Geomorphic Monitoring of Representative Channel Areas

El Dorado Hydroelectric Project No. 184
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List of Acronyms

cfs cubic feet per second
District El Dorado Irrigation District
FERC Federal Energy Regulatory Commission
mi² square miles
mm millimeter
Plan Project No. 184 Geomorphology Continuing Evaluation of Representative Channel Areas Monitoring Plan
Project No. 184 El Dorado Hydroelectric Project
USDA US Department of Agriculture
WY water year
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 2011a), 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 the Fluvial Geomorphology Objective defined in Appendix B, Section 1 of the El Dorado Relicensing Settlement Agreement:

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 August 2016, AECOM conducted geomorphic monitoring pursuant with the Plan at representative channel sites (Figure 1-1). Per the requirements of the Plan, geomorphic monitoring includes establishment and monitoring of permanent cross-sections, longitudinal profiles, and channel properties at the following sites:

- Caples 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 below Kyburz Diversion Dam
- Silver Fork American River at Forgotten Flat
- Lower Echo Creek

The purpose of this report is to present geomorphic monitoring data from the 2016 monitoring effort and to draw comparisons with previously collected data. All sites have established cross-sections with relevant geomorphic data collected within the past several years. The Plan calls for locating existing cross-sections, where possible, to enable comparison with historical geomorphic data. All cross-sections were successfully located during the 2016 monitoring effort, so comparisons to historical data were possible at all study sites.

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2 Data Collection and Analysis Methods

The following methods were used in the August 2016 channel geomorphic monitoring effort and subsequent data analysis. These methods followed the Plan (Entrix 2011a), as well as the 2011 and 2012 monitoring efforts conducted by Stillwater Sciences (Stillwater Sciences 2012a, Stillwater Sciences 2012b). Data collected in 2016 is compared to the 2011 and 2012 data, hereafter referred to as 2011 data.

2.1 Channel Cross-Sections

Three cross-sections were surveyed at each representative site. Existing headpins marking the endpoints of each cross-section were located whenever possible. Two or three temporary benchmarks were established near one headpin for each cross-section or group of cross-sections. The GPS positions of headpins and benchmarks were recorded using a Trimble GeoXT 600 Series GPS. The existing headpins and cross-section survey data were tied to the established temporary benchmarks. 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. A majority of the sites were surveyed using a rotating laser level, while a total station was employed at others. Representative photographs matching those from the 2011 monitoring effort (Stillwater Sciences 2012a, Stillwater Sciences 2012b) were taken and are included in Appendix A.

The Plan describes two indices that should be calculated to compare channel morphology changes over time: net percent change in area ($\Delta A\%$) and absolute percent change in area ($|\Delta A\%|$) (Entrix 2011a). 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 material movement since the last monitoring period. Autodesk AutoCAD was used to plot cross-sections surveyed in both 2011 and 2016 and measure the total cross-sectional area based on the survey data and notes.

2.2 Longitudinal Profiles

A longitudinal profile of the channel thalweg was surveyed for a minimum distance of ten times the bankfull width where that length of river could be safely accessed and the survey reach was positioned to intersect all three cross-sections. Bed elevation measurements were referenced to the local datum used for the cross-section survey. Longitudinal profile surveys 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). A majority of the sites were surveyed using a rotating laser level, while a total station was employed at others.

Longitudinal profile data were plotted with data from the 2011 monitoring effort (Stillwater Sciences 2012a, Stillwater Sciences 2012b). Where appropriate, the average slope of the reach was calculated and compared to 2011 data in order to assess changes in slope and identify areas of local channel aggradation or incision.

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2 Geomorphology monitoring was conducted in fall 2011 and summer 2012; the field work spanned two seasons due to the onset of winter weather in 2011. In this report, the "2011 monitoring effort" refers to field data collected during the fall 2011 and summer 2012.
2.3 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.” A photograph that best presented the bed particle size distribution was taken at each cross-section (Appendix A).

Pebble count data was plotted as a cumulative percentage distribution, and data from the 2011 monitoring effort (Stillwater Sciences 2012a, Stillwater Sciences 2012b) was included in the plots. The $D_{16}$ (particle size for which 16 percent of the distribution is finer), $D_{50}$ (median particle size), and $D_{84}$ (particle size for which 84 percent of the distribution is finer) were calculated and compared to 2007 and 2011 values to assess any recent trends in stream bed coarsening or fining.

2.4 Bank Erosion Potential Assessments

At each cross-section monitoring site, the bank erosion potential assessment rating was performed 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 >50). Erosion potential scores are presented for both banks of each cross-section.

2.5 General Geomorphic Assessment

Following data analysis, a general geomorphic assessment was developed. The assessment gives a broad indication of geomorphic change since 2011 based on comparisons of current and historical field data.
3 Data Analysis and Discussion

3.1 Caples Spillway Channel

3.1.1 General Site Description

The Caples Spillway Channel study site is approximately 420 feet long and is located 0.4 miles downstream of the Caples Lake Auxiliary Dam (Figure 3-1). The Caples Spillway Channel conveys water released from the Caples Lake Auxiliary Dam downstream to Caples Creek near the confluence of Caples and Kirkwood Creeks. Flow through the spillway channel is almost entirely controlled by releases through the Auxiliary Dam. The spillway channel was historically a much smaller drainage, but spill flows from the dam have resulted in incision and bank erosion (Entrix 2010). A 2002 report noted that the channel is adjusting to flows from the Auxiliary Dam and a floodplain is developing in the entrenched channel (Entrix 2002). There are two distinct channel types in the spillway channel: the upper 2,200 feet is a cascade channel type while the lower 840 feet is a pool-riffle channel type that is a seasonal backwater area of Caples Creek (Entrix 2002, Entrix 2010). The study site is located at the transition between these two channel types (Entrix 2002).

Releases from the Caples Lake Auxiliary Dam into the spillway channel are infrequent and typically only involve short-term low magnitude releases in order to remove accumulated woody debris and pollen that accumulates in front of the auxiliary dam. Under normal operations, the District routes outflows through the main dam outlet works and minimizes use of the spillway. No releases from the Caples Lake Auxiliary Dam into the spillway channel were made in the time since the previous geomorphology surveys were conducted in 2011 (Deason 2017).

3.1.2 Channel Cross-Sections

The Caples Spillway Channel study site cross-sections for 2011 and 2016 are shown in Figure 3-2, Figure 3-3, and Figure 3-4 and cross-section change metrics are summarized in Table 3-1. Photos of each cross-section at the Caples Spillway Channel study site are provided in Appendix A. The survey data appears to indicate that the upper cross-section (XS-1) experienced a small amount of net channel deposition (i.e., positive net percent change in channel area) and a low degree of absolute percent change in area over the past 5 years. The cross-section comparison plot (Figure 3-2) indicates slight erosion on the right bank and a small area of deposition in the middle of the channel. The middle cross-section (XS-2) experienced very little change between 2011 and 2016 (i.e., the net and absolute percent change are both under 5%). The cross-section comparison plot (Figure 3-3) shows a very small amount of erosion on the right bank and a very small amount of deposition in the channel. The lower cross-section (XS-3) experienced a small amount of net erosion (i.e., negative net percent change in channel area) and a low degree of absolute percent change over the past 5 years. The cross-section comparison plot (Figure 3-4) indicates some erosion that is mostly concentrated on the right bank. Overall, the data for all three cross sections indicate that this reach of the spillway channel has remained relatively stable between 2011 and 2016.
3.1.3 Longitudinal Profile

The Caples Spillway Channel study site longitudinal profiles for 2011 and 2016 are shown in Figure 3-5. The 2011 profile is approximately 550 feet in length and extends approximately 50 feet upstream from XS-1 and approximately 100 feet downstream from XS-3. The 2016 profile is approximately 600 feet in length and extends approximately 50 feet upstream from XS-1 and approximately 150 feet downstream from XS-3. Comparison of the survey profiles that this reach of the spillway channel has remained relatively stable between 2011 and 2016. In a channel having a pool-riffle bedform, the slope of the longitudinal profile is controlled by the location of the upstream ends, or crests of the riffles. Comparison of the profiles shows that the change in elevation between consecutive riffle crests has remained relatively consistent during the monitoring period.

3.1.4 Bed Particle Size Distributions

The bed particle size distribution data for Caples Spillway Channel XS-1, XS-2, and XS-3 are presented in Figure 3-6, Figure 3-7, and Figure 3-8, respectively. Figures contain data from the 2016 sampling effort, as well as from 2011 (Stillwater Sciences 2012b). Representative bed particle sizes for each cross-section collected in 2007, 2011, and 2016 are presented in Table 3-2. Photos A-5, A-10, and A-15 in Appendix A show the typical channel bed at each cross-section.

