek below Highway 88
- South Fork American River at Sand Flat
- Silver Fork American River at Forgotten Flat
- Lower Echo Creek

With the exception of Lower Echo Creek, all sites have established cross-sections and have had relevant geomorphic data collected within the past several years. The Plan therefore calls for re-occupying existing cross-sections where possible (to enable comparison with historical geomorphic data) and establish new cross-sections at Lower Echo Creek and other sites as needed (to establish baseline geomorphic conditions).

During the 2011 monitoring effort, considerable snow and duff accumulation combined with insufficient location data made finding existing cross-sections headpins at most sites extremely difficult. In addition, the snowstorms that passed through the study area in October and November curtailed the 2011 field efforts and prevented completion of all necessary data collection. As such, continued data collection is planned for 2012, once snow and ice have melted and access to the study sites has been restored.

[1] Section 7 of the El Dorado Relicensing Settlement Agreement, U.S. Forest Service 4(e) Condition No. 37, and California State Water Resources Control Board Section 401 Clean Water Act Water Quality Certification Condition No. 13

The purpose of this report is to present geomorphic monitoring data and comparisons with historical data at the sites where data collection was completed or mostly completed in 2011. Where appropriate, a general geomorphic assessment based on comparisons of historical and current geomorphic conditions is also given. Following the 2012 field effort, a follow-up geomorphic monitoring report addendum will be prepared to present the remaining data.

2 DATA COLLECTION & ANALYSIS METHODS

The methods used to conduct channel geomorphic monitoring at the representative sites surveyed in the fall of 2011 and subsequent analysis of the collected data followed the Plan.

2.1 Channel Cross-sections

Three cross-sections were surveyed at each representative site. At each cross-section, existing headpins (i.e., fixed elevation points at the each end of the cross-section) were relocated where possible, or established where previous headpins could not be located. Headpins were located sufficiently back from the top of bank to ensure that they are secure in the case of future bank erosion. The GPS position of at least one headpin for each cross-section was recorded to enable relocation during future monitoring efforts. At some sites, additional temporary benchmarks were established and their positions were recorded. Both a differential GPS (position error ≤ 3 ft) and hand-held GPS (position error ≥ 9 ft) were used to record headpin and benchmark locations.

The cross-section survey was conducted in sufficient detail to capture any change in grade and to characterize the channel geometry, following standard survey procedures established by the USDA Forest Service (Harrelson et al. 1994). This included capturing left and right bank water surface elevation, thalweg, approximate bankfull water surface elevation, and ground at both headpins. The survey approach ensured that all grade breaks across the channel cross-section were measured and referenced to a common arbitrary datum (e.g., at least one cross-section headpin). Channel photographs and field notes describing channel conditions were also taken during the cross-section survey.

Where possible, results from the cross-section surveys were compared with historical data to assess recent geomorphic change. Geomorphic change was assessed using two indices: 1) net percent change in channel area; and 2) absolute percent change in channel area. Net percentage change in area gives an indication of total change in channel area since the last survey, while absolute percentage change in area gives an indication of change in area for discrete portions of the channel cross-section since the last survey (i.e., an indication of how much bed elevation varies independent of any change in total channel area). The Plan provides more detail on the computations involved in determining each index.

2.2 Longitudinal Profiles

A longitudinal profile of the channel thalweg through the cross-section locations was surveyed at representative sites for a minimum distance of ten times the bankfull width, where feasible. In some instances, profile length was limited by the distance that could be safely surveyed or the length that was most appropriate for characterizing the site. The longitudinal profile survey included bed elevation measurements, which were referenced to the local datum used for the cross-section survey. The longitudinal profile survey followed procedures established by the

USDA Forest Service (Harrelson et al.1994), including surveying a sufficient number of points with which to capture the topography of pool, riffles, and other habitat features, as well as other significant breaks in channel gradient.

Longitudinal profile data were used to determine reach-average slope. Where historical data were available, the current longitudinal profile was compared to historical data to assess changes in slope and identify areas of local channel aggradation or incision.

2.3 Bed Particle Size Distributions

Along each cross section, a pebble count (Wolman 1954) was performed to characterize bed particle size distribution. The count entailed measuring the intermediate axis (b-axis) of a minimum of 100 particles as a means of classifying the bed particle size distribution. For the sake of simplicity, all silt- and sand-sized particles were classified as < 2mm. The dominant lithology was also noted and a photograph that best presented the bed particle size distribution was taken.

Bed particle size distribution data were used to determine commonly-used representative bed particle sizes: the particle size for which 16% of the distribution is finer (D_{16}), the particle size for which 50% of the distribution is finer (D_{50}, or the median size), and the particle size for which 84% of the distribution is finer (D_{84}). Where possible, these data were compared with historical data to assess any recent trends in bed coarsening or fining.

2.4 Bank Erosion Potential Assessments

A Rosgen (1996) analysis of bank erosion potential was also performed at each cross section. Determining bank erosion potential involved developing an erosion potential 'score' for five bank characteristics: 1) bank height/bankfull height; 2) root depth/bank height; 3) root density; 4) bank angle; and 5) an assessment of surface protection. Additional secondary characteristics included 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 score < 9.5) to extreme (total score > 50). As both banks were usually similar at the surveyed cross-sections, the erosion potential analysis covers both banks unless otherwise noted. At cross-sections where the banks were noticeably different with respect to erosion potential, the erosion potential assessment was focused on the less stable bank.

2.5 General Geomorphic Assessment

Following data compilation and analysis, a general geomorphic assessment was developed for those sites where data collection was mostly complete and where historical data at the cross-sections existed. The assessment gives a broad indication of geomorphic change over the past 5 years based solely on comparisons of current and historical field data.

3 DATA ANALYSIS & DISCUSSION

3.1 Caples Creek at Caples Meadow

3.1.1 General site description

The Caples Creek at Caples Meadow study site is an approximately 600 ft long reach of Caples Creek located immediately downstream of the confluences with Kirkwood Creek and the Caples Lake Spillway channel (Figure 3-1). At the Kirkwood Creek confluence, the Caples Creek watershed drainage area is approximately 18.6 mi^2 with approximately three-quarters of the drainage area controlled by Caples Lake (Cardno Entrix 2011). The channel through the site has a pool-riffle morphology, a moderate to highly sinuous planform, a relatively low gradient, and is moderately entrenched within a meadow floodplain.

Other than local snowmelt runoff, instream flows within Caples Meadow are primarily affected by the flow releases from Caples Dam. In general, dam operations tend to cause a decreased spring baseflow and increased summer baseflow compared to what would be expected under unregulated conditions. For the period between 1922 and 2000, mean monthly flows downstream of Caples Dam (USGS gage 11436999) ranged from 11 cfs for March to 84 cfs for June (EID 2003). Over the past 5 years, daily mean flow at that same gage has ranged from less than 3 cfs (due to emergency repairs) to over 400 cfs, with an average value of approximately 20 cfs (Figure 3-2). The highest flows occurred during the recent pulse flow releases in June 2010 and June 2011 (peak daily mean flow of 337 cfs and 429 cfs, respectively).

3.1.2 Channel cross-sections

The Caples Creek at Caples Meadow study site's cross-sections for 2007 and 2011 are shown in Figures 3-3 through 3-5 and change metrics are summarized in Table 3-1. The compilation of cross-section photos for this site is provided in Appendix A. At this site, three cross-sections surveyed in 2007 were re-occupied. All sites show some net aggradation, with XS-2 having the most change by far out of all of the cross-sections. This is due primarily to the growth of the left bank bar. All sites show a similar degree of absolute percent change, indicating a similar amount of bed elevation variability (i.e., localized scour and deposition) at each cross-section.

Table 3-1. Summary of cross-section change metrics for Caples Creek at Caples Meadow.

Channel cross-section change metric	XS-1 (Upper)	XS-2 (Middle)	XS-3 (Lower)
Net % change in channel area	3%	27%	12%
Absolute % change in channel area	26%	29%	26%

3.1.3 Longitudinal profile

The Caples Creek at Caples Meadow longitudinal profiles for 2007 and 2011 are shown in Figure 3-6. The 2011 profile is approximately 20 bankfull widths in length (605 ft) and extends approximately 140 ft upstream of XS-1 and approximately 100 ft downstream of XS-3. Comparison of the 2007 and 2011 profiles shows a slight increase in reach-average slope (from 0.0027 to 0.0032) and some noticeable increases in bed elevation just upstream of XS-2 (likely associated with localized bar deposition) and decrease in bed elevation upstream and downstream of XS-3, associated with apparent localized pool scour.

3.1.4 Bed particle size distributions

The Caples Creek at Caples Meadow study site bed particle size distribution data for 2007 and 2011 are shown in Figures 3-7 to 3-9 and representative sizes are shown in Table 3-2. The compilation of bed sediment photos for each cross-section surveyed at this site is provided in Appendix A. The 2011 data show that the bed is predominantly finer than very coarse gravel (< 32 mm) with the median particle size at all cross-sections being medium to coarse gravel (between 11 and 18 mm). The current bed sediment lithology is a mixed lithology and predominantly granitic. Comparison of 2011 data with 2007 data at XS-1 shows very little to essentially no change in the bed sediment size over the past 5 years.

Table 3-2. Representative bed particle sizes for Caples Creek at Caples Meadow.

Representative particle size (mm)	Monitoring year	XS-1 (Upper)	XS-2 (Middle)	XS-3 (Lower)
D_{16}	2007	2	--	--
	2011	3	3	5
D_{50}	2007	14	--	--
	2011	11	11	18
D_{84}	2007	26	--	--
	2011	23	22	29

3.1.5 Bank erosion potential

The Caples Creek at Caples Meadow study site current bank erosion potential assessment for each cross-section surveyed is summarized in Table 3-3. The assessment shows that the banks at the upper and middle cross-sections (XS-1 and XS-2) are currently relatively stable, but that the lower cross-section (XS-3) has banks with a relatively high erosion potential. The high score at XS-3 is mostly due to the fact that the flow is concentrated on the right bank during high flow events, resulting in an actively eroding cut bank.

Table 3-3. Bank erosion potential analysis scores for Caples Creek at Caples Meadow.

Bank erosion potential index	Index value[1]		
	XS-1 (Upper)	XS-2 (Middle)	XS-3 (Lower)
Bank height/bankfull height	1	1	1.5
Root depth/bank height	2	2	7.9
Root bank height (%)	1.5	1.5	7.9
Bank angle (degrees)	3	3	3
Surface protection (%)	1.5	1.5	7.9
Bank material[2]	0	0	5
Stratification[3]	0	0	0
SUM	9	9	33.2
Erosion potential category	Very low	Very low	High

[1] It should be noted that these index values are approximate and based on conformance with a qualitative assessment methodology.

[2] Value based on material type. In general, finer bank material is associated with a higher index value. See Rosgen (1996) for more detail.
[3] In general, more stratification is associated with a higher index value. See Rosgen (1996) for more detail.

3.1.6 General geomorphic assessment

Based on the comparison of historical and current data, the Caples Creek at Caples Meadow study site appears to be currently stable to moderately aggradational overall, with areas of local scour.

3.2 Caples Creek at Girl Scout Access

3.2.1 General site description

The Caples Creek at Girl Scout Access study site is located approximately 0.4 miles downstream of the Caples Meadow study site (Figure 3-10). The channel and adjacent meadow floodplain at the site are constrained by bedrock, which essentially 'locks' the channel position in place. The channel has pool-riffle morphology, a low degree of sinuosity, and a relatively low reach-average gradient.

Similar to the Caples Meadow site, instream flows at the Girl Scout Access site are affected primarily by Caples Dam flow releases. As there is not much drainage area difference between the Caples Meadow and the Girl Scout Access sites, it is likely that flows at the two sites are very similar.

3.2.2 Channel cross-sections

The Caples Creek at Girl Scout Access study site's cross-sections for 2007 and 2011 are shown in Figures 3-11 to 3-13 and change metrics are summarized in Table 3-4. The compilation of cross-section photos for this site is provided in Appendix A. At this site, three cross-sections surveyed in 2007 were re-occupied. The channel bed at XS-3 shows moderate channel incision (i.e., negative net percent change in channel area) over the past 5 years, and a moderate amount of absolute percent change. This indicates that the entire bed essentially incised in a uniform fashion across the width of the cross-section, which is also evident from the cross-section comparison plot (Figure 3-11). Cross-sections XS-B and XS-C both show a similar degree of very low net percent change (i.e., very little bed elevation change) and low absolute percent change (i.e., modest bed elevation variability).

Table 3-4. Summary of cross-section change metrics for Caples Creek at Girl Scout Access.

Channel cross-section change metric	XS-3 (Upper)	XS-B (Middle)	XS-C (Lower)
Net % change in channel area	-20%	1.5%	4.2%
Absolute % change in channel area	21%	11%	11%

3.2.3 Longitudinal profile

The Caples Creek at Girl Scout Access study site's longitudinal profile for 2011 is shown in Figure 3-14. The 2011 profile is a bit more than 10 bankfull widths in length (400 ft), extends approximately 175 ft upstream from XS-3 and approximately 30 ft downstream from XS-C, and has a reach-average slope of 0.0016. As 2007 longitudinal profile data for this site was not available, an assessment of longitudinal profile change over the past 5 years was not conducted.

3.2.4 Bed particle size distributions

The Caples Creek at Girl Scout Access study site's bed particle size distribution data for 2007 and 2011 are shown in Figures 3-15 to 3-17 and representative sizes are shown in Table 3-2. Bed particle size data were not collected at cross-sections XS-B or XS-C in 2007. The compilation of bed sediment photos for each cross-section surveyed at this site is provided in Appendix A. The 2011 data show that the bed is predominantly finer than very coarse gravel (< 32 mm), with the median particle size at all cross-sections being medium gravel (< 16 mm). The current bed sediment lithology is a mixed lithology and predominantly granitic. Comparison of 2011 data with 2007 data at XS-3 shows a noticeable fining of the bed sediment size over the past 5 years. This is likely due to the fact that XS-3 is within a pool where finer sediment deposits between high flow events.

Table 3-5. Representative bed particle sizes for Caples Creek at Girl Scout Access.

Representative particle size (mm)	Monitoring year	XS-3 (Upper)	XS-B (Middle)	XS-C (Lower)
D_{16}	2007	5	--	--
	2011	2	3	4
D_{50}	2007	12	--	--
	2011	6	13	15
D_{84}	2007	26	--	--
	2011	18	33	28

3.2.5 Bank erosion potential

The Caples Creek at Girl Scout Access study site's current bank erosion potential assessment for each cross-section surveyed is summarized in Table 3-6. The assessment shows that all banks have the essentially the same degree of moderate bank erosion potential.

Table 3-6. Bank erosion potential analysis scores for Caples Creek at Girl Scout Access.

Bank erosion potential index	Index value[1]		
	XS-3 (Upper)	XS-B (Middle)	XS-C (Lower)
Bank height/bankfull height	1.9	1.9	1
Root depth/bank height	3.5	3.5	3.9
Root bank height (%)	3.5	3.5	3.9
Bank angle (degrees)	3.9	3.9	3.9
Surface protection (%)	3.5	2.5	2.5
Bank material[2]	5	5	5
Stratification[3]	0	0	0
SUM	21.3	20.3	20.2
Erosion potential category	Moderate	Moderate	Moderate

[1] It should be noted that these index values are approximate and based on conformance with a qualitative assessment methodology.
[2] Value based on material type. In general, finer bank material is associated with a higher index value. See Rosgen (1996) for more detail.
[3] In general, more stratification is associated with a higher index value. See Rosgen (1996) for more detail.

3.2.6 General geomorphic assessment

Based on the comparison of historical and current data, the Caples Creek at Girl Scout Access study site appears overall to be moderately stable to stable, with some localized erosion at the pool near the upstream end of the reach.

3.3 Caples Creek at Jake Schneider Meadow

3.3.1 General site description

The Caples Creek at Jake Schneider Meadow study site is located approximately 6 miles downstream of the Girl Scout Access site (Figure 3-18). The drainage area to the site is approximately 30 mi^2, with a little less than half the drainage area regulated by Caples Lake (Cardno Entrix 2011). The channel through the site has pool-riffle morphology, a moderately sinuous planform, a low channel gradient, and is moderately entrenched. The large perched meadow on the right bank floodplain is more than 100 ft from the channel and appears inundated by overbank flow only during extreme high flow events.

Similar to both Caples Meadow and Girl Scout Access study sites, instream flows at Jake Schneider Meadow are affected by flow releases from Caples Dam. However, Jake Schneider has a much larger drainage area than either of the upstream sites and therefore is more influenced by localized runoff during snowmelt conditions and rain-on-snow events. For example, previous field observations suggest that the 1997 flood event caused considerable bank erosion and other geomorphic change at this site (Cardno Entrix 2011).

3.3.2 Channel cross-sections

The Caples Creek at Jake Schneider Meadow study site's cross-sections for 2007 and 2011 are shown in Figures 3-19 through 3-21 and change metrics are summarized in Table 3-7. The compilation of cross-section photos for this site is provided in Appendix A. At this site, three cross-sections surveyed in 2007 were re-occupied. All three cross-sections show very little net percent change and a similar low degree of absolute percent change over the past 5 years.

Table 3-7. Summary of cross-section change metrics for Caples Creek at Jake Schneider Meadow.

Channel cross-section change metric	XS-B (Upper)	XS-C (Middle)	XS-2[1] (Lower)
Net % change in channel area	-0.3%	1.6%	-3.6%
Absolute % change in channel area	6%	6%	7%

[1] A discrepancy with the survey stationing along the right bank resulted in the cross-section comparison extending from the left bank endpin to just the base of the right bank.

3.3.3 Longitudinal profile

The Caples Creek at Jake Schneider Meadow study site's longitudinal profiles for 2007 and 2011 are shown in Figure 3-22. The 2011 profile is approximately 10 bankfull widths in length (580 ft) and extends approximately 200 ft upstream from XS-B and approximately 150 ft downstream from XS-2. Comparison of the 2007 and 2011 profiles shows a decrease in reach-average slope (from 0.0022 to 0.0014) and some noticeable decreases in bed elevation at a deep scour pool between XS-B and XS-2.

3.3.4 Bed particle size distributions

The Caples Creek at Jake Schneider Meadow study site's bed particle size distribution data for 2007 and 2011 are shown in Figures 3-23 to 3-25 and representative sizes are shown in Table 3-8. Bed particle size data were not collected at cross-sections XS-C or XS-2 in 2007. The compilation of bed sediment photos for each cross-section surveyed at this site is provided in Appendix A. The 2011 data shows considerable variability among sampled cross-sections, indicating the differences in channel geomorphic features. The D_{50} currently ranges from fine gravel (5 mm) at XS-C (tail end of a run) to very coarse gravel (58 mm) at XS-2 (riffle crest). The D_{84} ranges from medium gravel (16 mm) at XS-C to fine cobble (104 mm) at XS-2. The current bed sediment lithology at all cross-sections is a mixed lithology and predominantly granitic. Comparison of 2011 data with 2007 data at XS-1 shows a noticeable coarsening of the bed sediment size over the past 5 years at XS-B. This is likely due to the fact that XS-B is located at a riffle that has been flushed of finer sediment during several high flow events over the past few years.

Table 3-8. Representative bed particle sizes for Caples Creek at Jake Schneider Meadow.

Representative particle size (mm)	Monitoring year	XS-B (Upper)	XS-C (Middle)	XS-2 (Lower)
D_{16}	2007	6	--	--
	2011	1	1	3
D_{50}	2007	11	--	--
	2011	18	5	58
D_{84}	2007	18	--	--
	2011	47	16	104

3.3.5 Bank erosion potential

The Caples Creek at Jake Schneider Meadow study site's current bank erosion potential assessment for each cross-section surveyed is summarized in Table 3-9. The assessment shows that all banks have essentially the same degree of low bank erosion potential.

Table 3-9. Bank erosion potential analysis scores for Caples Creek at Jake Schneider Meadow.

Bank erosion potential index	**Index value**[1]		
	XS-B[2] **(Upper)**	**XS-C (Middle)**	**XS-2 (Lower)**
Bank height/bankfull height	1.5	1	1
Root depth/bank height	1.9	1.9	3
Root bank height (%)	1.5	1.5	2.5
Bank angle (degrees)	4.3	3	4.2
Surface protection (%)	3	2.5	1.9
Bank material[3]	0	0	0
Stratification[4]	0	0	0
SUM	12.2	9.9	12.6
Erosion potential category	Low	Low	Low

1. It should be noted that these index values are approximate and based on conformance with a qualitative assessment methodology.
2. Assessment is focused on the left bank. The right bank appears to have a very low erosion potential.
3. Value based on material type. In general, finer bank material is associated with a higher index value. See Rosgen (1996) for more detail.
4. In general, more stratification is associated with a higher index value. See Rosgen (1996) for more detail.

3.3.6 General geomorphic assessment

Based on the comparison of historical and current data, the Jake Schneider Meadow site appears to be moderately stable to stable, with some coarsening occurring at the riffle near the upstream end of the reach and some scouring at a pool near the downstream end of the reach.

3.4 Oyster Creek below Highway 88

3.4.1 General site description

The Oyster Creek below Highway 88 study site is located approximately 1,500 ft downstream of where Highway 88 crosses over the creek (Figure 3-26). The channel through the site flows along the southern border of a low gradient meadow. The channel has pool-riffle morphology, a moderately to highly sinuous planform, a moderate channel gradient, and is entrenched within the meadow floodplain. A well developed low elevation terrace observed during 2007 field investigations (Blue Line Consulting 2009) is still intact and currently supports willow and conifer stands.

Instream flows at the Oyster Creek study site are affected by natural hydrologic processes, leakage from Silver Lake, and local road drainage. Leakage from Silver Lake and local road drainage have increased instream flows in Oyster Creek compared to historical conditions. A recent assessment of daily mean flow shows average monthly values range from 1 to 2 cfs during the winter months to approximately 15 cfs during the summer months (Blue Line Consulting 2009). During storms, the highway drainage system concentrates a considerable amount of road runoff into Oyster Creek at the Highway 88 bridge, resulting in a large pulse of water entering the channel downstream of the bridge (EID 2003).

3.4.2 Channel cross-sections

The Oyster Creek below Highway 88 study site's cross-sections for 2007 and 2011 are shown in Figures 3-27 through 3-29 and change metrics are summarized in Table 3-10. The compilation of cross-section photos for this site is provided in Appendix A. At this site, three cross-sections surveyed in 2007 were re-occupied. All cross-sections show a low degree of net percent change in channel area (with XS-6 showing net incision), but the degree of absolute percent change in channel area varies from moderate (XS-5) to low (XS-7). In fact, the low degree of net percent change at XS-5 is misleading; examination of the cross-section plots for XS-5 suggests that there is active left bank erosion and channel aggradation occurring. The negative net percent change at XS-6 is associated with active erosion along the right bank where the bank has retreated approximately 6 feet.

Table 3-10. 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 % change in channel area	1%	-7%	4%
Absolute % change in channel area	4%	14%	20%

3.4.3 Longitudinal profile

An Oyster Creek below Highway 88 longitudinal profile survey could not be conducted during the 2011 field effort due to snow and ice conditions. The survey is planned to occur during a follow-up field effort in 2012.

3.4.4 Bed particle size distributions

The Oyster Creek below Highway 88 study site's bed particle size distribution data for 2007 and 2011 are shown in Figures 3-30 to 3-32 and representative sizes are shown in Table 3-11. Bed particle size data were not collected at cross-sections XS-6 or XS-7 in 2007. The compilation of bed sediment photos for each cross-section surveyed at this site is provided in Appendix A. The 2011 particle size distribution data is very similar for all cross-sections, showing that the bed is medium gravel (< 32 mm) with the median particle size at all cross-sections being medium gravel (between 10 and 16 mm). The current bed sediment lithology is a mixed lithology and predominantly granitic. The bed particle size data at XS-1 show considerable fining over the past 5 years, most likely due to fine sediment input from eroding cutbanks.

Table 3-11. 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}	2007	15	--	--
	2011	4	4	3
D_{50}	2007	35	--	--
	2011	14	16	10
D_{84}	2007	78	--	--
	2011	25	26	20

3.4.5 Bank erosion potential

The Oyster Creek below Highway 88 study site's current bank erosion potential assessment for each cross-section surveyed is summarized in Table 3-12. The assessment shows that bank erosion potential ranges from moderate to high, with the lower two cross-sections having the highest bank erosion potential. The moderate to high channel sinuosity causes flow acceleration and high shear stresses at channel bends, resulting in steep, exposed banks that have a moderate to high bank erosion potential.

Table 3-12. Bank erosion potential analysis scores for Oyster Creek below Highway 88.

Bank erosion potential index	Index value[1]		
	XS-7 (Upper)	XS-6[2] (Middle)	XS-5 (Lower)
Bank height/bankfull height	5.9	5.9	7.5
Root depth/bank height	5.9	7.9	2.5
Root bank height (%)	5.9	7.9	3.7
Bank angle (degrees)	3.9	5	3.9
Surface protection (%)	2.5	6.5	2.5
Bank material[3]	0	0	5
Stratification[4]	0	5	5
SUM	24.1	38.2	30.1
Erosion potential category	Moderate	High	High

[1] It should be noted that these index values are approximate and based on conformance with a qualitative assessment methodology.
[2] Assessment is focused on the right bank. The left bank appears to have a very low to low erosion potential.
[3] Value based on material type. In general, finer bank material is associated with a higher index value. See Rosgen (1996) for more detail.
[4] In general, more stratification is associated with a higher index value. See Rosgen (1996) for more detail.

3.4.6 General geomorphic assessment

Based on the comparison of historical and current data, the Oyster Creek site appears to have a relatively stable channel bed elevation with steep banks and high erosion potential at meander bends.

3.5 Lower Echo Creek

3.5.1 General site description

The Lower Echo Creek study site is approximately 1,000 ft long and is located between the South Upper Truckee Road bridge crossing and the confluence with the Upper Truckee River (Figure 3-33). The channel is located atop a forested depositional alluvial fan deposit and splits into two distributary channels less than 200 ft downstream from the South Upper Truckee Road bridge crossing. Channels within this type of depositional geomorphic environment tend to migrate quite readily and are therefore unstable with respect to position. The channels have a forced pool-riffle morphology, are relatively shallow and steep, and have a moderate degree of sinuosity.

Instream flows at the Lower Echo Creek study site are affected by natural hydrologic processes associated with snowmelt and spring runoff events as well as flow regulation at Echo Lake.

Simulated average monthly flows for a normal water year (i.e., long-term average conditions) shows the highest daily mean flows occur in January, followed by April, May, and July (EID 2003).

3.5.2 Channel cross-sections

The Lower Echo Creek site's cross-sections for 2011 are shown in Figures 3-34 through 3-36. The compilation of cross-section photos for this site is provided in Appendix A. Since there are no existing cross-sections or geomorphic study sites on Lower Echo Creek, new cross-sections were established. Every effort was made to establish long-term monitoring cross-sections that can be considered representative of average reach-wide conditions.

The upper cross-section (XS-0) was established approximately 100 ft upstream of the channel split, the middle cross-sections (XS-1L and XS1-R) were established in both channels approximately 500 ft downstream of the channel split, and the lower cross-sections (XS-2L and XS-2R) were established approximately 700 ft downstream of the channel split. The channel bed through XS-0 appears moderately stable if not aggradational, and the creek appears to overflow its banks somewhat regularly at this location. Downstream of the channel split at the middle and lower cross-sections, the channel bed also appears moderately stable, with the left channel appears more incised than the right channel.

3.5.3 Longitudinal profile

A longitudinal profile survey of Lower Echo Creek was not conducted during the 2011 field effort due to snow and ice conditions. The survey is planned to occur during a follow-up field effort in 2012.

3.5.4 Bed particle size distributions

The Lower Echo Creek bed particle size distribution data for 2011 are shown in Figures 3-37 to 3-41, and representative sizes are shown in Table 3-13. The compilation of bed sediment photos for each cross-section surveyed at this site is provided in Appendix A. The 2011 particle size distribution data show considerable variability among cross-sections. The bed is coarsest at the upstream cross-section and shows some fining moving downstream. Downstream of the channel split, it appears that the left channel coarsens moving downstream (D_{50} increases from 24 mm to 65 mm) while the right channel bed sediment size stays the same size (D_{50} is 42 mm). The current bed sediment lithology is a mixed lithology and predominantly granitic.

Table 3-13. Representative bed particle sizes for Lower Echo Creek.

Representative particle size (mm)	Monitoring year	XS-0 (Upper)	XS-1L (Middle)	XS-1R (Middle)	XS-2L (Lower)	XS-2R (Lower)
D_{16}	2007	--	--	--	--	--
	2011	7	4	6	30	19
D_{50}	2007	--	--	--	--	--
	2011	72	24	42	65	42
D_{84}	2007	--	--	--	--	--
	2011	116	90	82	110	90

3.5.5 Bank erosion potential

The Lower Echo Creek site's current bank erosion potential assessment for each cross-section surveyed is summarized in Table 3-14. The assessment shows that all banks have a low to very low bank erosion potential.

Table 3-14. Bank erosion potential analysis scores for Lower Echo Creek.

Bank erosion potential index	Index value[1]				
	XS-0 (Upper)	XS-1L (Middle)	XS-1R (Middle)	XS-2L (Lower)	XS-2R (Lower)
Bank height/bankfull height	1.5	4	1	1.5	0.95
Root depth/bank height	1	2.75	3.9	2.75	3
Root bank height (%)	1.9	1.9	4.5	1.9	2.5
Bank angle (degrees)	2.75	5.9	6	3.9	5
Surface protection (%)	1.75	1.75	1.5	1.75	1.75
Bank material[2]	0	0	0	0	0
Stratification[3]	0	0	0	0	0
SUM	8.9	16.3	16.9	11.8	13.2
Erosion potential category	Very Low	Low	Low	Low	Low

[1] It should be noted that these index values are approximate and based on conformance with a qualitative assessment methodology.
[2] Value based on material type. In general, finer bank material is associated with a higher index value. See Rosgen (1996) for more detail.
[3] In general, more stratification is associated with a higher index value. See Rosgen (1996) for more detail.

3.5.6 General geomorphic assessment

There is no historical data at this site for comparison, so no general geomorphic assessment is provided. However, observations from the 2011 field campaign suggest the channel currently has moderately stable to stable channel morphology (e.g., moderately stable to stable bed elevation and low bank erosion potential throughout).

4 NEXT STEPS

As mentioned above, a 2012 field effort will be required to complete the geomorphic monitoring at sites where data collection was not possible due to snow and ice conditions. The 2012 field effort will occur once sites can be safely accessed. Remaining data collection includes the following:

- **Oyster Creek below Highway 88** – longitudinal profile survey
- **Lower Echo Creek** – longitudinal profile survey and GPS survey of headpins
- **South Fork American River at Sand Flat** –cross-section survey completion, longitudinal profile survey, pebble counts, GPS survey of headpins, and bank stability assessment
- **Silver Fork American River at Forgotten Flat** – cross-section survey completion, longitudinal profile survey, pebble counts, GPS survey of headpins, and bank stability assessment.
- **Caples Spillway Channel** – longitudinal profile survey, pebble counts, GPS survey of headpins, and bank stability assessment.

Following the 2012 field effort, newly-collected data will be compiled and appropriate geomorphic analyses for summarizing current conditions and assessing change over the past 5 years (as appropriate) will be conducted. A follow-up report addendum that presents only the new data and analyses will then be prepared.

5 LITERATURE CITED

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Figures

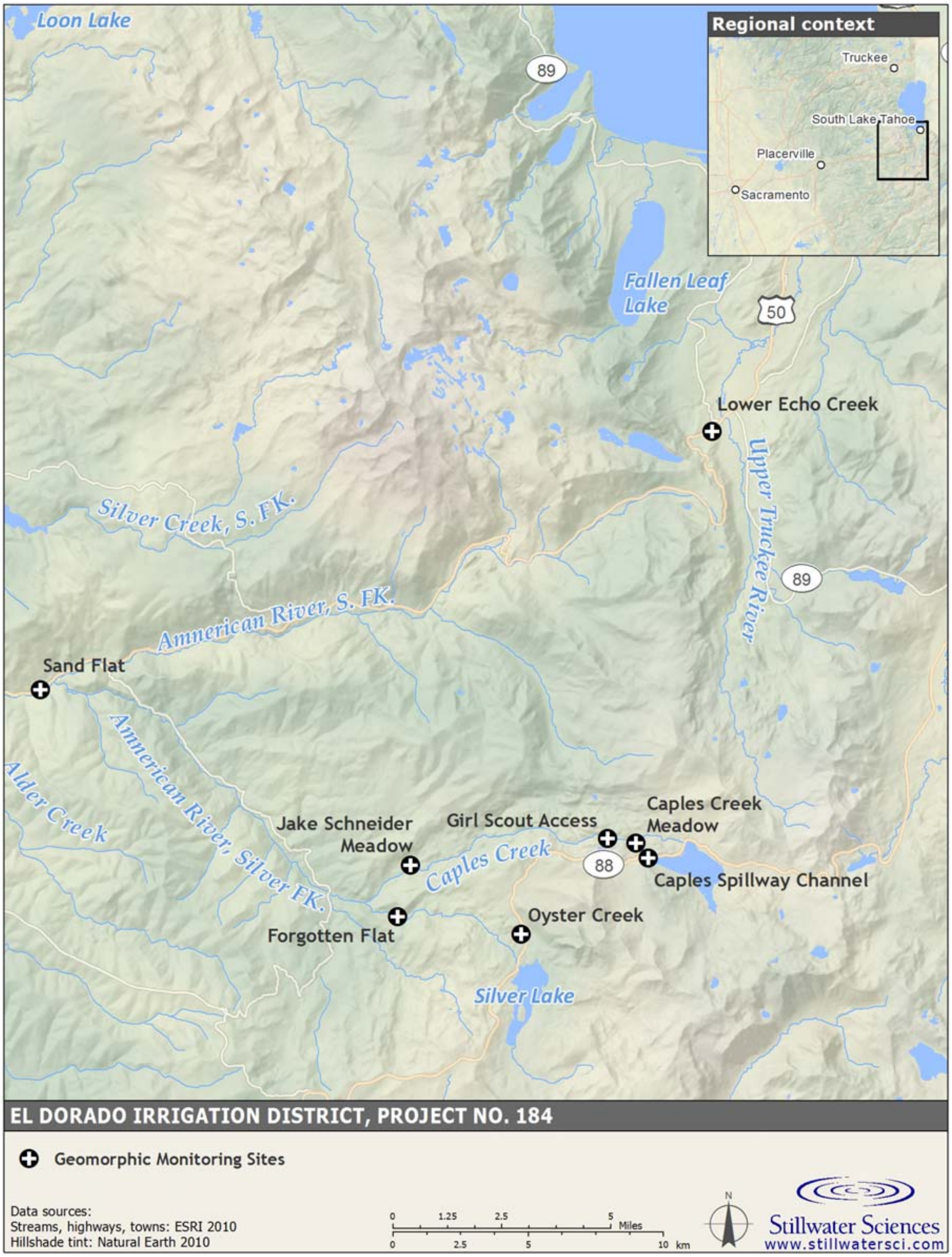


Figure 1-1. Map of geomorphic monitoring sites.