In 2016, the pebble count data show that the bed is primarily finer than very large cobble (<180 millimeters [mm]) with the median size at all cross-sections ranging from fine to very coarse gravel (between 7.7 and 52.4 mm). Particle sizes at XS-1 were larger than at XS-2 and XS-3, a trend that has been consistent since 2007. This trend is representative of the transition between cascade and pool-riffle bedforms. At XS-1, the 2016 data show that the cross-section is more well-graded (i.e., there is a more equal distribution of particle sizes) compared to 2011. The 2016 XS-1 data are very similar to 2007 XS-1 pebble count data (plotted in Stillwater Sciences 2012b), suggesting that there has been little change in bed particle size distribution at XS-1 between 2007 and 2016. As reported in 2011, the bed at XS-2 and XS-3 appeared to be coarsening between 2007 and 2011; however, there has been very little change in particle size distribution between 2011 and 2016 at these cross-sections.

| Table 3-1. Summary of Cross-Section Change Metrics for Caples Spillway Channel |
|---------------------------------------------------|-----------------|-----------------|-----------------|
| Channel Cross-Section Change Metric               | XS-1 (Upper)    | XS-2 (Middle)   | XS-3 (Lower)    |
| Net percent change in channel area                | 2%              | 1%              | -8%             |
| Absolute percent change in channel area           | 6%              | 4%              | 4%              |

| Table 3-2. Representative Bed Particle Sizes for Caples Spillway Channel |
|---------------------------------------------------|-----------------|-----------------|-----------------|
| Representative Particle Size (mm)                  | Monitoring Year | XS-1 (Upper)   | XS-2 (Middle)   | XS-3 (Lower)   |
| D<sub>16</sub>                                     | 2007            | 6.1            | < 2            | < 2            |
|                                                   | 2011            | 30.8           | < 2            | < 2            |
|                                                   | 2016            | 14.4           | < 2            | 10.0           |
| D<sub>50</sub>                                     | 2007            | 60             | 2.8            | 14.5           |
|                                                   | 2011            | 50.0           | 11.0           | 16.0           |
|                                                   | 2016            | 52.4           | 7.7            | 22.6           |
| D<sub>84</sub>                                     | 2007            | 170            | 13.9           | 27.9           |
|                                                   | 2011            | 88.3           | 24.0           | 32.0           |
|                                                   | 2016            | 152.5          | 25.1           | 39.3           |
3.1.5 Bank Erosion Potential

The Caples Spillway Channel study site bank erosion potential assessment for each cross-section is summarized in Table 3-3. The 2011 bank erosion potential assessment had shown that the cross-sections had a high or moderately high erosion potential. The results of the 2016 assessment ranged from very low potential for erosion of the bedrock left bank at cross section 1 to an extreme potential for erosion of the right bank, which is largely unvegetated at the cross section location and comprised of sand. At cross sections 2 and 3 bank erosion potential is moderate on the right bank and high to very high on the left bank.

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<tr>
<th>Bank Erosion Potential Index</th>
<th>Index Value</th>
<th>XS-1 (Upper) Left Bank</th>
<th>XS-1 (Upper) Right Bank</th>
<th>XS-2 (Middle) Left Bank</th>
<th>XS-2 (Middle) Right Bank</th>
<th>XS-3 (Lower) Left Bank</th>
<th>XS-3 (Lower) Right Bank</th>
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<td>10</td>
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<td>Very High</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
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</table>

3.1.6 General Geomorphic Assessment

While the Caples Spillway Channel has previously experienced some significant instability, the monitoring data indicate that the channel has remained stable during the 2011-2016 monitoring period. Previous indications of bed coarsening may have been the result of slightly differing pebble count sampling methodologies. There are several commonly used sampling procedures which might be considered consistent with the comparatively unspecific methods described in Wolman (1954). Comparison of the results of cross section and longitudinal profile surveys, as well as site photographs taken during both monitoring efforts, indicate channel stability from 2011-2016. This is likely due to the lack of releases from Caples Auxiliary Dam into the spillway channel during this timeframe. However, potential for bank erosion to occur in this reach during future flow events remains relatively high and the capacity for geomorphic change at this location will largely be controlled by the frequency and magnitude of future releases from the Caples Auxiliary Dam.

3.2 Caples Creek at Caples Meadow

3.2.1 General Site Description

The Caples Creek at Caples Meadow study site is an approximately 350-foot long reach of Caples Creek located immediately downstream of the confluence of Kirkwood Creek and the Caples Spillway Channel (Figure 3-9). At the confluence of Kirkwood Creek and the Caples Spillway Channel, the watershed drainage area is approximately 18.6 square miles (mi²) with approximately three-quarters of the drainage area (13.6 mi²) controlled by Caples Lake (Entrix 2011b). This low-gradient and sinuous pool-riffle reach of Caples Creek runs through a large meadow and is relatively unconfined by bedrock valley walls in comparison to reaches both upstream and downstream.
Streamflow at the study site is influenced primarily by releases from Caples Lake Main Dam, but releases from the Caples Lake Auxiliary Dam, instream flows from Kirkwood Creek and local snowmelt runoff can also affect streamflow. USGS Gage 11436999 is located downstream of Caples Dam and approximately 1.5 miles upstream of the study site.

### 3.2.2 Channel Cross-Sections

The Caples Creek at Caples Meadow study site cross-sections for 2011 and 2016 are shown in Figure 3-10, Figure 3-11, and Figure 3-12 and change metrics are summarized in Table 3-4. Photos of each cross-section at the Caples Creek at Caples Meadow study site are provided in Appendix A. The survey data appears to indicate that the upper cross-section (XS-1) experienced a small amount of net erosion and a high degree of absolute percent change in area over the past 5 years. The cross-section comparison plot (Figure 3-10) shows erosion on both banks and no areas of deposition. The survey data appears to indicate that the middle cross-section (XS-2) experienced slight net deposition and a high degree of absolute percent change in area over the past 5 years. The cross-section comparison plot (Figure 3-11) shows deposition on the left bank and erosion on the right bank. The survey data appears to indicate that the lower cross-section (XS-3) experienced a large amount of net erosion and a high degree of absolute percent change over the past 5 years. The cross-section comparison plot (Figure 3-12) shows some deposition on the left bank and a large amount of erosion in the channel and on the right bank.

### Table 3-4.

Summary of Cross-Section Change Metrics for Caples Creek at Caples Meadow

<table>
<thead>
<tr>
<th>Channel Cross-Section Change Metric</th>
<th>XS-1 (Upper)</th>
<th>XS-2 (Middle)</th>
<th>XS-3 (Lower)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net percent change in channel area</td>
<td>-6%</td>
<td>3%</td>
<td>-26%</td>
</tr>
<tr>
<td>Absolute percent change in channel area</td>
<td>34%</td>
<td>44%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Some of the difference in the cross-section data between 2011 and 2016 may be due to differences in conditions during the monitoring efforts. The presence of snow at the study site in 2011 could have resulted in the survey rod being positioned higher than the 2016 ground surface. This is evident at XS-1 where it appears that the channel experienced erosion; however, both the cross sectional area and shape of the channel were very consistent between 2011 and 2016, making it more likely that the differences in cross sectional area and shape are the result of surveying with snow accumulated on the banks.

### 3.2.3 Longitudinal Profile

The Caples Creek at Caples Meadow longitudinal profiles for 2011 and 2016 are shown in Figure 3-13. The 2011 profile is approximately 600 feet in length and extends approximately 140 feet upstream of XS-1 and approximately 100 feet downstream of XS-3. The 2016 profile is approximately 530 feet in length and extends approximately 80 feet downstream from XS-3. Comparison of the two profiles appears to indicate a moderate degree of aggradation in the reach.

### 3.2.4 Bed Particle Size Distributions

The bed particle size distribution data for Caples Creek at Caples Meadow XS-1, XS-2, and XS-3 are presented in Figure 3-14, Figure 3-15, and Figure 3-16, respectively. Figures contain data from the 2016 sampling effort, as well as from 2011 (Stillwater Sciences 2012a). Representative bed particle sizes for each cross-section collected in 2007, 2011, and 2016 are presented in Table 3-5. Photos A-20, A-25, and A-30 in Appendix A show the typical channel bed at each cross-section.
In 2016, the pebble count data show that the bed is primarily finer than very coarse gravel (<32 mm) with the median size at all cross-sections being medium gravel (11.6 to 12.5 millimeters). Particle size distributions were similar at all three cross-sections in both 2011 and 2016. Comparison of 2016 data with 2011 data for all three cross-sections shows almost no change in particle size distribution in the past 5 years. Stillwater Sciences (2012a) noted that comparison of XS-1 particle size distribution data from 2011 and 2007 also showed essentially no changes.

Table 3-5. Representative Bed Particle Sizes for Caples Creek at Caples Meadow

<table>
<thead>
<tr>
<th>Representative Particle Size (mm)</th>
<th>Monitoring Year</th>
<th>XS-1 (Upper)</th>
<th>XS-2 (Middle)</th>
<th>XS-3 (Lower)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D_{16}</td>
<td>2007</td>
<td>2</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>3.0</td>
<td>3.0</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>3.5</td>
<td>4.9</td>
<td>4.8</td>
</tr>
<tr>
<td>D_{50}</td>
<td>2007</td>
<td>14</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>11.0</td>
<td>11.0</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>11.6</td>
<td>12.5</td>
<td>12.0</td>
</tr>
<tr>
<td>D_{84}</td>
<td>2007</td>
<td>26</td>
<td>--</td>
<td>--</td>
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<td></td>
<td>2011</td>
<td>23.0</td>
<td>22.0</td>
<td>28.2</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>25.0</td>
<td>26.8</td>
<td>23.6</td>
</tr>
</tbody>
</table>

3.2.5 Bank Erosion Potential

The Caples Creek at Caples Meadow study site bank erosion potential assessment for each cross-section is summarized in Table 3-6. The 2011 bank erosion potential assessment showed that the banks at the upper and middle cross-sections (XS-1 and XS-2) were relatively stable. The lower cross-section (XS-3) had banks with relatively high erosion potential, which was likely due to flow concentration on the right bank of XS-3 during high flow events resulting in an actively eroding cut bank. The results of the 2016 assessment indicate that banks at XS-1 and XS-2 have a low to moderate erosion potential and that the erosion potential of both banks at XS-3 is high. While the results of the 2016 assessment are generally higher than those from 2011, there has been no significant change in the condition of the banks at the site.