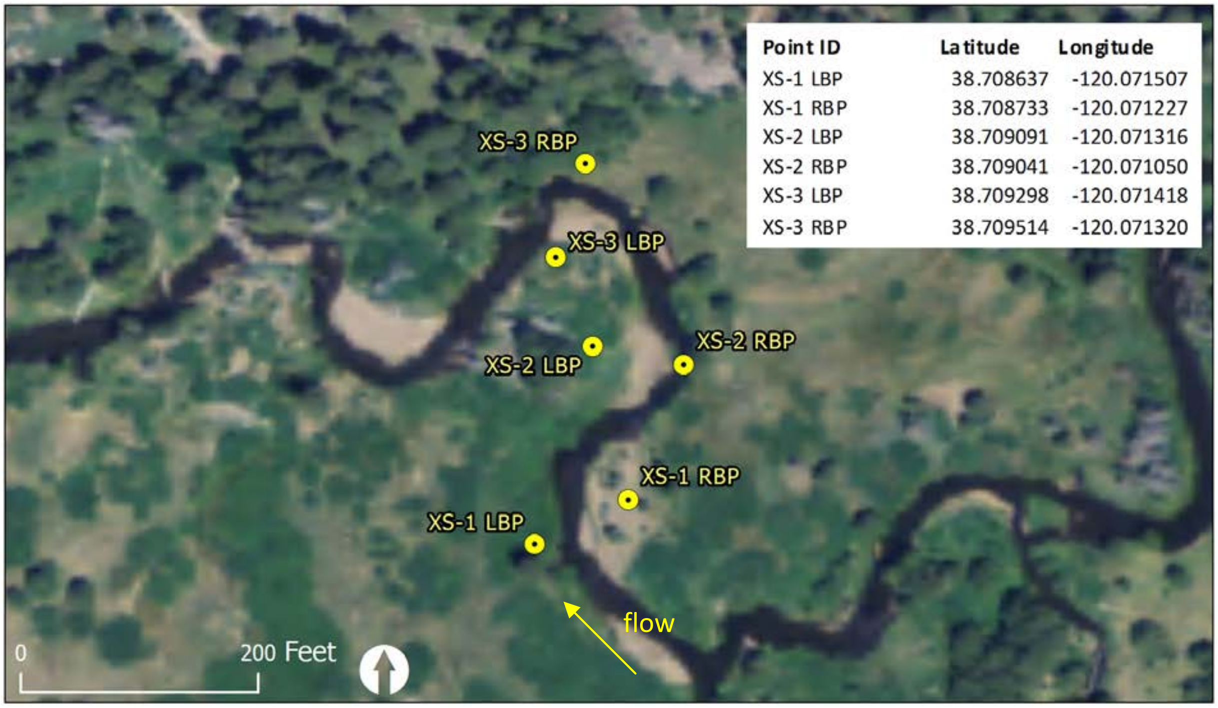


Figure 3-1. Site map of Caples Meadow site showing cross-section endpins and coordinates (in decimal degrees). LBP is left bank pin and RBP is right bank pin.

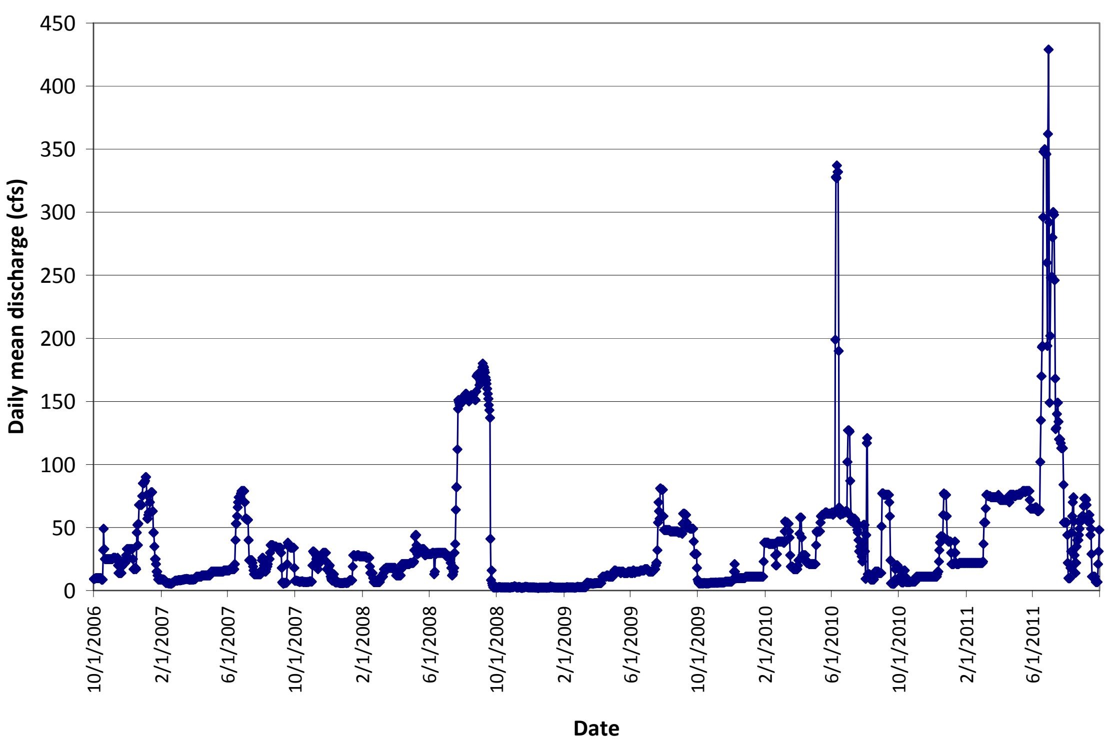


Figure 3-2. Daily mean flow at USGS gage 11436999 (Caples Creek below Caples Dam) for WY 2007 through 2011. This dataset does not include spill from Caples Dam.

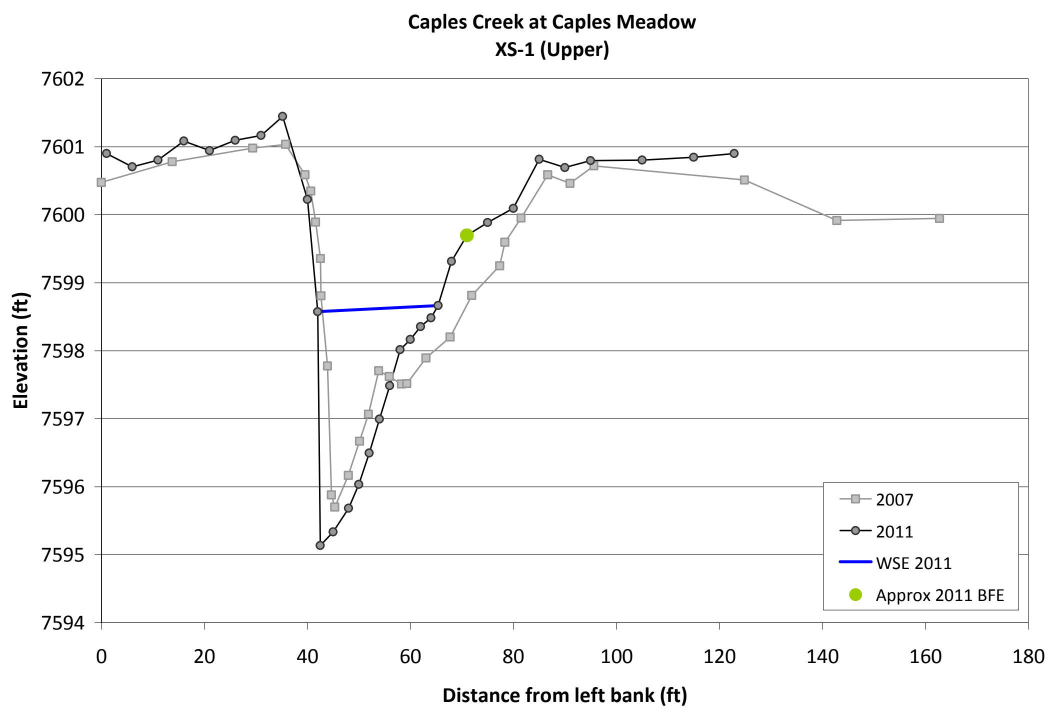


Figure 3-3. Caples Creek at Caples Meadow XS-1 survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

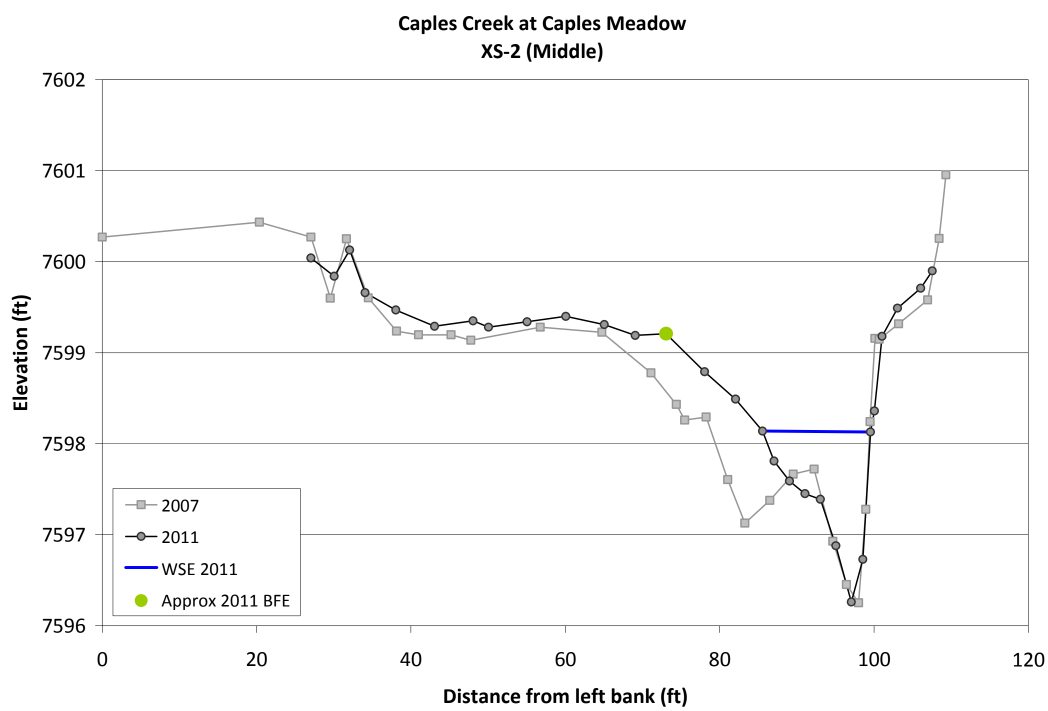


Figure 3-4. Caples Creek at Caples Meadow XS-2 survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

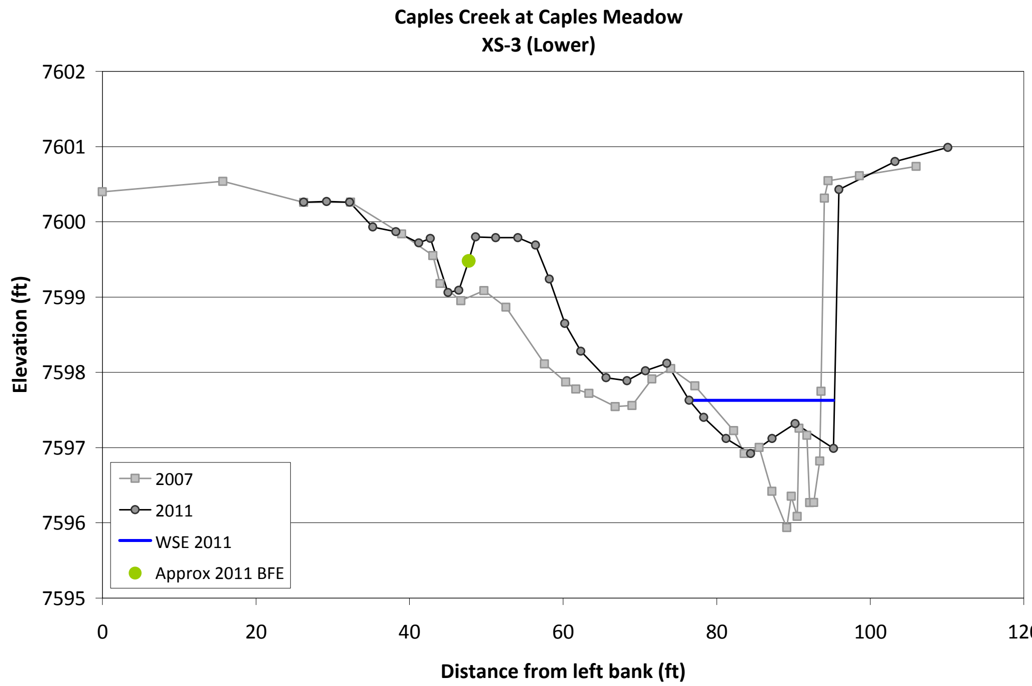


Figure 3-5. Caples Creek at Caples Meadow XS-3 survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

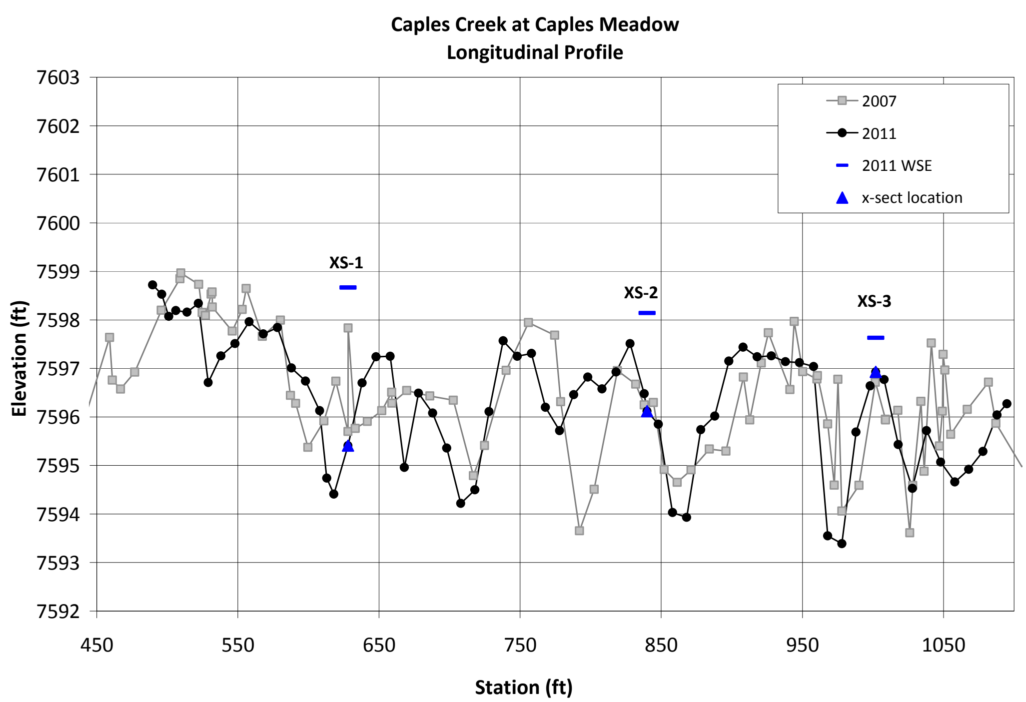


Figure 3-6. Caples Creek at Caples Meadow longitudinal profile. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation.

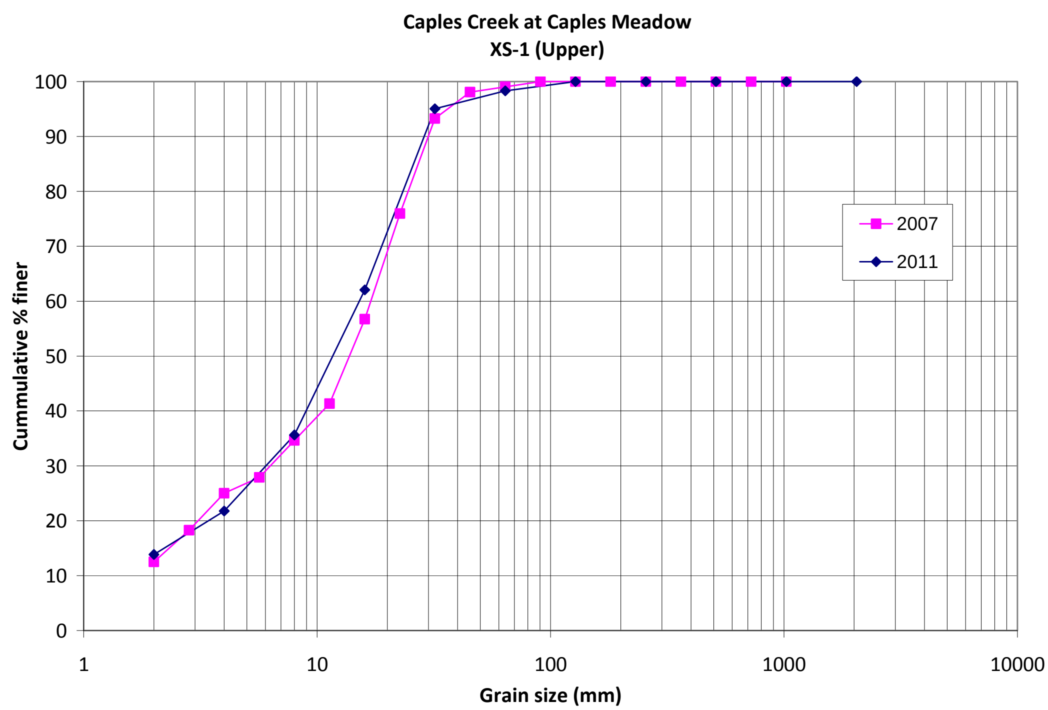


Figure 3-7. Caples Creek at Caples Meadow XS-1 bed particle size distribution.

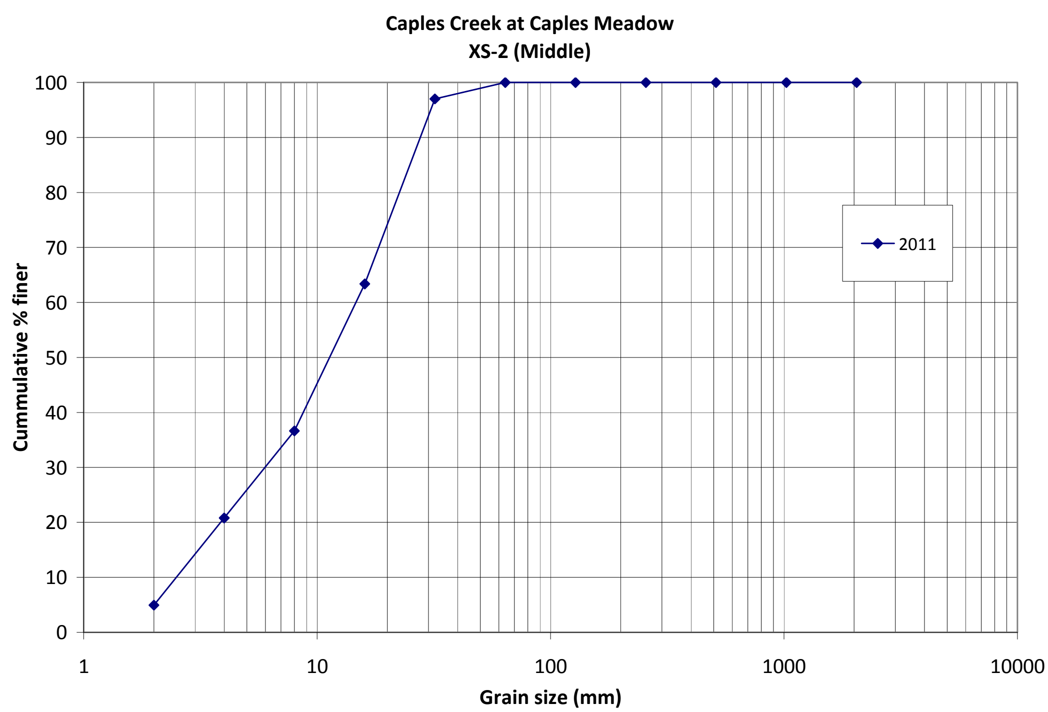


Figure 3-8. Caples Creek at Caples Meadow XS-2 bed particle size distribution.