Table 3-6. Bank Erosion Potential Analysis Scores for Caples Creek at Caples Meadow

<table>
<thead>
<tr>
<th>Bank Erosion Potential Index</th>
<th>Index Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>XS-1 (Upper) Left Bank</td>
<td>1</td>
</tr>
<tr>
<td>XS-1 (Upper) Right Bank</td>
<td>1</td>
</tr>
<tr>
<td>XS-2 (Middle) Left Bank</td>
<td>1</td>
</tr>
<tr>
<td>XS-2 (Middle) Right Bank</td>
<td>1</td>
</tr>
<tr>
<td>XS-3 (Lower) Left Bank</td>
<td>1</td>
</tr>
<tr>
<td>XS-3 (Lower) Right Bank</td>
<td>1</td>
</tr>
<tr>
<td>Bank Height/Bankfull Height</td>
<td>4.5</td>
</tr>
<tr>
<td>Root Depth/Bank Height</td>
<td>5.5</td>
</tr>
<tr>
<td>Root Bank Height (%)</td>
<td>8</td>
</tr>
<tr>
<td>Bank Angle (degrees)</td>
<td>3.5</td>
</tr>
<tr>
<td>Surface Protection (%)</td>
<td>0</td>
</tr>
<tr>
<td>Bank Material</td>
<td>5</td>
</tr>
<tr>
<td>Stratification</td>
<td>0</td>
</tr>
<tr>
<td>SUM</td>
<td>22.9</td>
</tr>
<tr>
<td>Erosion Potential Category</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

AECOM

June 2017
3.2.6 General Geomorphic Assessment

Based on the monitoring data collected to date, Caples Creek at Caples Meadow appears to have a dynamically active channel with some areas experiencing deposition and others experiencing scour, both of which are likely episodic. The channel banks appear to be unstable in some areas and actively eroding. However, the channel shows no evidence of any significant degradation or aggradation.

Evidence of beaver activity was observed at Caples Creek in 2016, including remnants of a large beaver dam (approximately 3 feet in height) located on Caples Creek approximately 350 feet upstream of XS-1. The dam created a substantial pond that was inundating portions of Caples Meadow by April 2015. Only remnants of the dam were present at the time geomorphology monitoring was conducted in 2016 indicating the dam may have been blown out sometime over the previous winter or spring. A large piece of corrugated metal pipe culvert (24 inch diameter by 20 feet long) was also observed in channel between XS-2 and XS-3 (Deason 2017b).

3.3 Caples Creek at Girl Scout Access

3.3.1 General Site Description

The Caples Creek at Girl Scout Access study site is approximately 200 feet long and is located 0.4 miles downstream of the Caples Meadow study site (Figure 3-17). The study site is located at the next low-gradient meadow downstream from Caples Meadow and the two are separated by a reach in which the floodplain is confined by bedrock. The Girl Scout Access study site is confined by bedrock on the right bank side and reach immediately downstream is also tightly bedrock confined. The channel at this study site has a pool-riffle bedform and is much less sinuous than the channel at Caples Meadow.

Similar to the Caples Meadow study site, instream flows at the Girl Scout Access site are primarily controlled by releases from Caples Lake Main Dam, but releases from the Caples Lake Auxiliary Dam, instream flows from Kirkwood Creek, and local snowmelt runoff also can affect streamflow. At the study site, Caples Lake controls about three-quarter of the approximately 18-mi² watershed area (Entrix 2002). 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.

3.3.2 Channel Cross-Sections

The Caples Creek at Girl Scout Access study site cross-sections for 2011 and 2016 are shown in Figure 3-18, Figure 3-19, and Figure 3-20 and change metrics are summarized in Table 3-7. Photos of each cross-section at the Caples Creek at Girl Scout Access study site are provided in Appendix A. The survey data appears to indicate that during the 2011 or 2016 monitoring efforts, the upper cross-section (XS-1) experienced a small amount of net channel deposition and a moderate degree of absolute percent change in area over the past 5 years. The cross-section comparison plot (Figure 3-18) shows erosion on the right bank and alternating areas of erosion and deposition on the left bank. The middle cross-section (XS-2) experienced a moderate amount of net erosion and a moderate amount of absolute percent change in area over the past 5 years. The cross-section comparison plot (Figure 3-19) shows erosion on the right bank and in the channel. The lower cross-section (XS-3) experienced a small amount of net erosion and a high degree of absolute percent change over the past 5 years. The cross-section comparison plot (Figure 3-20) shows a small amount of deposition on the left bank, erosion of the thalweg and on the right bank, and deposition on the right side of the channel.
Some of the difference in the cross-section data between 2011 and 2016 may be due to differences in conditions during the monitoring efforts. The presence of snow at the study site in 2011 could have resulted in the survey rod being positioned higher than the 2016 ground surface. As described above at Caples Creek at Caples Meadow cross-sections, some differences in cross sectional area and shape between 2011 and 2016 are likely the result of surveying with snow accumulated on the banks. However, even when taking field conditions into account, it is apparent that the right bank has eroded at both XS-1 and XS-2. The 2011 monitoring data noted undercut banks at both locations and it appears that a portion of the bank has collapsed into the channel, effectively widening the channel on the right bank side by approximately 1 foot. Large woody debris was observed partially spanning the width of the channel bed just downstream of XS-3 and it is possible that this may have contributed to some deposition at this location.

### 3.3.3 Longitudinal Profile

The Caples Creek at Girl Scout Access longitudinal profiles for 2011 and 2016 are shown in Figure 3-21. The 2011 profile is approximately 400 feet in length and extends approximately 175 feet upstream from XS-1 and approximately 30 feet downstream from XS-3. The 2016 profile is approximately 450 feet in length and extends approximately 150 feet upstream from XS-1 and approximately 90 feet downstream from XS-3. Slope of pool-riffle channels is controlled at riffle crest locations. The average slope between the crest of the riffle upstream of XS-1 and the crest of the riffle located between XS-2 and XS-3 increased from 0.08% in 2011 to 0.17% in 2016. However, in light of the apparent deposition in the channel downstream of XS-3, it does not seem likely that this change is indicative of reach wide channel incision.

### 3.3.4 Bed Particle Size Distributions

The bed particle size distribution data for Caples Creek at Girl Scout Access XS-1, XS-2, and XS-3 are presented in Figure 3-22, Figure 3-23, and Figure 3-24, respectively. Figures contain data from the 2016 sampling effort, as well as from 2011 (Stillwater Sciences 2012a). Representative bed particle sizes for each cross-section collected in 2007, 2011, and 2016 are presented in Table 3-8. Photos A-35, A-40, and A-55 in Appendix A show the typical channel bed at each cross-section.

In 2016, the pebble count data show that the bed is primarily finer than very coarse gravel (<32 mm) with the median size at all cross-sections being medium gravel (8.5 to 10.6 mm). Particle size distributions were similar at all three cross-sections in both 2011 and 2016, although particles at XS-1 have been slightly finer than those at XS-3. Stillwater Sciences (2012a) noted that XS-1 particle size distribution data from 2007 and 2011 showed a noticeable fining. Comparison of 2016 data with 2011 data for XS-1 and XS-3 shows almost no change in particle size distribution in the past 5 years. Comparison of 2016 data with 2011 data for XS-2 shows a slight fining.

### Table 3-7

<table>
<thead>
<tr>
<th>Channel Cross-Section Change Metric</th>
<th>XS-1 (Upper)</th>
<th>XS-2 (Middle)</th>
<th>XS-3 (Lower)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net percent change in channel area</td>
<td>6%</td>
<td>-21%</td>
<td>-4%</td>
</tr>
<tr>
<td>Absolute percent change in channel area</td>
<td>14%</td>
<td>16%</td>
<td>41%</td>
</tr>
</tbody>
</table>
Representative Bed Particle Sizes for Caples Creek at Girl Scout Access

<table>
<thead>
<tr>
<th>Representative Particle Size (mm)</th>
<th>Monitoring Year</th>
<th>XS-1 (Upper)</th>
<th>XS-2 (Middle)</th>
<th>XS-3 (Lower)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{16}$</td>
<td>2007</td>
<td>5</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>2.0</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>2.6</td>
<td>&lt; 2</td>
<td>4.7</td>
</tr>
<tr>
<td>$D_{50}$</td>
<td>2007</td>
<td>12</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>6.0</td>
<td>13.5</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>8.5</td>
<td>9.1</td>
<td>10.6</td>
</tr>
<tr>
<td>$D_{84}$</td>
<td>2007</td>
<td>26</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>17.2</td>
<td>32.2</td>
<td>26.3</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>21.8</td>
<td>24.6</td>
<td>24.3</td>
</tr>
</tbody>
</table>

3.3.5 Bank Erosion Potential

The Caples Creek at Girl Scout Access study site bank erosion potential assessment for each cross-section is summarized in Table 3-9. The 2011 bank erosion potential assessment showed that the banks of all three cross-sections had essentially the same degree of moderate bank erosion potential. The results of the 2016 assessment indicate that bank erosion potential is high to very high throughout much of the study reach. These results are largely due to the near vertical or undercut angle of the banks, the significant fraction of sand in the bank material, and the shallow root depth of the predominant grass and sedge bank vegetation.