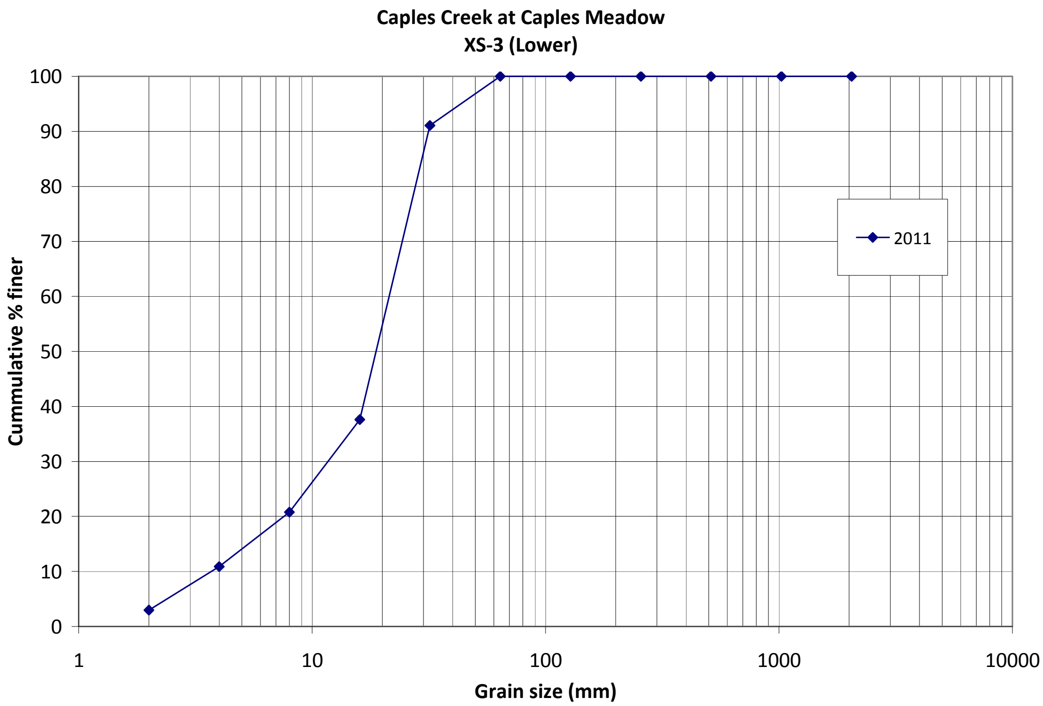


Figure 3-9. Caples Creek at Caples Meadow XS-3 bed particle size distribution.

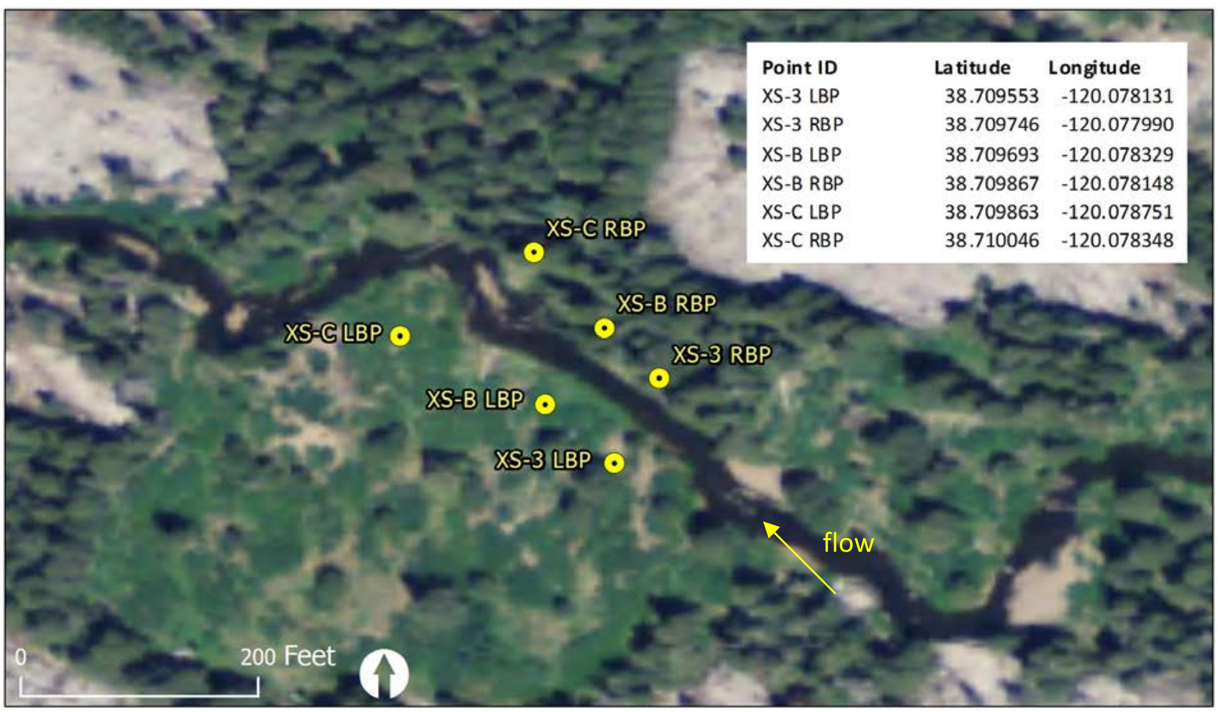


Figure 3-10. Site map of Girl Scout Access site showing cross-section endpins and coordinates (in decimal degrees). LBP is left bank pin and RBP is right bank pin. The longitudinal profile starting location is also noted.

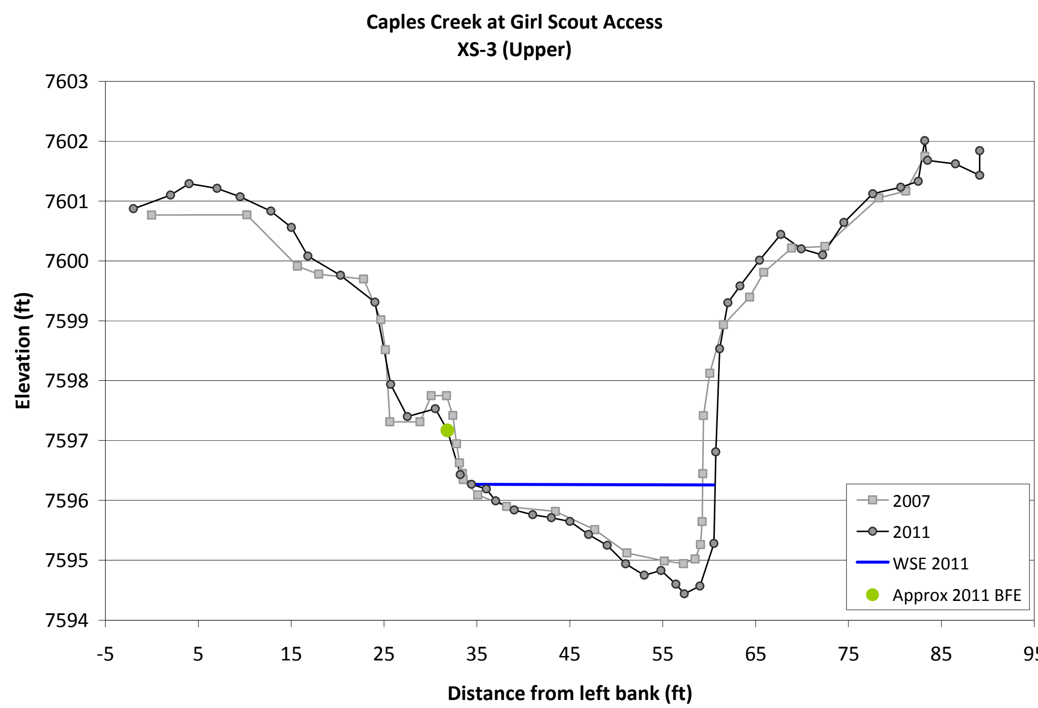


Figure 3-11. Caples Creek at Girl Scout Access XS-3 survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

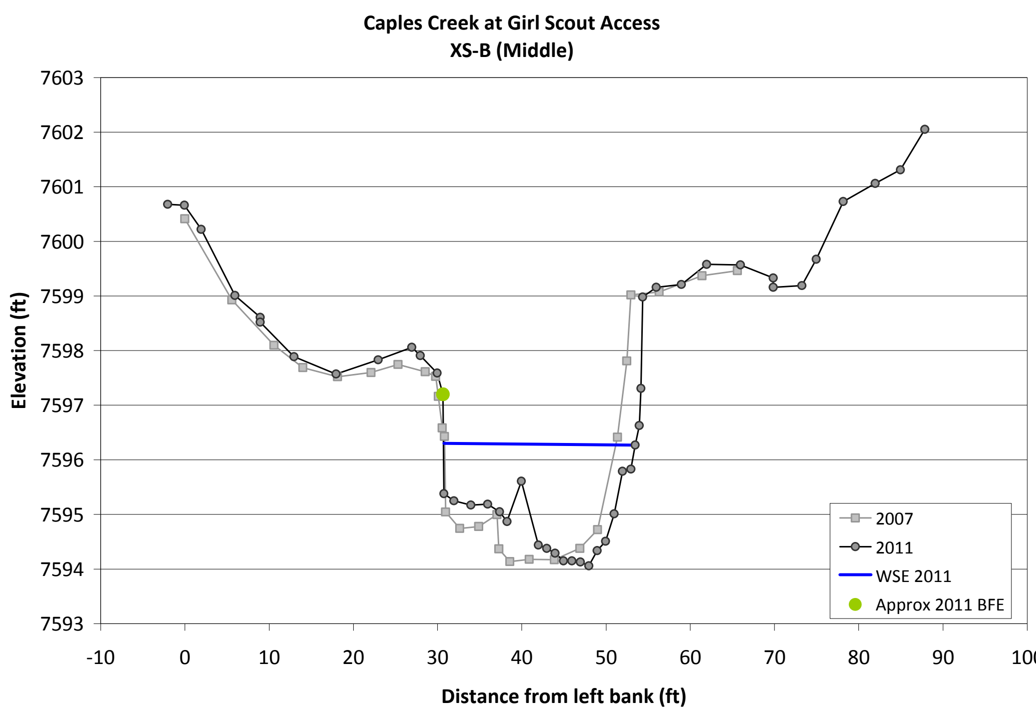


Figure 3-12. Caples Creek at Girl Scout Access XS-B survey data. Elevation is shown relative to a datum established for the 2007 survey. Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

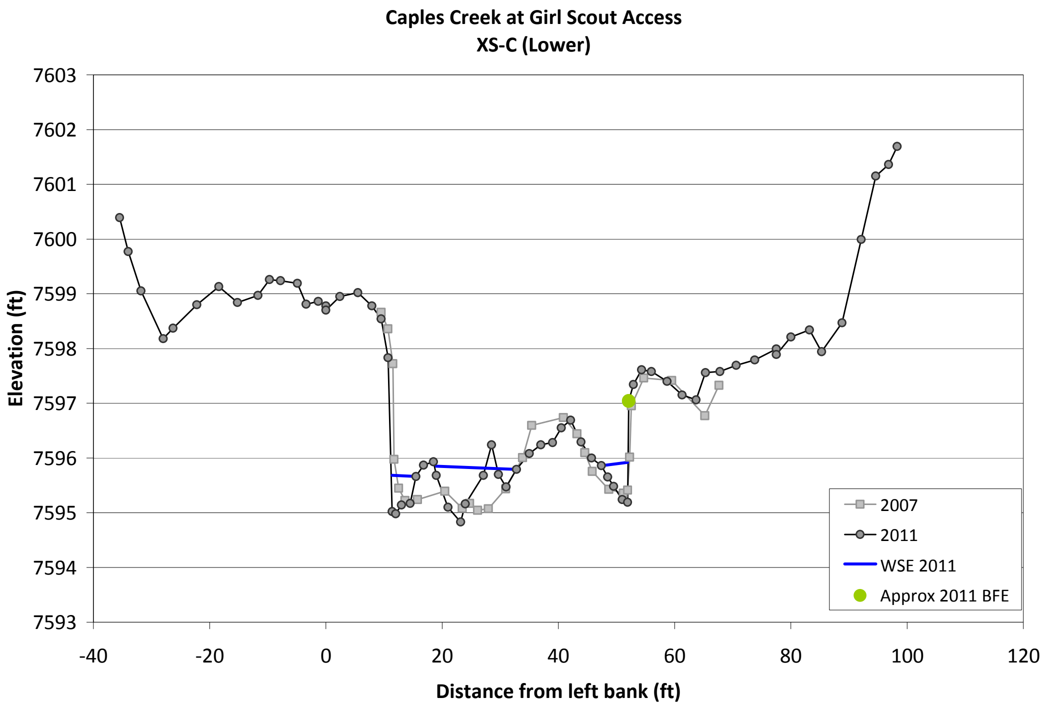


Figure 3-13. Caples Creek at Girl Scout Access XS-C survey data. Elevation is shown relative to a datum established for the 2007 survey. Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

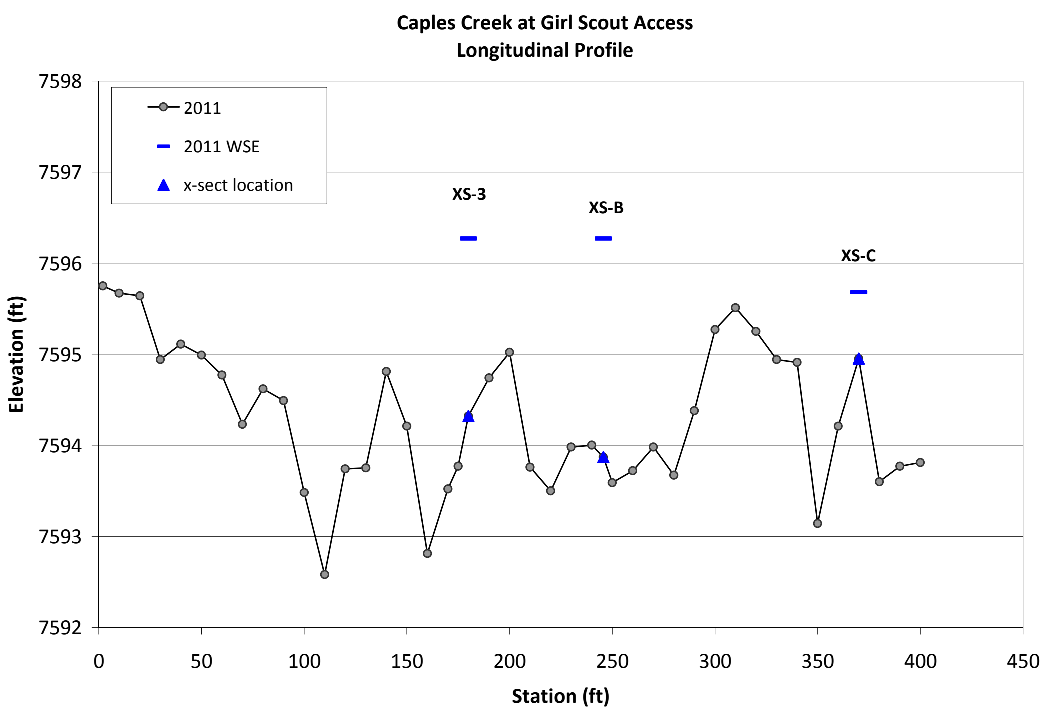


Figure 3-14. Caples Creek at Girl Scout Access longitudinal profile data. Elevation is shown relative to a datum established for the 2007 survey. Legend abbreviations: WSE = Water Surface Elevation.

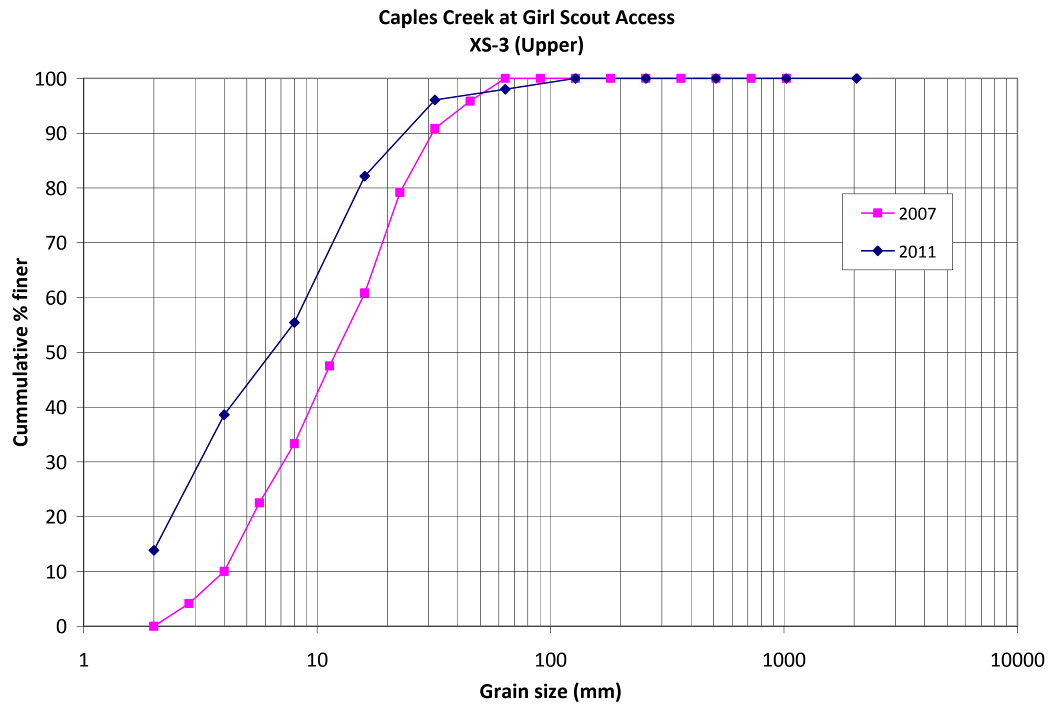


Figure 3-15. Caples Creek at Girl Scout Access XS-3 bed particle size distribution.

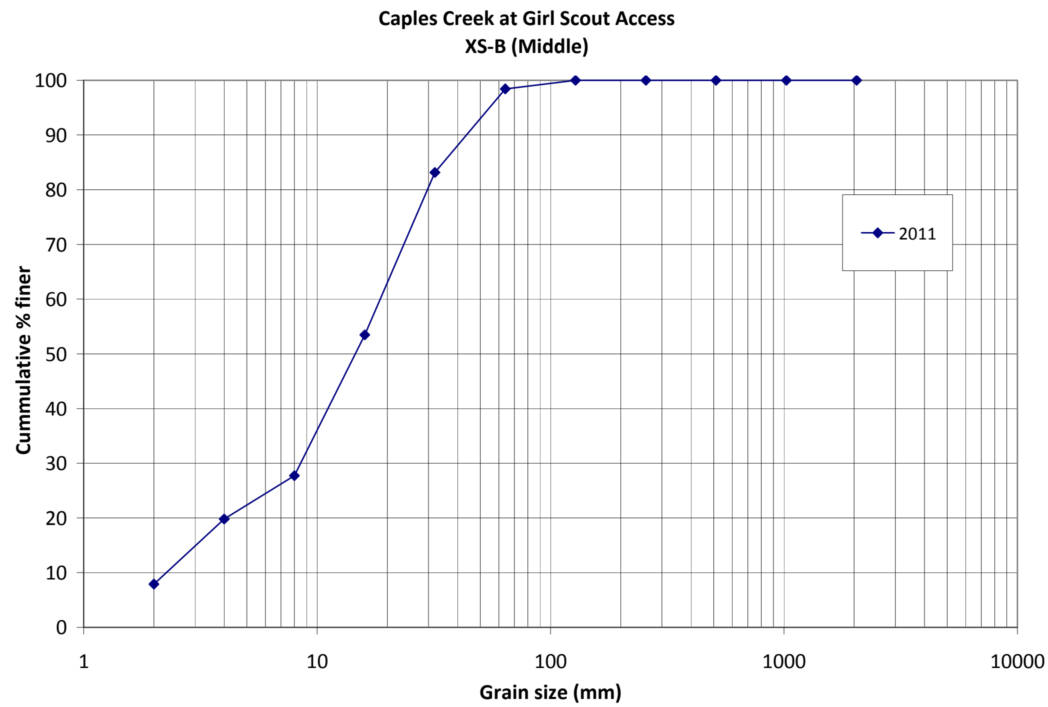


Figure 3-16. Caples Creek at Girl Scout Access XS-B bed particle size distribution.

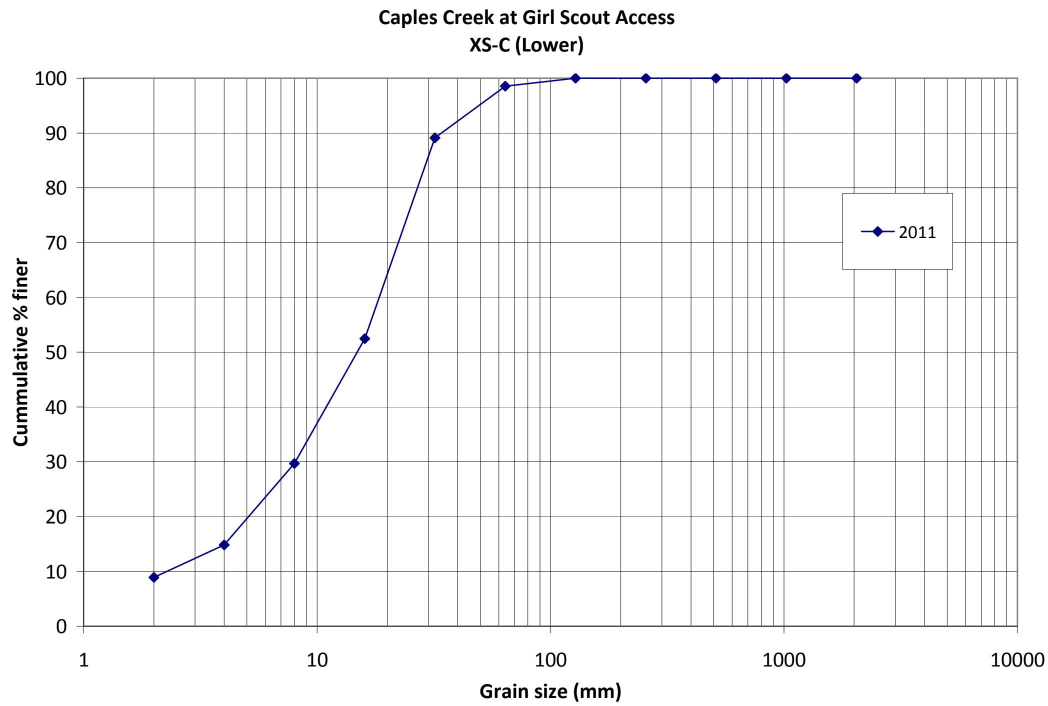


Figure 3-17. Caples Creek at Girl Scout Access XS-C bed particle size distribution.

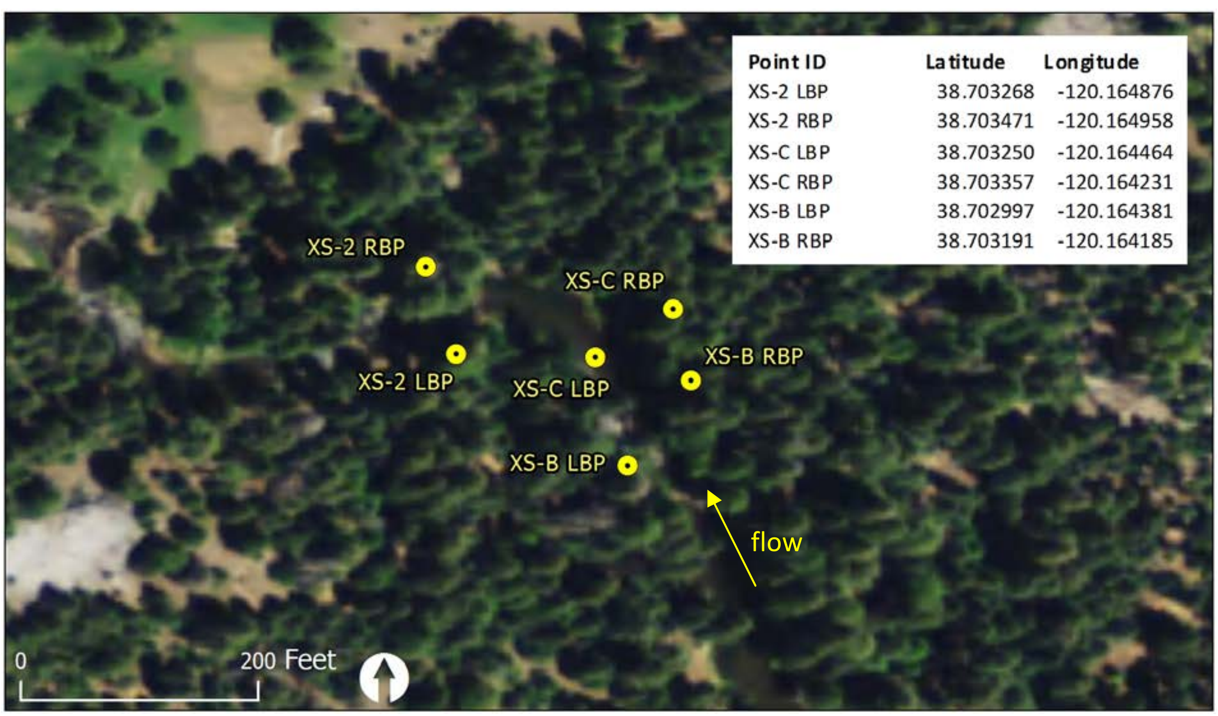


Figure 3-18. Site map of Jake Schneider Meadow site showing cross-section endpins and coordinates (in decimal degrees). LBP is left bank pin and RBP is right bank pin. The longitudinal profile starting and ending locations are also noted.

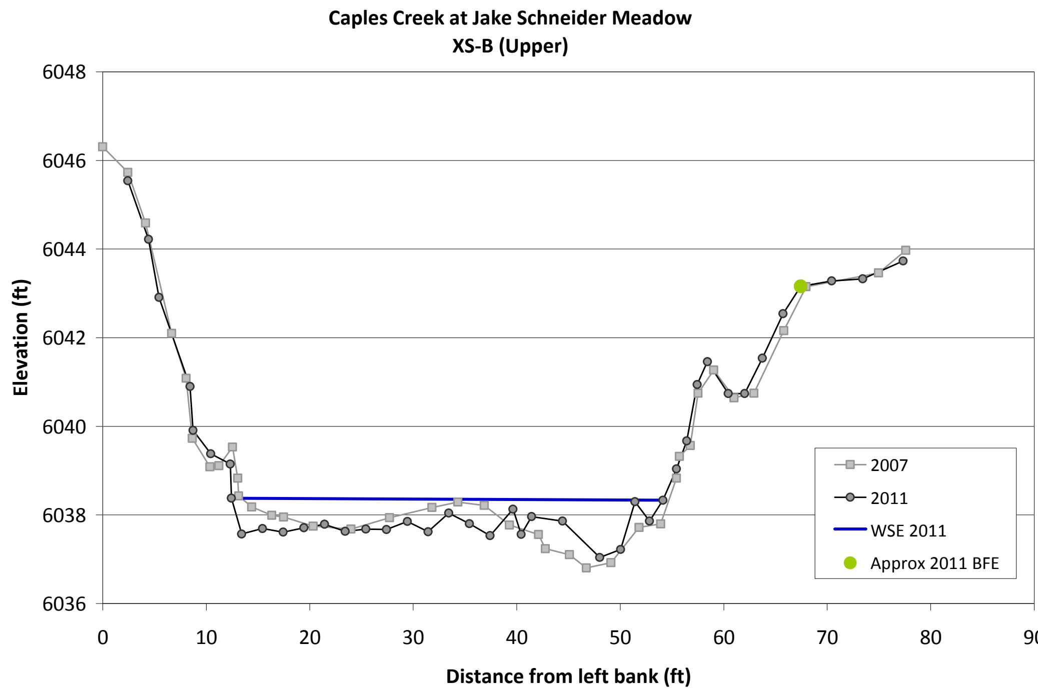


Figure 3-19. Caples Creek at Jake Schneider Meadow XS-B survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

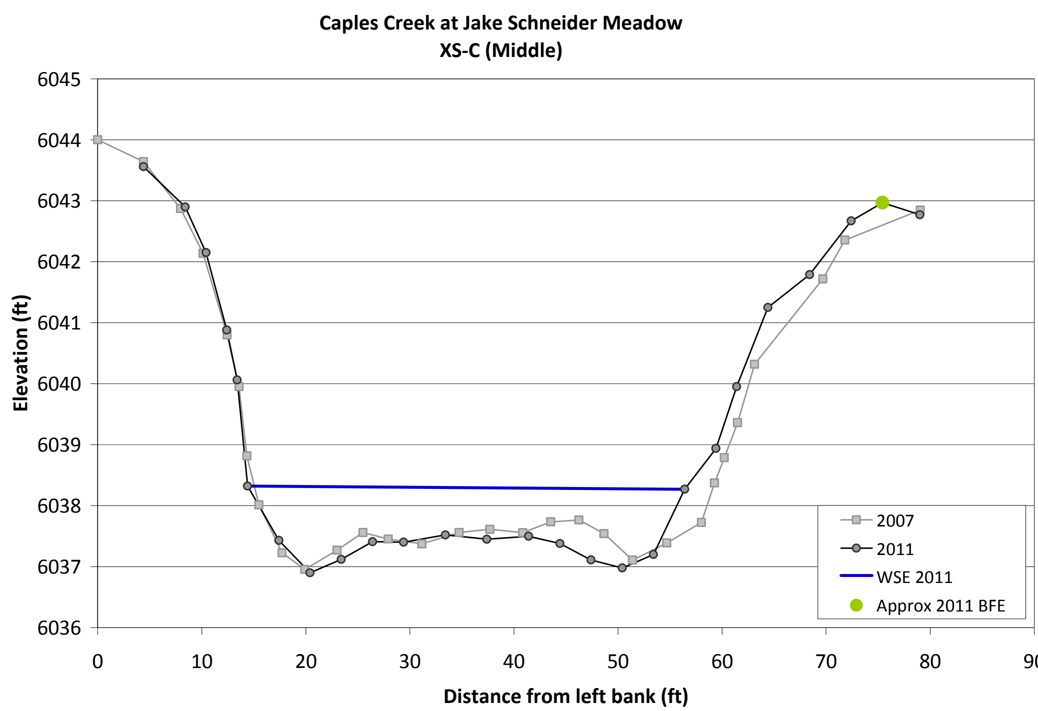


Figure 3-20. Caples Creek at Jake Schneider Meadow XS-C survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

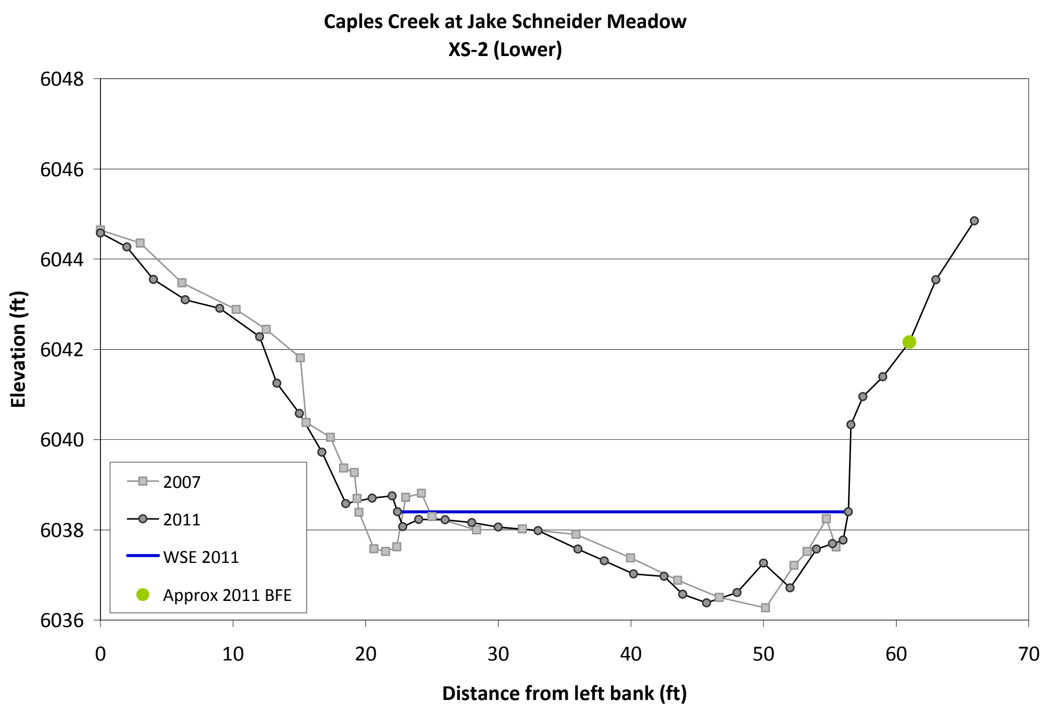


Figure 3-21. Caples Creek at Jake Schneider Meadow XS-2 survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

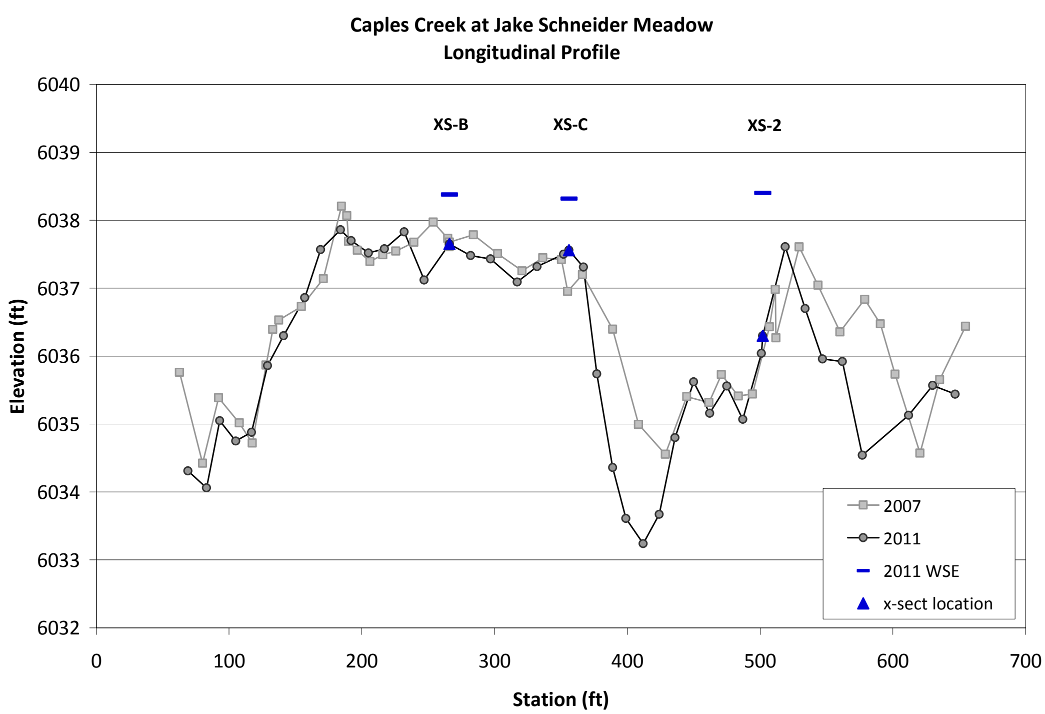


Figure 3-22. Caples Creek at Jake Schneider Meadow longitudinal profile data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation.