<table>
<thead>
<tr>
<th>Bank Erosion Potential Index</th>
<th>XS-1 (Upper) Left Bank</th>
<th>XS-1 (Upper) Right Bank</th>
<th>XS-2 (Middle) Left Bank</th>
<th>XS-2 (Middle) Right Bank</th>
<th>XS-3 (Lower) Left Bank</th>
<th>XS-3 (Lower) Right Bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Height/Bankfull Height</td>
<td>7.5</td>
<td>8</td>
<td>5</td>
<td>7.9</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Root Depth/Bank Height</td>
<td>6.5</td>
<td>3</td>
<td>5.4</td>
<td>7.8</td>
<td>5.5</td>
<td>2.3</td>
</tr>
<tr>
<td>Root Bank Height (%)</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>9.8</td>
<td>8.8</td>
<td>5.6</td>
</tr>
<tr>
<td>Bank Angle (degrees)</td>
<td>3.6</td>
<td>7.8</td>
<td>8</td>
<td>4</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Surface Protection (%)</td>
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<td>10</td>
<td>10</td>
<td>5</td>
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<td>4.7</td>
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<td>41.8</td>
<td>41.4</td>
<td>39.5</td>
<td>33.3</td>
<td>26.6</td>
</tr>
</tbody>
</table>

Bank Erosion Potential Category

- High
- Very High
- Erosion Potential Category

3.3.6 General Geomorphic Assessment

Similar to at Caples Meadow, Caples Creek at the Girl Scout Access site appears to have a dynamically active channel with localized areas of deposition and scour, both of which are likely episodic. The channel banks appear to be unstable in some areas and actively eroding. However, the channel shows no evidence of any significant degradation or aggradation.
3.4 Caples Creek at Jake Schneider Meadow

3.4.1 General Site Description

The Caples Creek at Jake Schneider Meadow study site is approximately 250 feet long and is located 6 mi. downstream of the Girl Scout Access study site (Figure 3-25). The channel through the study 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 feet from the stream 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 Caples Creek at Jake Schneider Meadow are primarily controlled by flow releases from Caples Dam. However, Caples Creek at Jake Schneider has a much larger drainage area than either of the upstream sites and therefore is more influenced by localized runoff and accretive tributary flows. The drainage area to the study site is approximately 30 mi², with a little less than half the drainage area (13.6 mi²) regulated by Caples Lake (Entrix 2011b).

3.4.2 Channel Cross-Sections

The Caples Creek at Jake Schneider Meadow study site cross-sections for 2011 and 2016 are shown in Figure 3-26, Figure 3-27, and Figure 3-28 and change metrics are summarized in Table 3-10. Photos of each cross-section at the Caples Creek at Jake Schneider Meadow study site are provided in Appendix A. The survey data appears to indicate that the upper cross-section (XS-B) experienced very little change over the past 5 years. The cross-section comparison plot (Figure 3-26) shows slight erosion on the left and right banks and small alternating areas of erosion and deposition in the channel. The middle cross-section (XS-C) experienced a small amount of net channel deposition and a low degree of absolute percent change in area over the past 5 years. The cross-section comparison plot (Figure 3-27) shows some erosion on the left bank and in the left side of the channel and deposition on the right side of the channel. The lower cross-section (XS-2) experienced a small amount of net deposition and a low degree of absolute percent change over the past 5 years. The cross-section comparison plot (Figure 3-28) shows very small changes across most of the cross-section, with one small area of deposition on the right side of the channel.

Overall, the data for all three cross sections indicate that this Caples Creek at Jake Schneider Meadow has remained relatively stable between 2011 and 2016.

3.4.3 Longitudinal Profile

Figure 3-29 shows the longitudinal profile data for Caples Creek at Jake Schneider Meadow from the 2016 and 2011 monitoring efforts. The 2011 profile is approximately 580 feet in length and extends approximately 200 feet upstream of XS-B and approximately 150 feet downstream from XS-2. The 2016 profile is approximately 700 feet in length and extends approximately 260 feet upstream from XS-B and approximately 175 feet downstream from XS-2. Comparison of the profiles indicates that some deposition may have occurred in the scour pool located between XS-C and XS-2, but that there are no obvious indications of instability.
3.4.4 Bed Particle Size Distributions

The bed particle size distribution data for Caples Creek at Jake Schneider Meadow XS-B, XS-C, and XS-2 are presented in Figure 3-30, Figure 3-31, and Figure 3-32, respectively. Figures contain data from the 2016 sampling effort, as well as from 2011 (Stillwater Sciences 2012a). Representative bed particle sizes for each cross-section collected in 2007, 2011, and 2016 are presented in Table 3-11. Photos A-50, A-55, and A-60 in Appendix A show the typical channel bed at each cross-section.

Both the 2016 and 2011 pebble count data show high variability in particle size distribution between cross-sections. The 2016 median particle sizes range from sand/silt/clay (< 2 millimeters) at XS-B (Upper) to medium or coarse gravel (16 millimeters) at XS-2 (Lower). The 2016 D84 values range from fine gravel (7.6 mm) at XS-C (Middle) to small cobble (83.3 mm) at XS-2. Overall, 2016 data showed that bed particle sizes at XS-B and XS-C were much finer than at XS-2. Pebble count data collected from XS-B in 2007 (Stillwater Sciences 2012a) showed that the cross-section was finer and more well-graded in 2011 compared to 2007. Comparison of 2016 data with 2011 data for XS-B shows a considerable fining of the bed sediment over the past 5 years. Both XS-C and XS-2 showed a slight fining of bed particle sizes between 2011 and 2016.

Table 3-11. Representative Bed Particle Sizes for Caples Creek at Jake Schneider Meadow

<table>
<thead>
<tr>
<th>Representative Particle Size (mm)</th>
<th>Monitoring Year</th>
<th>XS-B (Upper)</th>
<th>XS-C (Middle)</th>
<th>XS-2 (Lower)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D16</td>
<td>2007</td>
<td>6</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>2011</td>
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<td>3.0</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>D50</td>
<td>2007</td>
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<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td>16.0</td>
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</tr>
<tr>
<td></td>
<td>2016</td>
<td>18.0</td>
<td>7.6</td>
<td>83.3</td>
</tr>
</tbody>
</table>

3.4.5 Bank Erosion Potential

Bank erosion potential assessment scores for each cross-section’s left and right bank at Caples Creek at Jake Schneider Meadow are presented in Table 3-12. The assessment shows moderate and high levels of erosion potential at each cross-section. The 2011 bank erosion potential assessment showed that the banks of all three cross-sections had essentially the same degree of low bank erosion potential. Differences in erosion potential scores between 2011 and 2016 are more likely a result of different evaluators conducting the assessment than a result of actual changes in erosion potential. For example, the 2016 assessments included an addition of ten points as a bank material adjustment to account for the significant sand fraction observed in the banks, while no such adjustment was made in 2011.
3.4.6 General Geomorphic Assessment

Based on the monitoring data collected to date, Caples Creek appears to be relatively stable at the Jake Schneider Meadow study site. The longitudinal profile and cross sectional areas of the channel have remained stable during this five year monitoring period. However, there is a relatively high potential for the channel banks to erode during future high flow events.

3.5 Oyster Creek below Highway 88

3.5.1 General Site Description

The Oyster Creek watershed begins at Oyster Lake, which is fed by subsurface leakage from Silver Lake and snowmelt, and covers 1.3 mi² (Blue Line Consulting 2009). Approximately 0.5 miles downstream of Oyster Lake, a small tributary, Thunder Mountain tributary, joins Oyster Creek. Oyster Creek flows for approximately 1.4 miles before joining the Silver Fork American River. The Oyster Creek below Highway 88 study site is approximately 350 feet long and is located 1,500 feet downstream of where Highway 88 crosses over the creek (Figure 3-33). At the study site, Oyster Creek flows along the southern border of a low gradient meadow. It has a low degree of entrenchment and is highly sinuous (Entrix 2002). The creek is dominated by riffles and runs and has a well-developed inset floodplain (Blue Line Consulting 2009).

Instream flows at the Oyster Creek study site are affected by natural hydrologic processes from the Thunder Mountain tributary, leakage from Silver Lake, and local road drainage. Leakage from Silver Lake and local road drainage has increased instream flows in Oyster Creek compared to historical conditions.

3.5.2 Channel Cross-Sections

The Oyster Creek below Highway 88 study site cross-sections for 2011 and 2016 are shown in Figure 3-34, Figure 3-35, and Figure 3-36 and change metrics are summarized in Table 3-13. Photos of each cross-section at the Oyster Creek below Highway 88 study site are provided in Appendix A. The survey data appears to indicate that the upper cross-section (XS-7) experienced very little change over the past 5 years. The cross-section comparison plot (Figure 3-34) shows a small amount of deposition on the left bank and on the left side of the channel and erosion on the right bank and on the right side of the channel. The middle cross-section (XS-6) experienced a small amount of net channel erosion and a
low degree of absolute percent change in area over the past 5 years. The cross-section comparison plot (Figure 3-35) shows a small amount of erosion mostly on the right bank and in the thalweg. The lower cross-section (XS-5) experienced a moderate amount of erosion and a moderate degree of absolute percent change over the past 5 years. The cross-section comparison plot (Figure 3-36) shows erosion throughout the cross-section.

Overall, the data for all three cross sections indicate that the Oyster Creek study site has remained relatively stable between 2011 and 2016. Some of the difference in the cross-section data between 2011 and 2016 may be due to differences in conditions during the monitoring efforts. For example, the presence of snow at the study site in 2011 could have resulted in the survey rod being positioned higher than the 2016 ground surface.

### 3.5.3 Longitudinal Profile

Figure 3-37 shows the longitudinal profile data for Oyster Creek below Highway 88 from the 2011 and 2016 monitoring efforts. The 2011 profile is 520 feet in length. The 2016 profile is approximately 500 feet in length and extends 25 feet upstream from XS-7. Comparison of the 2011 and 2016 profiles shows that the average reach slope, as measured between the riffle crest at the upstream end of the reach and the riffle crest downstream of 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 the fact that bedform features were not noted during the 2011 survey.

### 3.5.4 Bed Particle Size Distributions

The bed particle size distribution data for Oyster Creek below Highway 88 XS-7, XS-6, and XS-5 are presented in Figure 3-38, Figure 3-39, and Figure 3-40, respectively. Figures contain data from the 2016 sampling effort, as well as from 2011 (Stillwater Sciences 2012a). Representative bed particle sizes for each cross-section collected in 2007, 2011, and 2016 are presented in Table 3-14. Photos A-65, A-70, and A-75 in Appendix A show the typical channel bed at each cross-section.

In 2016, the pebble count data show that the bed is primarily finer than very coarse gravel (<64 mm) with the median particle size ranging from medium gravel (14.5 mm) at XS-6 (Middle) to coarse gravel (18.8 mm) at XS-5 (Lower). Particle size distributions were similar at all three cross-sections in both 2011 and 2016. Stillwater Sciences (2012a) noted that XS-1 particle size distribution from 2007 and 2011 showed a considerable fining. Comparison of 2016 data with 2011 data for all three cross-sections shows almost no change in particle size distribution in the past 5 years.
3.5.5 Bank Erosion Potential

Bank erosion potential assessment scores for each cross-sections’ left and right bank at Oyster Creek below Highway 88 are presented in Table 3-15. The 2011 bank erosion potential assessment showed that the banks ranged from moderate to high erosion potential, with the two lower cross-sections having the highest erosion potential. The moderate to high bank erosion potential ratings were due to moderate to high channel sinuosity, which caused flow acceleration and high shear stresses at channel bends, resulting in steep, exposed banks.

### Table 3-14.
Representative Bed Particle Sizes for Oyster Creek below Highway 88

<table>
<thead>
<tr>
<th>Representative Particle Size (mm)</th>
<th>Monitoring Year</th>
<th>XS-7 (Upper)</th>
<th>XS-6 (Middle)</th>
<th>XS-5 (Lower)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D&lt;sub&gt;16&lt;/sub&gt;</td>
<td>2007</td>
<td>15</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>4.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>3.7</td>
<td>6.0</td>
<td>5.4</td>
</tr>
<tr>
<td>D&lt;sub&gt;50&lt;/sub&gt;</td>
<td>2007</td>
<td>35</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>14.0</td>
<td>16.0</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>17.4</td>
<td>14.5</td>
<td>18.8</td>
</tr>
<tr>
<td>D&lt;sub&gt;84&lt;/sub&gt;</td>
<td>2007</td>
<td>78</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>25.0</td>
<td>26.0</td>
<td>19.2</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>39.2</td>
<td>29.3</td>
<td>34.3</td>
</tr>
</tbody>
</table>

### Table 3-15.
Bank Erosion Potential Analysis Scores for Oyster Creek below Highway 88

<table>
<thead>
<tr>
<th>Bank Erosion Potential Index</th>
<th>Index Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Height/Bankfull Height</td>
<td>10 1 1 10 10 1</td>
</tr>
<tr>
<td>Root Depth/Bank Height</td>
<td>8 3 3.5 7.9 6.5 0</td>
</tr>
<tr>
<td>Root Bank Height (%)</td>
<td>9.5 4.5 4.5 9.9 9.5 3.5</td>
</tr>
<tr>
<td>Bank Angle (degrees)</td>
<td>3 5 1.1 3 3.5 4.5</td>
</tr>
<tr>
<td>Surface Protection (%)</td>
<td>7 0.5 1 8 8 1</td>
</tr>
<tr>
<td>Bank Material</td>
<td>0 0 10 10 10 10</td>
</tr>
<tr>
<td>Stratification</td>
<td>0 0 0 0 0 0</td>
</tr>
<tr>
<td>SUM</td>
<td>37.5 14 21.1 48.8 47.5 20</td>
</tr>
<tr>
<td>Erosion Potential Category</td>
<td>High Low Moderate Extreme Extreme Moderate</td>
</tr>
</tbody>
</table>

3.5.6 General Geomorphic Assessment

Based on the monitoring data collected to date the Oyster Creek site appears to have a relatively stable channel bed with steep banks and extremely high erosion potential at meander bends. While the channel at this location has remained relatively stable during the 5-year monitoring period, it is likely that erosion along the channel banks could occur from future high flow events.
3.6 South Fork American River below Kyburz Diversion Dam

3.6.1 General Site Description

The South Fork American River below Kyburz Diversion Dam study site is approximately 0.3 miles long and is located 0.25 miles downstream of the Kyburz Diversion Dam near the confluence of the South Fork and Silver Fork American River (Figure 3-41). The channel through the study site is a steep, coarse-bedded, bedrock controlled channel with low sinuosity step pool morphology, a moderately steep reach-average channel slope, and a moderate degree of entrenchment (i.e., a moderate width to depth ratio). The reach is confined by valley walls, which impede lateral migration of the channel (Entrix 2002).

3.6.2 Channel Cross-Sections

The South Fork American River below Kyburz Diversion Dam study site cross-sections for 2011 and 2016 are shown in Figure 3-42, Figure 3-43, and Figure 3-44 and change metrics are summarized in Table 3-16. Photos of each cross-section at the South Fork American River below Kyburz Diversion Dam study site are provided in Appendix A. The survey data appears to indicate that all three cross-sections experienced a very small amount of deposition and low degrees of absolute percent change in area over the past 5 years. The lower cross-section (XS-3) experienced the most change, including erosion in the thalweg and an area of deposition on the right bank.

Overall, the data for all three cross sections indicate that the channel area and shape at South Fork American River below Kyburz Diversion Dam study site has remained relatively stable between 2011 and 2016.

3.6.3 Longitudinal Profile

Figure 3-45 shows the longitudinal profile data for South Fork American River at Kyburz Diversion Dam from the 2016 and 2011 monitoring efforts. The 2011 profile is approximately 2,075 feet in length and extends approximately 35 feet upstream from XS-1 and approximately 100 feet downstream from XS-3. The 2016 profile is approximately 2,000 feet in length and extends approximately 110 feet upstream from XS-1 and approximately 100 feet downstream from XS-3. Comparison of the profiles suggests the possibility of a datum shift between surveys. However, there are no obvious indications of instability.

3.6.4 Bed Particle Size Distributions

The bed particle size distribution data for South Fork American River below Kyburz Diversion Dam XS-1, XS-2, and XS-3 are presented in Figure 3-46, Figure 3-47, and Figure 3-48, respectively. Figures contain data from the 2016 sampling effort, as well as from 2011 (Stillwater Sciences 2012b). Representative bed particle sizes for each cross-section collected in 2007, 2011, and 2016 are presented in Table 3-17. Photos A-80, A-85, and A-90 in Appendix A show the typical channel bed at each cross-section.

In 2016, the $D_{84}$ particles in all three cross-sections ranged from small boulders (328.4 mm) at XS-3 to medium boulders (714.0 mm) at XS-1 and the median particle sizes range from medium cobble (95.7
mm) at XS-3 to large cobble (180.0 mm) at XS-1. Particles at this site were generally coarser upstream and became finer moving downstream. Pebble count data was not collected at XS-1 in 2011 because water depths and flows prohibited safe access, so trends in particle size distribution cannot be assessed at that cross section. Comparison of 2016 data with 2011 data for XS-2 and XS-3 shows fining at both cross-sections, however the degree of fining at XS-3 is much larger than at XS-2.