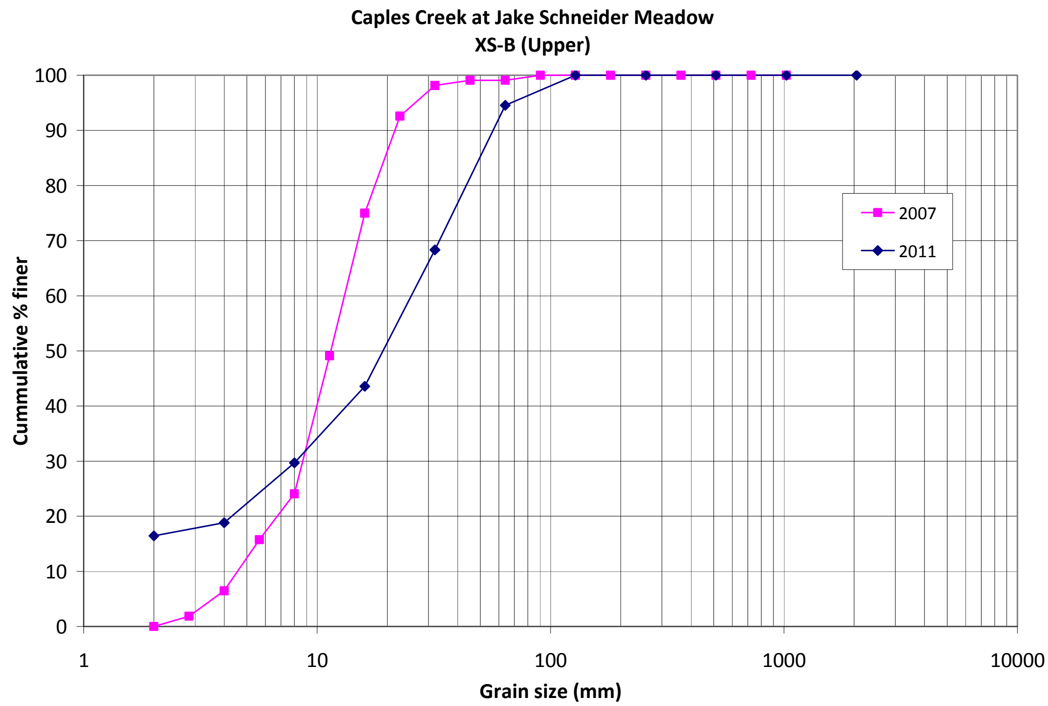


Figure 3-23. Caples Creek at Jake Schneider Meadow XS-B bed particle size distribution.

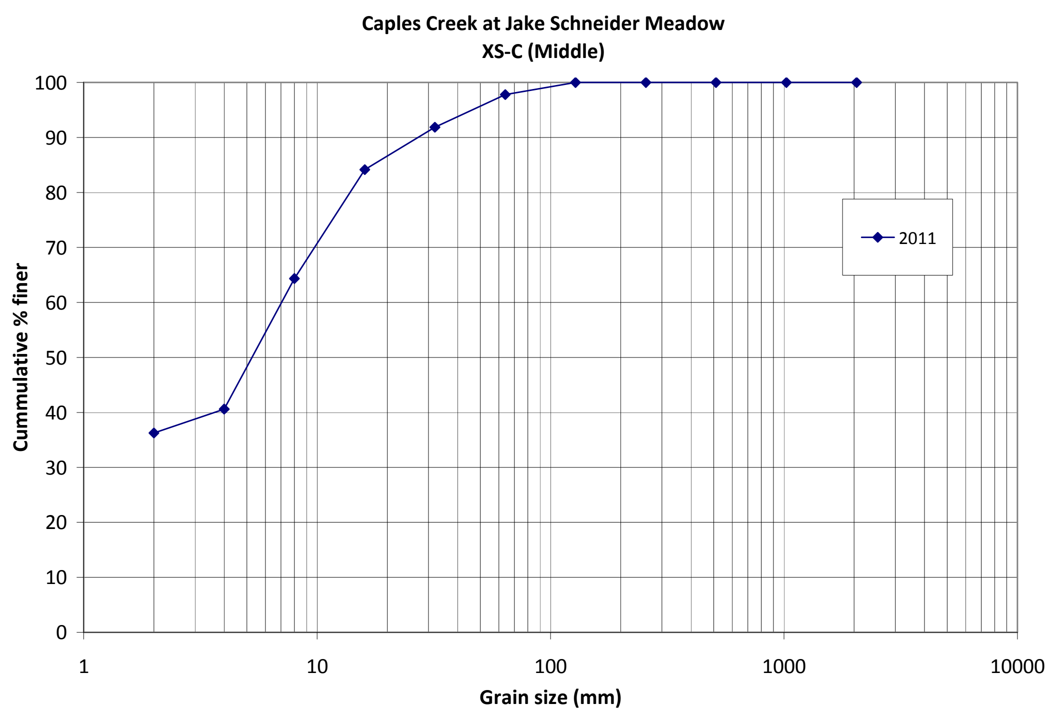


Figure 3-24. Caples Creek at Jake Schneider Meadow XS-C bed particle size distribution.

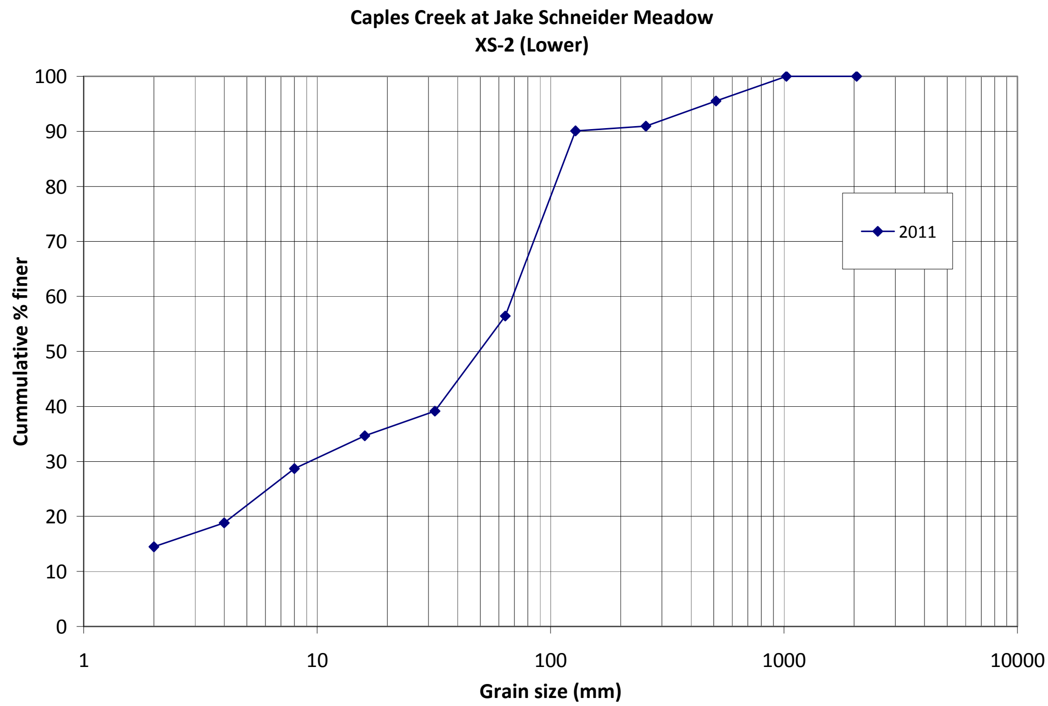
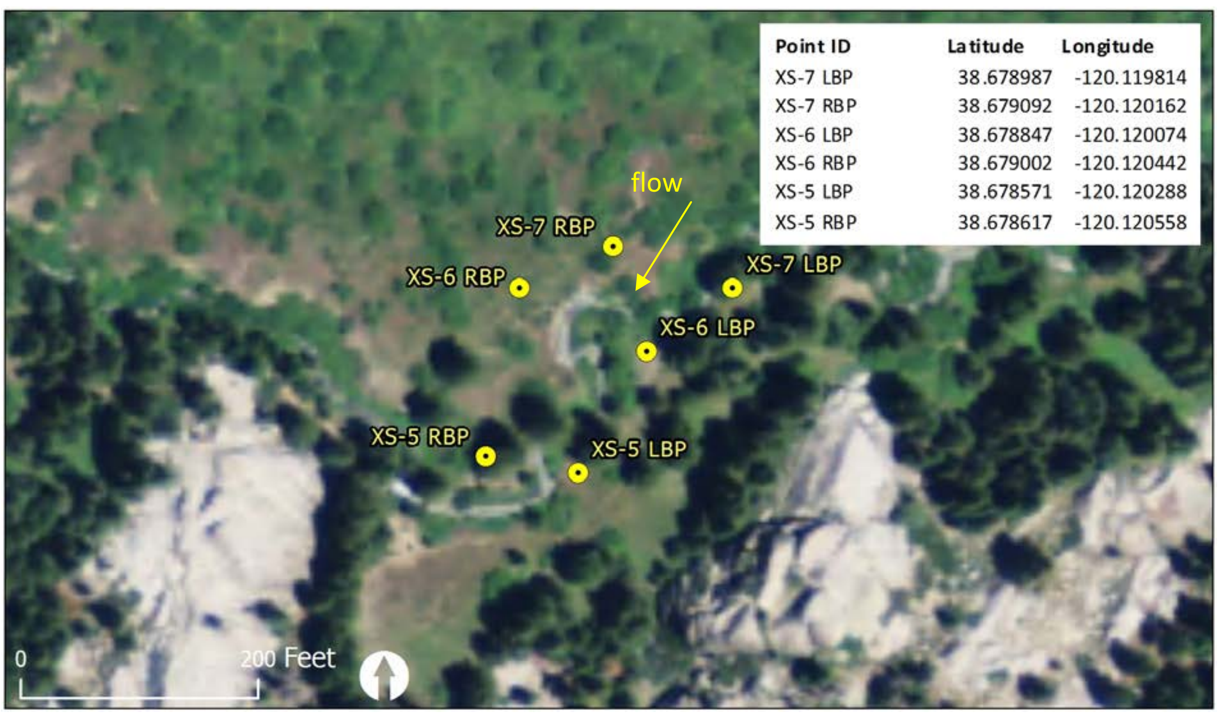


Figure 3-25. Caples Creek at Jake Schneider Meadow XS-2 bed particle size distribution.



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

Figure 3-26. Site map of the Oyster Creek below Highway 88 site showing cross-section endpins and coordinates (in decimal degrees). LBP is left bank pin and RBP is right bank pin.

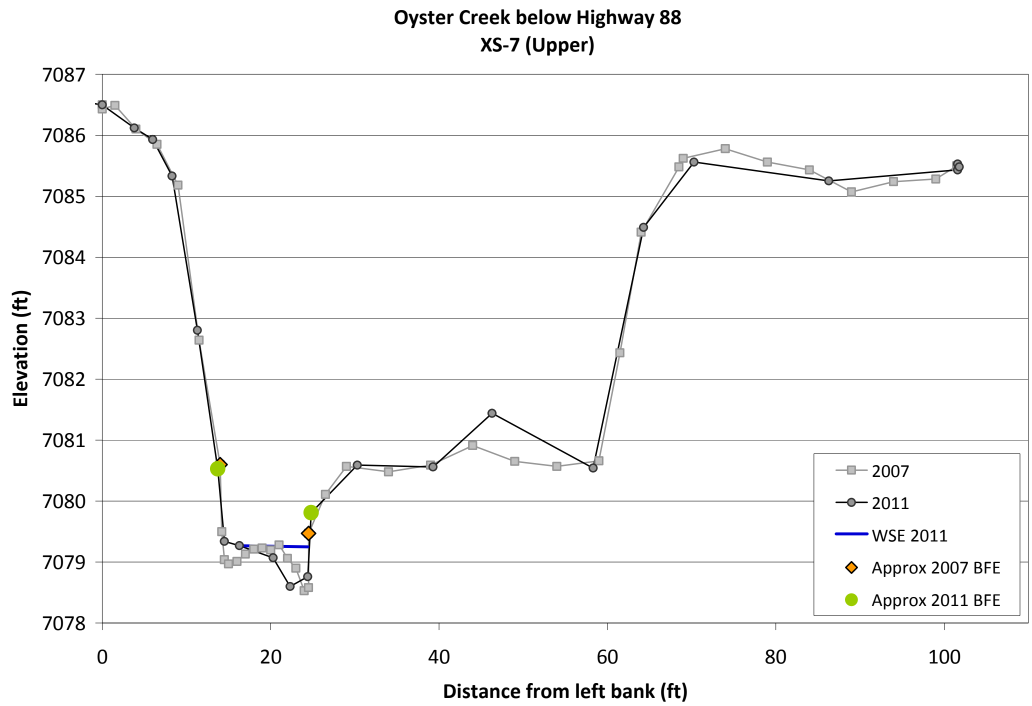


Figure 3-27. Oyster Creek below Highway 88 XS-7 survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

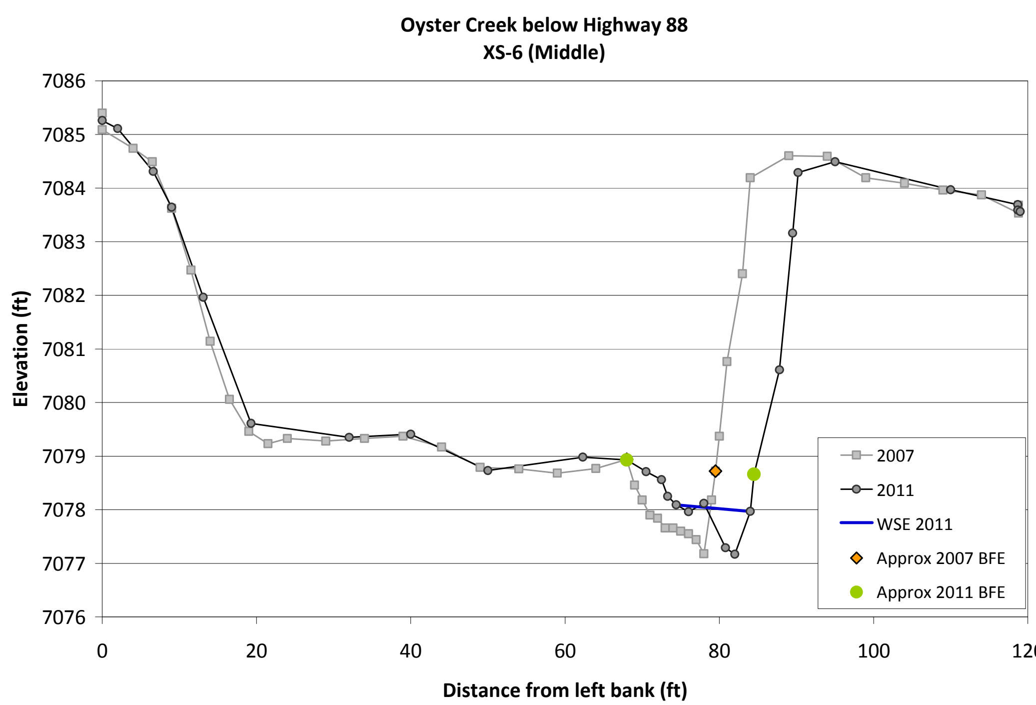


Figure 3-28. Oyster Creek below Highway 88 XS-6 survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

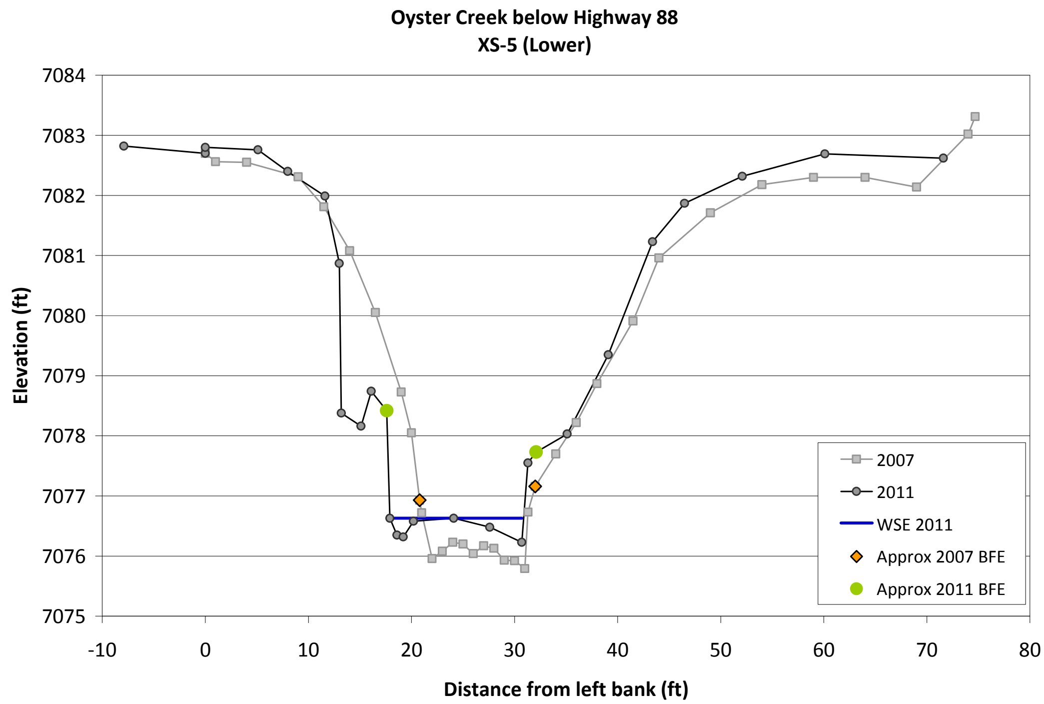


Figure 3-29. Oyster Creek below Highway 88 XS-5 survey data. Elevation is shown relative to the datum used for the 2007 survey (see Cardno Entrix 2011). Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

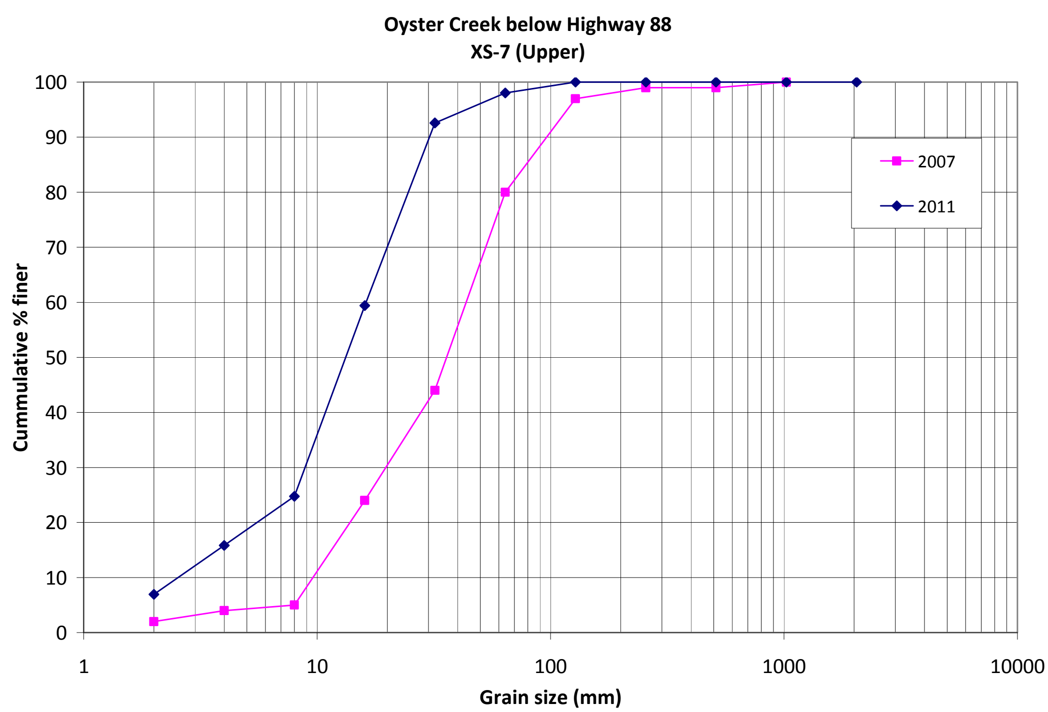


Figure 3-30. Oyster Creek below Highway 88 XS-7 bed particle size distribution.