<table>
<thead>
<tr>
<th>Representative Particle Size (mm)</th>
<th>Monitoring Year</th>
<th>XS-1 (Upper)</th>
<th>XS-2 (Middle)</th>
<th>XS-3 (Lower)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D_{16}</td>
<td>2007</td>
<td>--</td>
<td>&lt; 2</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>--</td>
<td>1.0</td>
<td>48.8</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>D_{50}</td>
<td>2007</td>
<td>--</td>
<td>144</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>--</td>
<td>147.0</td>
<td>108.5</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>180.0</td>
<td>112.0</td>
<td>95.7</td>
</tr>
<tr>
<td>D_{84}</td>
<td>2007</td>
<td>--</td>
<td>380</td>
<td>255</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>--</td>
<td>371.6</td>
<td>250.8</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>714.0</td>
<td>377.8</td>
<td>328.4</td>
</tr>
</tbody>
</table>

3.6.5 Bank Erosion Potential

Bank erosion potential assessment scores for each cross-sections’ left and right bank at South Fork American River below Kyburz Diversion Dam are presented in Table 3-18. The stream banks are armored with large sediment (large cobbles and boulders) that reduce the erosion potential, resulting in low or very low erosion potential at several of the sample locations. Two locations (XS-2 right bank and XS-3 left bank) have moderate erosion potential. The 2011 bank erosion potential assessment showed that all three cross-sections had essentially the same degree of low bank erosion potential.

<table>
<thead>
<tr>
<th>Bank Erosion Potential Index</th>
<th>Index Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Height/Bankfull Height</td>
<td>5.7</td>
</tr>
<tr>
<td>Root Depth/Bank Height</td>
<td>0</td>
</tr>
<tr>
<td>Root Bank Height (%)</td>
<td>8.5</td>
</tr>
<tr>
<td>Bank Angle (degrees)</td>
<td>1</td>
</tr>
<tr>
<td>Surface Protection (%)</td>
<td>7.5</td>
</tr>
<tr>
<td>Bank Material</td>
<td>-10</td>
</tr>
<tr>
<td>Stratification</td>
<td>0</td>
</tr>
<tr>
<td>SUM</td>
<td>12.7</td>
</tr>
<tr>
<td>Erosion Potential Category</td>
<td>Low</td>
</tr>
</tbody>
</table>

3.6.6 General Geomorphic Assessment

Based on the monitoring data collected to date, the analysis was consistent with the previous assertion that the channel of the South Fork American River appears to be stable at this location and that observable geomorphic change at the study site is likely to occur very infrequently.
3.7 Silver Fork American River at Forgotten Flat

3.7.1 General Site Description

The Silver Fork American River at Forgotten Flat study site is an approximately 300-foot long reach located 3.5 miles downstream of Silver Lake (Figure 3-49). Oyster Creek converges with the Silver Fork American River approximately 3 miles upstream of the study site. The channel bed through the study site has a coarse-grained boulder framework and plane bed morphology with a relatively flat average gradient, moderate entrenchment, and low sinuosity (Entrix 2002).

Approximately 70 percent of the 22-mi² drainage area upstream of the study site is regulated by Silver Lake (Entrix 2002). Flows from Oyster Creek and local snowmelt runoff also affect streamflow at the study site. In general, Silver Lake Dam operations tend to cause a reduction in spring baseflow with attenuated snowmelt runoff peak flows and increased summer baseflow compared to what would be expected under unregulated conditions.

3.7.2 Channel Cross-Sections

The Silver Fork American River at Forgotten Flat study site cross-sections for 2011 and 2016 are shown in Figure 3-50, Figure 3-51, and Figure 3-52 and change metrics are summarized in Table 3-19. Photos of each cross-section at the Silver Fork American River at Forgotten Flat study site are provided in Appendix A. The survey data appears to indicate that the upper cross-section (XS-1) experienced a small amount of net channel erosion and a moderate degree of absolute percent change in area over the past 5 years. The cross-section comparison plot (Figure 3-50) shows deposition on the right bank and in small areas within the channel. The middle cross-section (XS-2) experienced a moderate amount of net deposition and a low degree of absolute percent change in area over the past 5 years. The cross-section comparison plot (Figure 3-51) shows a small amount of deposition on the right bank and a very small area of deposition on the left bank. The lower cross-section (XS-3) experienced a small amount of net erosion and a moderate degree of absolute percent change over the past 5 years. The cross-section comparison plot (Figure 3-52) shows deposition on the right bank and alternating erosion and deposition in the channel.

<table>
<thead>
<tr>
<th>Channel Cross-Section Change Metric</th>
<th>XS-1 (Upper)</th>
<th>XS-2 (Middle)</th>
<th>XS-3 (Lower)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net percent change in channel area</td>
<td>-3%</td>
<td>17%</td>
<td>-8%</td>
</tr>
<tr>
<td>Absolute percent change in channel area</td>
<td>14%</td>
<td>10%</td>
<td>19%</td>
</tr>
</tbody>
</table>

Overall, the data for all three cross sections indicate that the Silver Fork American River at Forgotten Flat study site has remained relatively stable and unchanged between 2011 and 2016. The minor differences observed in the cross-section data are likely due to minor inconsistencies in field measurements. For example, in channels with coarse substrate, cross section differences could represent a slight difference in placement of the survey rod for a single point and not an actual change in the channel cross section shape or area.

3.7.3 Longitudinal Profile

Figure 3-53 shows the longitudinal profile data for Silver Fork American River at Forgotten Flat from the 2016 and 2011 monitoring efforts. The 2011 profile is approximately 500 feet in length and extends approximately 165 feet upstream from XS-1 and approximately 60 feet downstream from XS-3. The 2016 profile is approximately 480 feet in length and extends approximately 165 feet upstream from XS-
1 and approximately 45 feet downstream from XS-3. Comparison of the 2011 and 2016 profiles shows that the average reach slope, as measured between the step crest at the upstream end of the reach and the step crest downstream of XS-3, has remained nearly constant, indicating that the channel has remained stable during the monitoring period.

### 3.7.4 Bed Particle Size Distributions

The bed particle size distribution data for Silver Fork American River at Forgotten Flat XS-1, XS-2, and XS-3 are presented in Figure 3-54, Figure 3-55, and Figure 3-56, respectively. Figures contain data from the 2016 sampling effort, as well as from Stillwater Sciences 2011 (Stillwater Sciences 2012b). Representative bed particle sizes for each cross-section collected in 2007, 2011, and 2016 are presented in Table 3-20. Photos A-95 and A-100 in Appendix A show the typical channel bed at each cross-section.

The 2016 pebble count data show high variability in particle size distribution between cross-sections. The 2016 median particle sizes range from medium gravel (8.3 mm) at XS-1 to large cobble (157.8 mm) at XS-3. The 2016 $D_{84}$ particles in all three cross-sections range from very large cobble (189.5 mm) at XS-2 to medium/large boulders (1024.0 mm) at XS-3. Overall, 2016 data showed that bed particle sizes were generally finer upstream and became coarser moving downstream. Comparison of 2016 data with 2011 data for XS-1 seems to indicate that the bed has become somewhat less well-graded, with a greater proportion of small particles and very large particles. There has been very little change in the bed particle size distribution at XS-2 between 2011 and 2016. At XS-3, there appears to have been considerable coarsening of the bed between 2011 and 2016.

<table>
<thead>
<tr>
<th>Representative Particle Size (mm)</th>
<th>Monitoring Year</th>
<th>XS-1 (Upper)</th>
<th>XS-2 (Middle)</th>
<th>XS-3 (Lower)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{16}$</td>
<td>2007</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>&lt; 2</td>
<td>3.2</td>
<td>28.4</td>
</tr>
<tr>
<td>$D_{50}$</td>
<td>2007</td>
<td>25</td>
<td>42</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>25.5</td>
<td>51.0</td>
<td>53.0</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>8.3</td>
<td>41.2</td>
<td>157.8</td>
</tr>
<tr>
<td>$D_{84}$</td>
<td>2007</td>
<td>260</td>
<td>290</td>
<td>290</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>243.2</td>
<td>290.0</td>
<td>264.8</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>296.9</td>
<td>189.5</td>
<td>1024.0</td>
</tr>
</tbody>
</table>

### 3.7.5 Bank Erosion Potential

Bank erosion potential assessment scores for each cross-section at Silver Fork American River at Forgotten Flat are presented in Table 3-21. The left and right banks at each cross-section were very similar, so scores representing both banks were recorded for each cross-section. The assessment shows low and very low erosion potential at each cross-section. The 2011 bank erosion potential assessment showed that the cross-sections had a low erosion potential and were considered stable.
### Table 3-21.
Bank Erosion Potential Analysis Scores for Silver Fork American River at Forgotten Flat

<table>
<thead>
<tr>
<th>Bank Erosion Potential Index</th>
<th>XS-1 (Upper) Left and Right Banks</th>
<th>XS-2 (Middle) Left and Right Banks</th>
<th>XS-3 (Lower) Left and Right Banks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Height/Bankfull Height</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Root Depth/Bank Height</td>
<td>1.9</td>
<td>2.2</td>
<td>2</td>
</tr>
<tr>
<td>Root Bank Height (%)</td>
<td>6.5</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Bank Angle (degrees)</td>
<td>2.5</td>
<td>2.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Surface Protection (%)</td>
<td>3</td>
<td>3.5</td>
<td>6.8</td>
</tr>
<tr>
<td>Bank Material</td>
<td>0</td>
<td>0</td>
<td>-10</td>
</tr>
<tr>
<td>Stratification</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>SUM</strong></td>
<td><strong>13.9</strong></td>
<td><strong>13.9</strong></td>
<td><strong>7.3</strong></td>
</tr>
<tr>
<td>Erosion Potential Category</td>
<td>Low</td>
<td>Low</td>
<td>Very Low</td>
</tr>
</tbody>
</table>

#### 3.7.6 General Geomorphic Assessment

Based on the monitoring data collected to date, the channel of the Silver Fork American River at the Forgotten Flat study site has remained stable during the five year monitoring period. The relatively low gradient of the bed profile for a plane bed reach and the low bank erosion potential indicate that the study reach should remain stable in the future.

#### 3.8 Lower Echo Creek

##### 3.8.1 General Site Description

The Lower Echo Creek study site is approximately 350 feet long and is located between the South Upper Truckee Road bridge crossing and the confluence with the Upper Truckee River (Figure 3-61). The channel is located atop a forested depositional alluvial fan deposit and splits into two distributary channels less than 200 feet 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 at the study site 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 primarily affected by releases from Echo Lake as well as local snowmelt and spring runoff events. Diversions from Echo Lake only occur between Labor Day and October first of each year. (Deason, 2017)

##### 3.8.2 Channel Cross-Sections

The Lower Echo Creek site cross-sections for 2011 and 2016 are shown in Figure 3-58, Figure 3-59, and Figure 3-60 and change metrics are summarized in Table 3-22. Photos of each cross-section at the Lower Echo Creek study site are provided in Appendix A. The survey data appears to indicate that all three cross-sections experienced small amounts of erosion (XS-1) and deposition (XS-0b and XS-2) and low degrees of absolute percent change in area over the past 5 years. Overall, the data for all three cross sections indicate that the Echo Creek study site has remained relatively stable and unchanged between 2011 and 2016.
3.8.3 Longitudinal Profile

Figure 3-61 shows the longitudinal profile data for Lower Echo Creek Left Channel from the 2016 and 2011 monitoring efforts and Figure 3-62 shows Lower Echo Creek Right Channel. The 2011 left channel profile is approximately 385 feet in length and extends approximately 30 feet upstream from XS-0b and approximately 10 feet downstream from XS-2. The 2016 left channel profile is approximately 460 feet in length and extends approximately 30 feet upstream from XS-0b and approximately 90 feet downstream from XS-2. The 2011 right channel profile is approximately 350 feet in length and extends approximately 30 feet upstream from XS-0b and approximately 60 feet downstream from XS-2. The 2016 right channel profile is 370 feet in length and extends approximately 35 feet upstream from XS-0b and approximately 90 feet downstream from XS-2. Comparison of the 2011 and 2016 profiles shows that the average reach slope appears to have 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 the fact that bedform features were not noted during the 2011 survey.

3.8.4 Bed Particle Size Distributions

The bed particle size distribution data for Lower Echo Creek Left Channel XS-0b, XS-1, and XS-2 are presented in Figure 3-63, Figure 3-65, and Figure 3-67, respectively, and the data for Lower Echo Creek Right Channel XS-0b, XS-1, and XS-2 are presented in Figure 3-64, Figure 3-66 and Figure 3-67, respectively. Figures contain data from the 2016 sampling effort, as well as from 2011 (Stillwater 2012a, Stillwater Sciences 2012b). Representative bed particle sizes for each cross-section collected in 2007, 2011, and 2016 are presented in Table 3-23. Photos A-109, A-114, A-119, A-124, A-129, and A-134 in Appendix A show the typical channel bed at each cross-section.

In 2016, the pebble count data show that particle sizes in the Lower Echo Creek right channel are generally larger than the left channel. In both channels the bed is primarily finer than large cobble (< 180 mm) and the median particle sizes range from coarse gravel (18.9 mm) at XS-1 (Middle) in the left channel to very coarse gravel (59.7 mm) at XS-0B (Upper) in the right channel. Data from 2016 shows that particle sizes were slightly coarser at XS-0B and XS-2 (Lower) compared to XS-1 in the left channel and particle sizes were similar at all three cross-sections in the right channel. Comparison of 2016 data with 2011 data shows the following changes in bed particle size distribution:

- **Left Channel XS-0b:** The cross-section was slightly more well-graded and contained a greater proportion of fine material in 2016 compared to 2011.
- **Left Channel XS-1:** The cross-section was slightly less well-graded and contained a greater proportion of coarse gravel (16 to 32 mm) in 2016 compared to 2011.
- **Left Channel XS-2:** The cross-section was slightly more well-graded and contained a greater proportion of fine material in 2016 compared to 2011.
Right Channel XS-0b: The cross-section contained a slightly greater proportion of fine material in 2016 compared to 2011.

Right Channel XS-1: There was almost no change in this cross-section between 2011 and 2016.

Right Channel XS-2: There was almost no change in this cross-section between 2011 and 2016.

Table 3-23. Representative Bed Particle Sizes for Lower Echo Creek

<table>
<thead>
<tr>
<th>Representative Particle Size (mm)</th>
<th>Monitoring Year</th>
<th>LC XS-0b (Upper)</th>
<th>RC XS-0b (Upper)</th>
<th>LC XS-1 (Middle)</th>
<th>RC XS-1 (Middle)</th>
<th>LC XS-2 (Lower)</th>
<th>RC XS-2 (Lower)</th>
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<td>D_{16}</td>
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<tr>
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<td>2011</td>
<td>40.0</td>
<td>30.0</td>
<td>4.0</td>
<td>6.8</td>
<td>30.0</td>
<td>21.5</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>9.5</td>
<td>10.3</td>
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<td>8.4</td>
<td>8.0</td>
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<tr>
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<td>--</td>
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<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>70.0</td>
<td>60.0</td>
<td>24.5</td>
<td>42.0</td>
<td>65.5</td>
<td>42.0</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>39.4</td>
<td>59.7</td>
<td>18.9</td>
<td>47.7</td>
<td>31.1</td>
<td>56.6</td>
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<tr>
<td>D_{84}</td>
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<td>--</td>
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</tr>
<tr>
<td></td>
<td>2011</td>
<td>125.6</td>
<td>111.5</td>
<td>84.1</td>
<td>80.3</td>
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<tr>
<td></td>
<td>2016</td>
<td>94.4</td>
<td>125.5</td>
<td>40.8</td>
<td>85.2</td>
<td>77.4</td>
<td>120.8</td>
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</table>

*Note: LC = left channel; RC = right channel*

### 3.8.5 Bank Erosion Potential

Bank erosion potential assessment scores for each cross-section at the Lower Echo Creek Left Channel are presented in Table 3-24 and scores for each cross-section at the Lower Echo Creek Right Channel are presented in Table 3-25. The left and right banks at each cross-section were very similar, so scores representing both banks were recorded for each cross-section. The assessments show moderate to very high bank erosion potential at Lower Echo Creek. The 2011 bank erosion potential assessment showed that the cross-sections had a low to very low erosion potential.
Table 3-24. Bank Erosion Potential Analysis Scores for Lower Echo Creek Left Channel

<table>
<thead>
<tr>
<th>Bank Erosion Potential Index</th>
<th>Index Value</th>
<th>XS-0b (Upper) Left and Right Banks</th>
<th>XS-1 (Middle) Left and Right Banks</th>
<th>XS-2 (Lower) Left and Right Banks</th>
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<td>1.3</td>
<td>6.3</td>
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<tr>
<td>Root Bank Height (%)</td>
<td>9.5</td>
<td>8.7</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>Bank Angle (degrees)</td>
<td>10</td>
<td>6.7</td>
<td>4</td>
<td></td>
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<tr>
<td>Surface Protection (%)</td>
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<td></td>
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<td>Bank Material</td>
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<tr>
<td>SUM</td>
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Table 3-25. Bank Erosion Potential Analysis Scores for Lower Echo Creek Right Channel

<table>
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<tr>
<th>Bank Erosion Potential Index</th>
<th>Index Value</th>
<th>XS-0b (Upper) Left and Right Banks</th>
<th>XS-1 (Middle) Left and Right Banks</th>
<th>XS-2 (Lower) Left and Right Banks</th>
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<td>Root Depth/Bank Height</td>
<td>3.6</td>
<td>2.6</td>
<td>2.2</td>
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</tr>
<tr>
<td>Root Bank Height (%)</td>
<td>8.5</td>
<td>9.5</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>Bank Angle (degrees)</td>
<td>6</td>
<td>9</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>Surface Protection (%)</td>
<td>4.2</td>
<td>6</td>
<td>4.3</td>
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<tr>
<td>Bank Material</td>
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<tr>
<td>SUM</td>
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3.8.6 General Geomorphic Assessment

The monitoring data collected to date suggest that the study reach of Echo Creek has largely remained stable during the 5-year monitoring period. However, frequent channel changes are common in such depositional channels and the bank erosion potential is relatively high. In the long term, avulsion of the main thread channel or reoccupation of floodplain side channels may occur during high flow events.
4 Literature Cited


Deason, Mr. Brian, El Dorado Irrigation District. 2017. Personal communication.