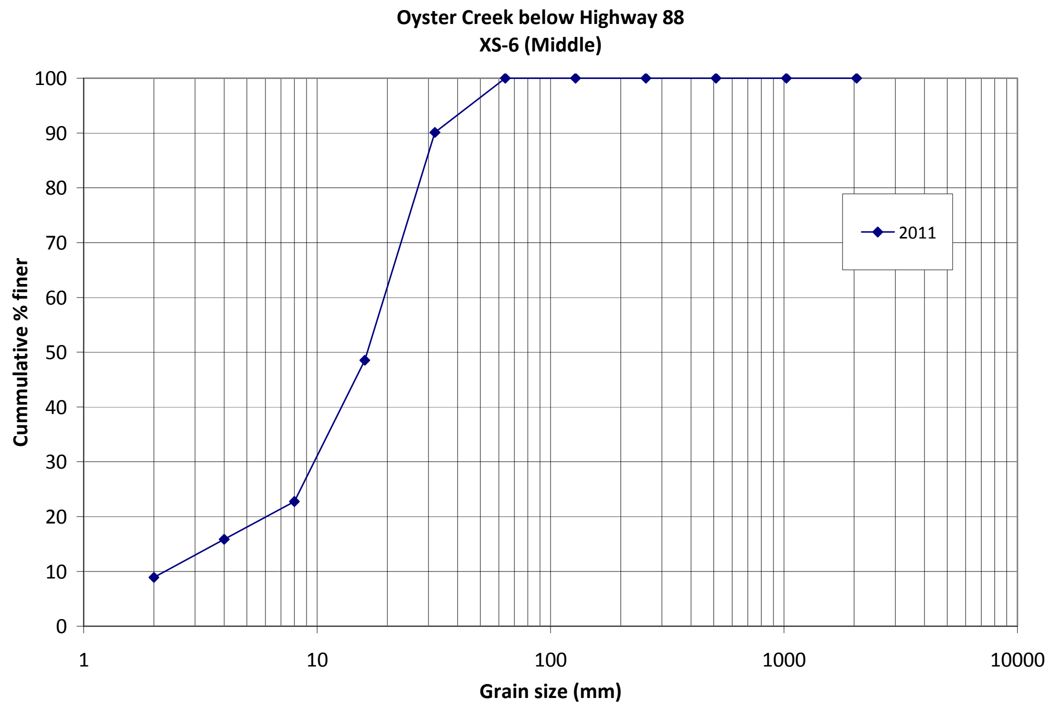


Figure 3-31. Oyster Creek below Highway 88 XS-6 bed particle size distribution.

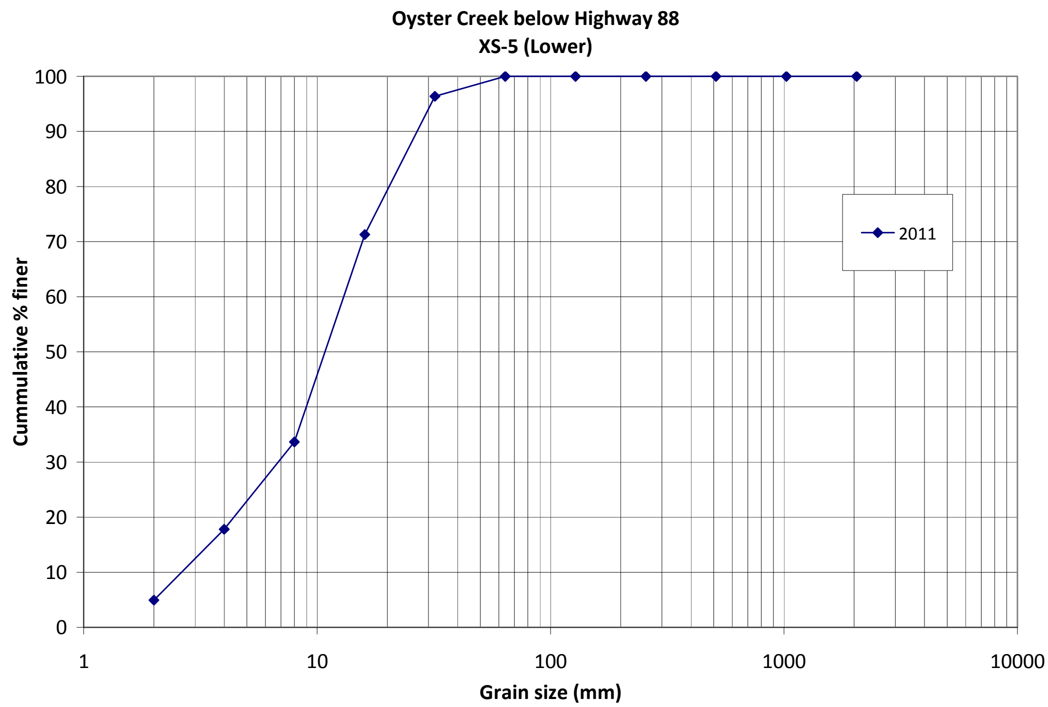


Figure 3-32. Oyster Creek below Highway 88 XS-5 bed particle size distribution.

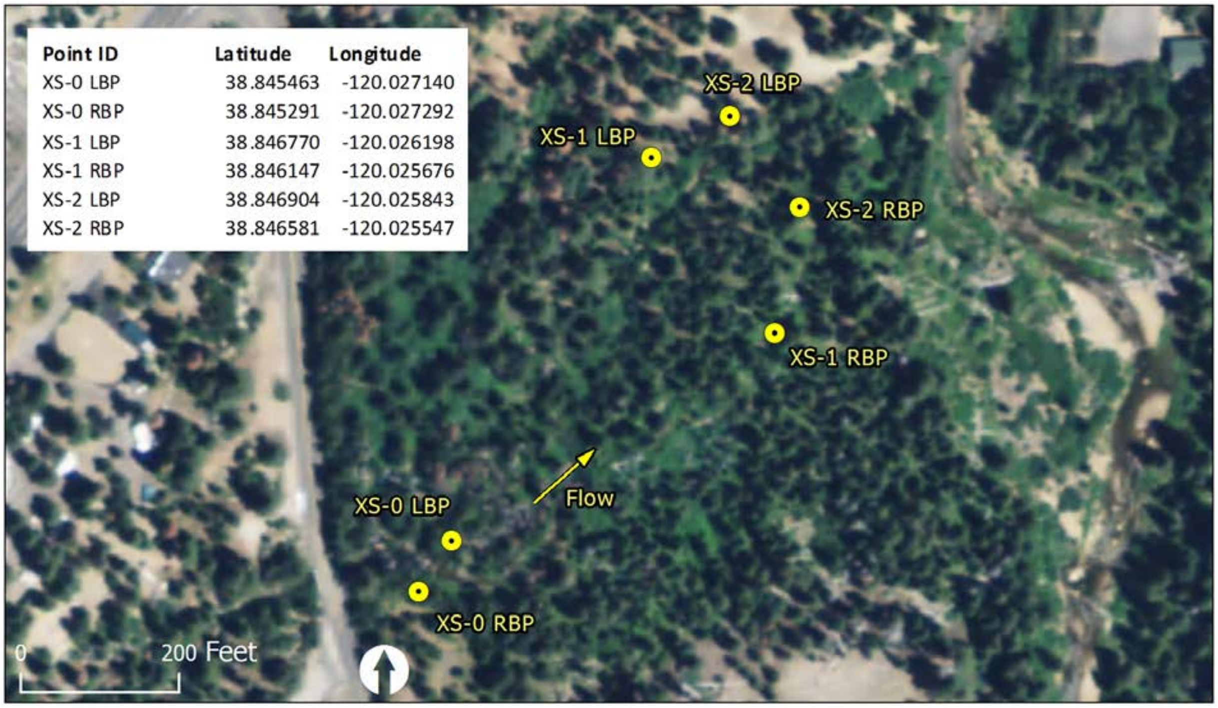


Figure 3-33. Site map of Lower Echo Creek site showing cross-section endpins and coordinates (in decimal degrees). LBP is left bank pin and RBP is right bank pin.

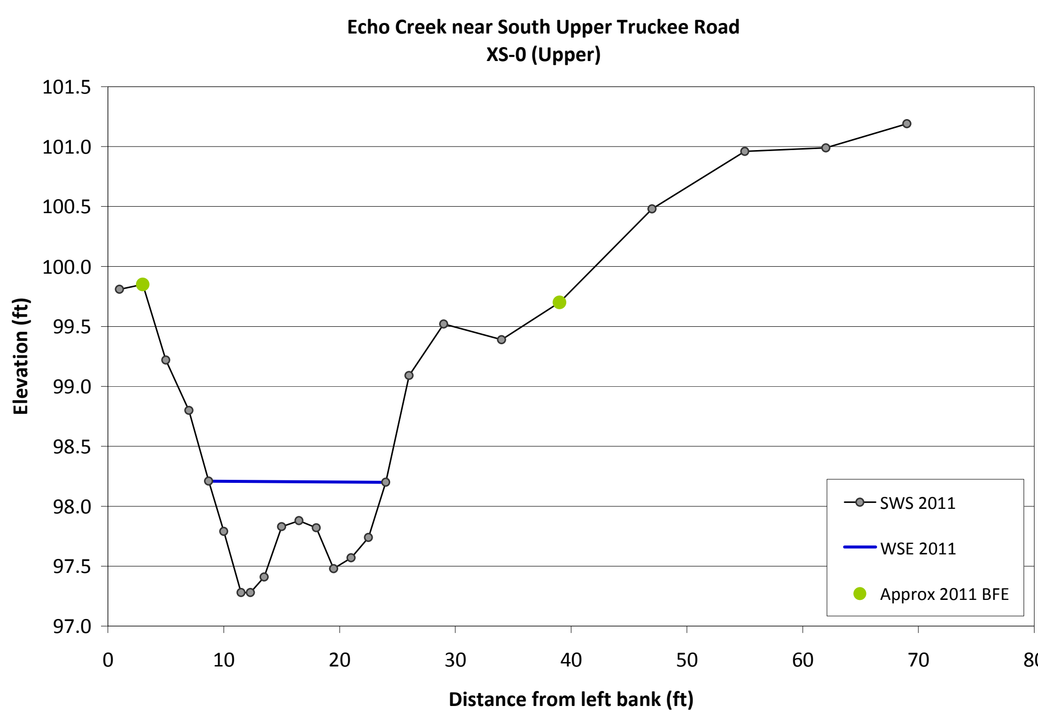


Figure 3-34. Lower Echo Creek XS-0 survey data. Elevation is shown relative to a datum established for cross-section during the 2011 survey. Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

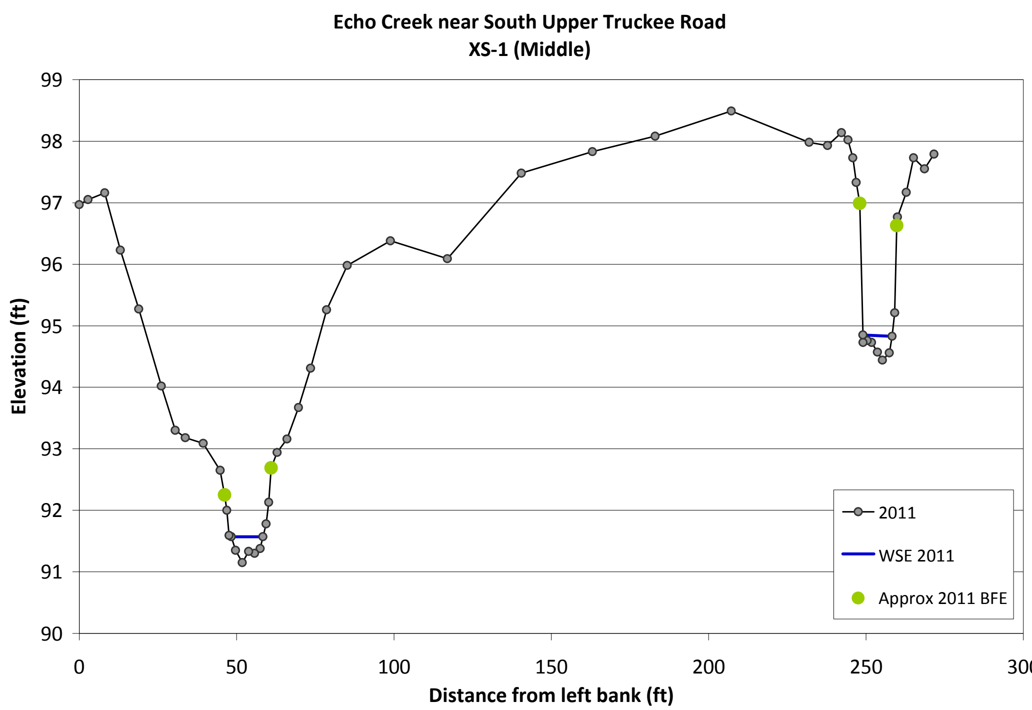


Figure 3-35. Lower Echo Creek XS-1 survey data. Elevation is shown relative to a datum established for cross-section during the 2011 survey. Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

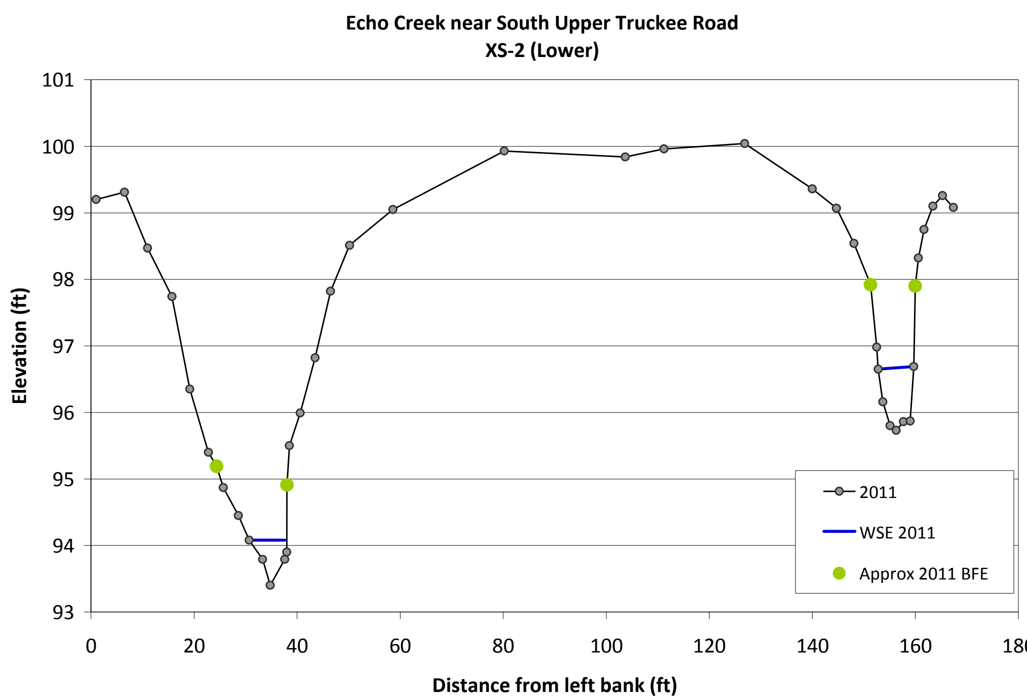


Figure 3-36. Lower Echo Creek XS-2 survey data. Elevation is shown relative to a datum established for cross-section during the 2011 survey. Legend abbreviations: WSE = Water Surface Elevation; BFE = Bankfull Elevation.

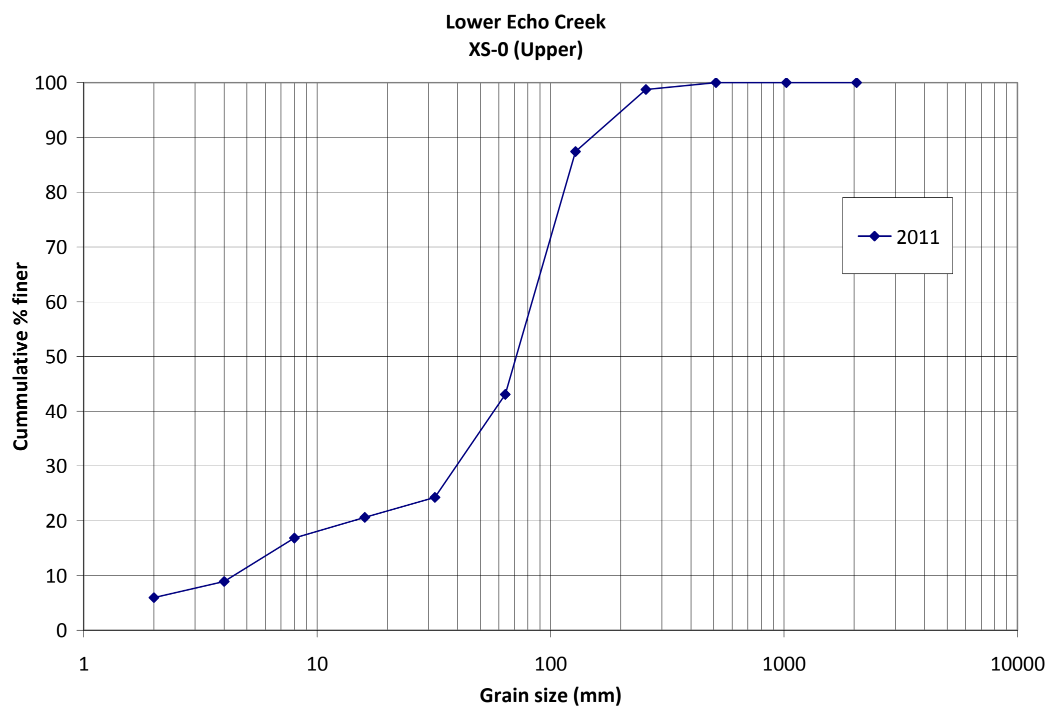


Figure 3-37. Lower Echo Creek XS-0 bed particle size distribution.

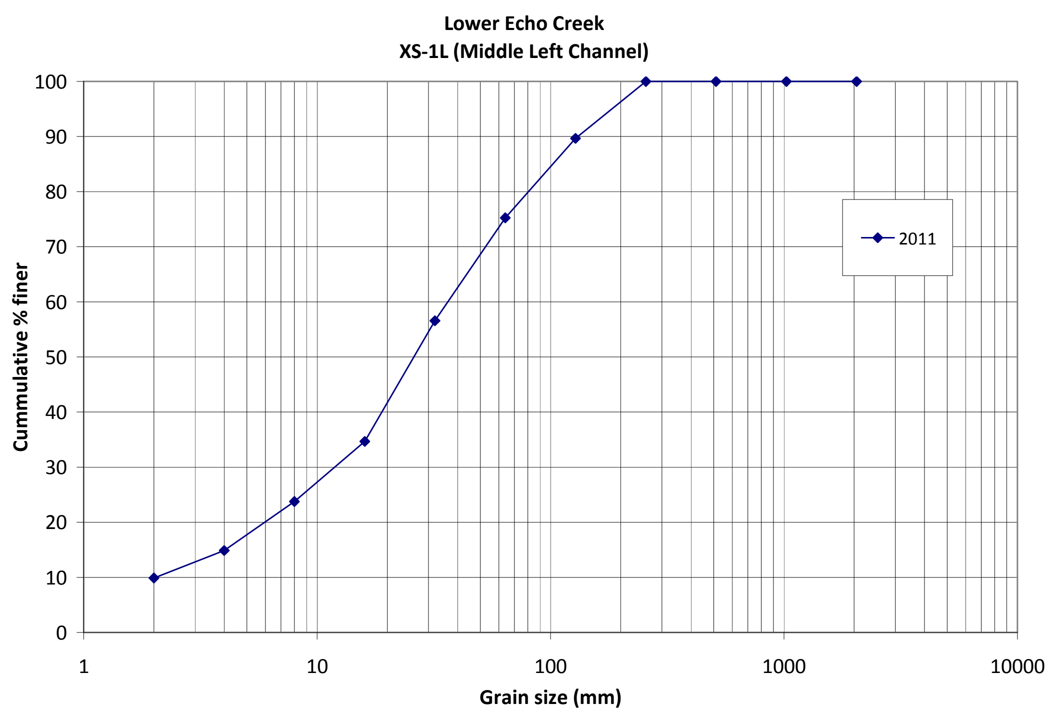


Figure 3-38. Lower Echo Creek XS-1L bed particle size distribution.

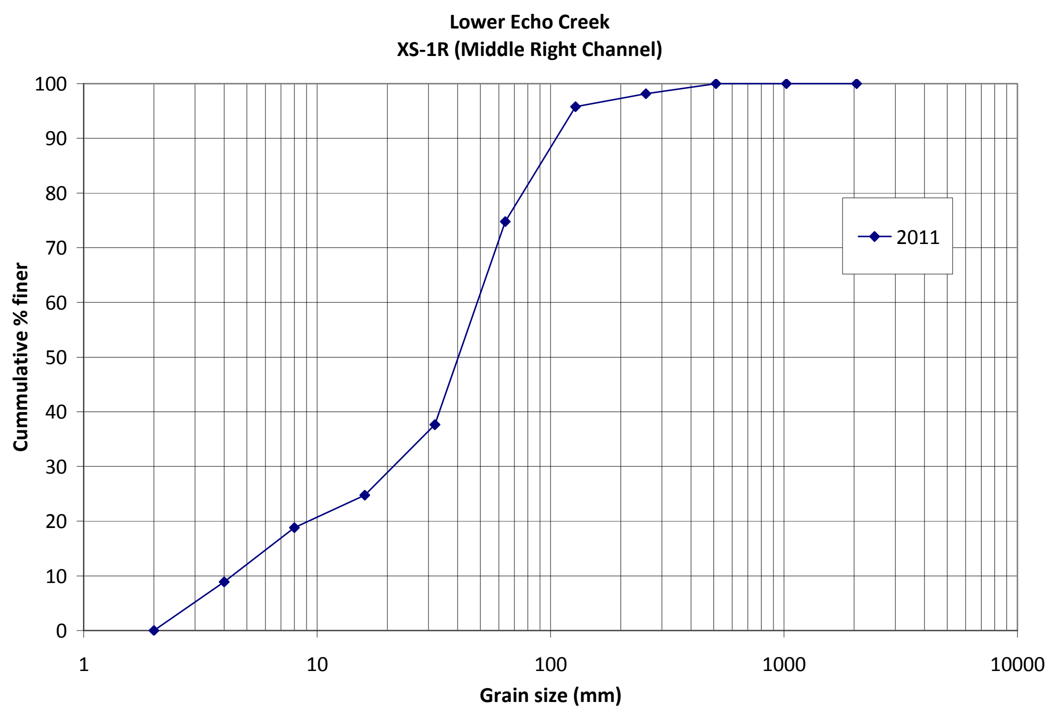


Figure 3-39. Lower Echo Creek XS-1R bed particle size distribution.

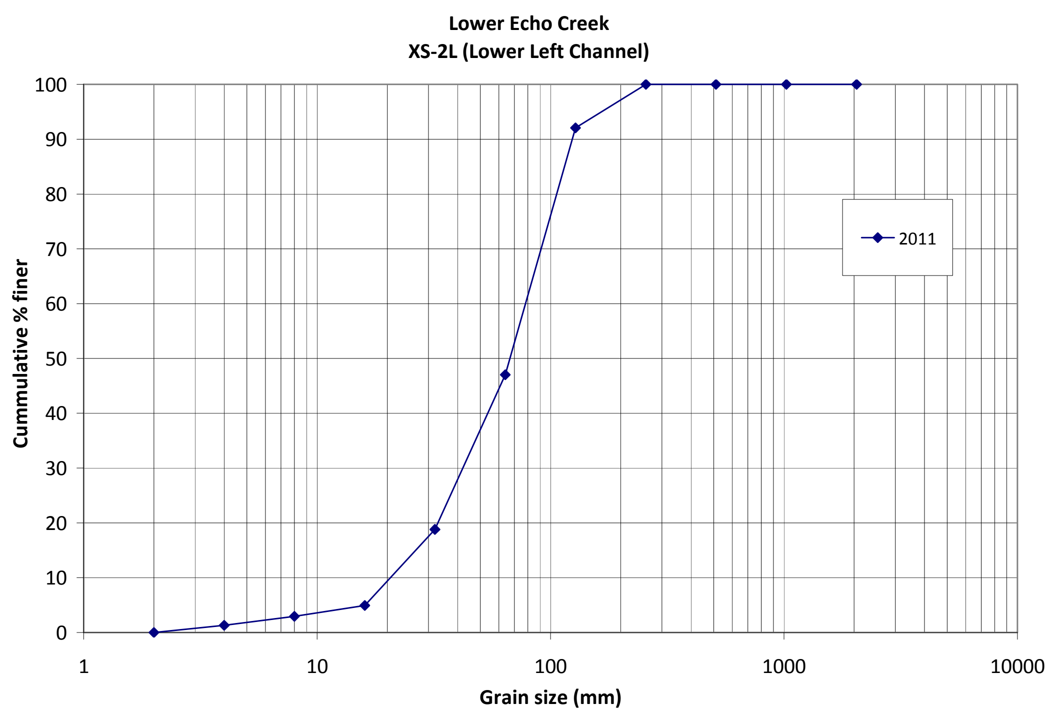


Figure 3-40. Lower Echo Creek XS-2L bed particle size distribution.

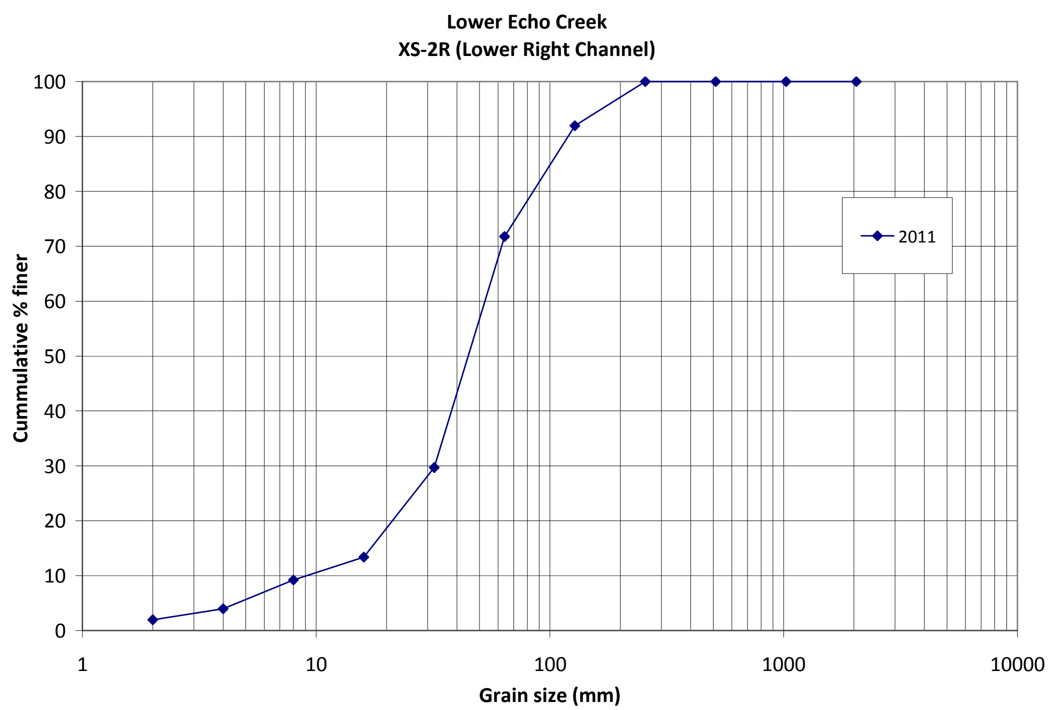


Figure 3-41. Lower Echo Creek XS-2R bed particle size distribution.

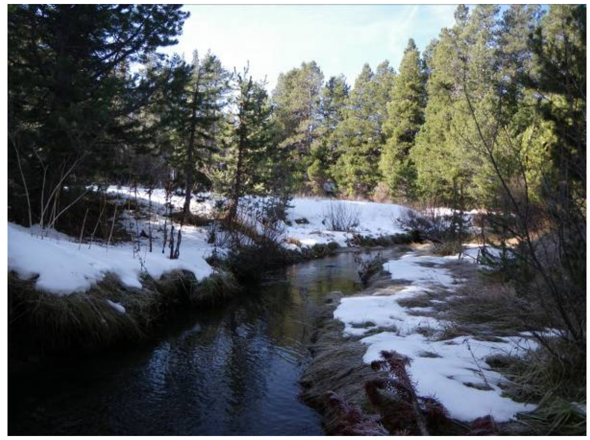
Appendices

Appendix A

Site Photos

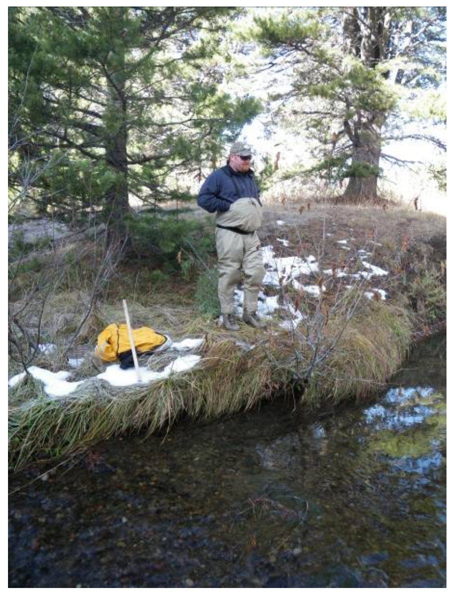
a.

b.



c.

d.



e.

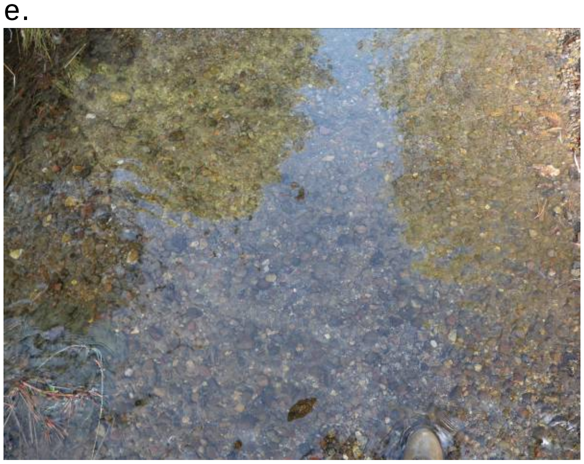


Figure A-1. Oyster Creek, XS- 1 (Lower): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; (e) looking at the bed.

Figure A-2. Oyster Creek, XS-2 (Mid): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

e.

Figure A-3. Oyster Creek, XS-3 (Upper): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

e.

Figure A-4. Caples Creek at Caples Meadow, XS-1 (Upper): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

e.

Figure A-5. Caples Creek at Caples Meadow, XS-2 (Mid): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

e.

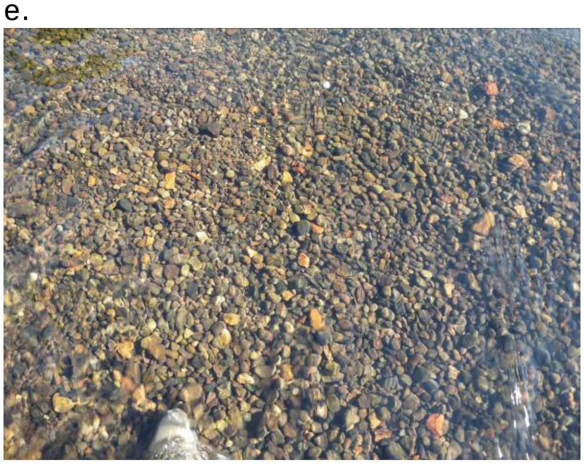


Figure A-6. Caples Creek at Caples Meadow, XS-3 (Lower): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

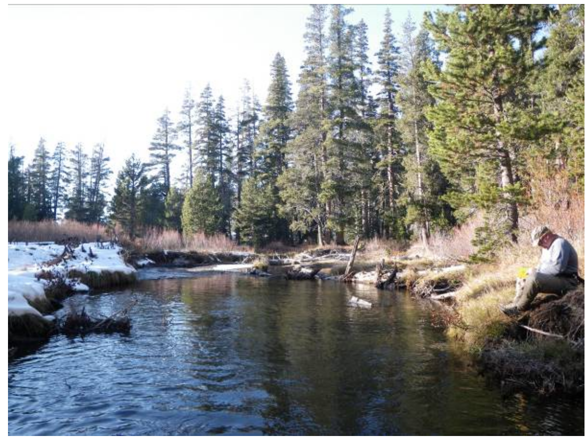
d.

e.

Figure A-7. Caples Creek at Girl Scout Access, XS-3 (Lower): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.



c.

d.

e.

Figure A-8. Caples Creek at Girl Scout Access, XS-2 (Mid): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

e.

Figure A-9. Caples Creek at Girl Scout Access, XS-1 (Upper): (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

e.

Figure A-10. Caples Creek at Jake Schneider Meadow, XS-B: (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

Figure A-11. Caples Creek at Jake Schneider Meadow, XS- C: (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

Figure A-12. Caples Creek at Jake Schneider Meadow, XS-2: (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

e.

Figure A-13. Echo Creek, XS-1 at Left Channel: (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

Figure A-14. Echo Creek, XS-1 at Right Channel: (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

e.

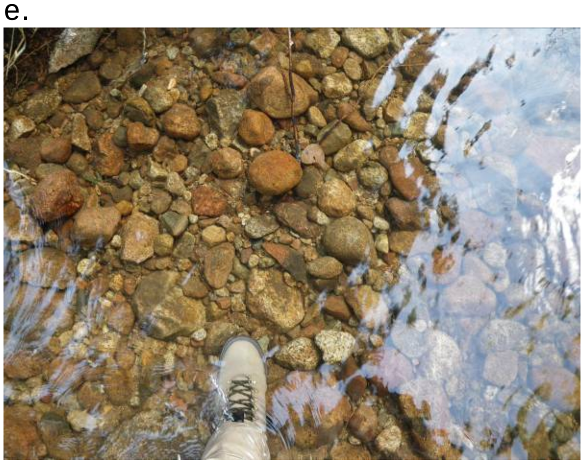


Figure A-15. Echo Creek, XS-2 at Right Channel: (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a.

b.

c.

d.

e.

Figure A-16. Echo Creek, XS- 2 at Left Channel: (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.

a. b. c. d. e.

Figure A-17. Echo Creek, XS-0: (a) looking upstream; (b) looking downstream; (c) looking at the left bank; (d) looking at the right bank; and (e) looking at the bed.