Figures
Figure 1-1. Geomorphic Monitoring Sites
Figure 3-1. Caples Creek Spillway Channel cross-section endpoints and coordinates.

Figure 3-2. Caples Creek Spillway Channel XS-1 survey data.
Figure 3-3. Caples Creek Spillway Channel XS-2 survey data.

Figure 3-4. Caples Creek Spillway Channel XS-3 survey data.
Figure 3-5. Caples Creek Spillway Channel longitudinal profile survey data.

Figure 3-6. Caples Creek Spillway Channel XS-1 bed particle size distribution.
Figure 3-7. Caples Creek Spillway Channel XS-2 bed particle size distribution.

Figure 3-8. Caples Creek Spillway Channel XS-3 bed particle size distribution.
Figure 3-9. Caples Creek at Caples Meadow cross-section endpoints and coordinates.

Figure 3-10. Caples Creek at Caples Meadow XS-1 survey data.
Figure 3-11. Caples Creek at Caples Meadow XS-2 survey data.

Figure 3-12. Caples Creek at Caples Meadow XS-3 survey data.
Figure 3-13. Caples Creek at Caples Meadow longitudinal profile survey data.

Figure 3-14. Caples Creek at Caples Meadow XS-1 bed particle size distribution.
Figure 3-15. Caples Creek at Caples Meadow XS-2 bed particle size distribution.

Figure 3-16. Caples Creek at Caples Meadow XS-3 bed particle size distribution.
Figure 3-17. Caples Creek at Girl Scout Access cross-section endpoints and coordinates.

Figure 3-18. Caples Creek at Girl Scout Access XS-1 survey data.
Figure 3-19. Caples Creek at Girl Scout Access XS-2 survey data.

Figure 3-20. Caples Creek at Girl Scout Access XS-3 survey data.
Figure 3-21. Caples Creek at Girl Scout Access longitudinal profile survey data.

Figure 3-22. Caples Creek at Girl Scout Access XS-1 bed particle size distribution.
Figure 3-23. Caples Creek at Girl Scout Access XS-2 bed particle size distribution.

Figure 3-24. Caples Creek at Girl Scout Access XS-3 bed particle size distribution.
Figure 3-25. Caples Creek at Jake Schneider Meadow cross-section endpoints and coordinates.

Figure 3-26. Caples Creek at Jake Schneider Meadow XS-B survey data.
Figure 3-27. Caples Creek at Jake Schneider Meadow XS-C survey data.

Figure 3-28. Caples Creek at Jake Schneider Meadow XS-2 survey data.
Figure 3-29. Caples Creek at Jake Schneider Meadow longitudinal profile survey data.

Figure 3-30. Caples Creek at Jake Schneider Meadow XS-B bed particle size distribution.
Figure 3-31. Caples Creek at Jake Schneider Meadow XS-C bed particle size distribution.

Figure 3-32. Caples Creek at Jake Schneider Meadow XS-2 bed particle size distribution.
Figure 3-33. Oyster Creek below Highway 88 cross-section endpoints and coordinates.

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LBP – left bank pin  
RBP – right bank pin

Figure 3-34. Oyster Creek below Highway 88 XS-7 survey data.
Figure 3-35. Oyster Creek below Highway 88 XS-6 survey data.

Figure 3-36. Oyster Creek below Highway 88 XS-5 survey data.
Figure 3-37. Oyster Creek below Highway 88 longitudinal profile survey data.

Figure 3-38. Oyster Creek below Highway 88 XS-7 bed particle size distribution.
Figure 3-39. Oyster Creek below Highway 88 XS-6 bed particle size distribution.

Figure 3-40. Oyster Creek below Highway 88 XS-5 bed particle size distribution.
Figure 3-41. South Fork American River below Kyburz Diversion Dam cross-section endpoints and coordinates.

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LBP – left bank pin  
RBP – right bank pin

Figure 3-42. South Fork American River below Kyburz Diversion Dam XS-1 survey data.

Sand deposit behind a large boulder
Figure 3-43. South Fork American River below Kyburz Diversion Dam XS-2 survey data.

Figure 3-44. South Fork American River below Kyburz Diversion Dam XS-3 survey data.
Figure 3-45. South Fork American River below Kyburz Diversion Dam longitudinal profile survey data.

Figure 3-46. South Fork American River below Kyburz Diversion Dam XS-1 bed particle size distribution.
Figure 3-47. South Fork American River below Kyburz Diversion Dam XS-2 bed particle size distribution.

Figure 3-48. South Fork American River below Kyburz Diversion Dam XS-3 bed particle size distribution.
Figure 3-49. Silver Fork American River at Forgotten Flat cross-section endpoints and coordinates.

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LBP – left bank pin  
RBP – right bank pin

Figure 3-50. Silver Fork American River at Forgotten Flat XS-1 survey data.
Figure 3-51. Silver Fork American River at Forgotten Flat XS-2 survey data.

Figure 3-52. Silver Fork American River at Forgotten Flat XS-3 survey data.
Figure 3-53. Silver Fork American River at Forgotten Flat longitudinal profile survey data.

Figure 3-54. Silver Fork American River at Forgotten Flat XS-1 bed particle size distribution.
Figure 3-55. Silver Fork American River at Forgotten Flat XS-2 bed particle size distribution.

Figure 3-56. Silver Fork American River at Forgotten Flat XS-3 bed particle size distribution.
Figure 3-57. Lower Echo Creek cross-section endpoints and coordinates.

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LBP – left bank pin
RBP – right bank pin

Figure 3-58. Lower Echo Creek XS-0b survey data.
Figure 3-59. Lower Echo Creek XS-1 survey data.

Figure 3-60. Lower Echo Creek XS-2 survey data.
Figure 3-61. Lower Echo Creek Left Channel longitudinal profile survey data.

Figure 3-62. Lower Echo Creek Right Channel longitudinal profile survey data.
Figure 3-63. Lower Echo Creek Left Channel XS-0b bed particle size distribution.

Figure 3-64. Lower Echo Creek Right Channel XS-0b bed particle size distribution.
Figure 3-65. Lower Echo Creek Left Channel XS-1 bed particle size distribution.

Figure 3-66. Lower Echo Creek Right Channel XS-1 bed particle size distribution.
Figure 3-67. Lower Echo Creek Left Channel XS-2 bed particle size distribution.

Figure 3-68. Lower Echo Creek Right Channel XS-2 bed particle size distribution.
Appendix A.
Site Photos
Photo A-1. Caples Creek Spillway Channel XS-1 looking upstream.

Photo A-2. Caples Creek Spillway Channel XS-1 looking downstream.
Photo A-3. Caples Creek Spillway Channel XS-1 looking at the left bank.

Photo A-4. Caples Creek Spillway Channel XS-1 looking at the right bank.
Photo A-5. Caples Creek Spillway Channel XS-1 looking at the bed.

Photo A-6. Caples Creek Spillway Channel XS-2 looking upstream.
Photo A-7. Caples Creek Spillway Channel XS-2 looking downstream.

Photo A-8. Caples Creek Spillway Channel XS-2 looking at the left bank.
Photo A-9. Caples Creek Spillway Channel XS-2 looking at the right bank.

Photo A-10. Caples Creek Spillway Channel XS-2 looking at the bed.
Photo A-11. Caples Creek Spillway Channel XS-3 looking upstream.

Photo A-12. Caples Creek Spillway Channel XS-3 looking downstream.
Photo A-13. Caples Creek Spillway Channel XS-3 looking at the left bank.

Photo A-14. Caples Creek Spillway Channel XS-3 looking at the right bank.
Photo A-15. Caples Creek Spillway Channel XS-3 looking at the bed.

Photo A-16. Caples Creek at Caples Meadow XS-1 looking upstream.
Photo A-17. Caples Creek at Caples Meadow XS-1 looking downstream.

Photo A-18. Caples Creek at Caples Meadow XS-1 looking at the left bank.
Photo A-19. Caples Creek at Caples Meadow XS-1 looking at the right bank.

Photo A-20. Caples Creek at Caples Meadow XS-1 looking at the bed.
Photo A-21. Caples Creek at Caples Meadow XS-2 looking upstream.

Photo A-22. Caples Creek at Caples Meadow XS-2 looking downstream.
Photo A-23. Caples Creek at Caples Meadow XS-2 looking at the left bank.

Photo A-24. Caples Creek at Caples Meadow XS-2 looking at the right bank.
Photo A-25. Caples Creek at Caples Meadow XS-2 looking at the bed.

Photo A-26. Caples Creek at Caples Meadow XS-3 looking upstream.
Photo A-27. Caples Creek at Caples Meadow XS-3 looking downstream.

Photo A-28. Caples Creek at Caples Meadow XS-3 looking at the left bank.
Photo A-29. Caples Creek at Caples Meadow XS-3 looking at the right bank.

Photo A-30. Caples Creek at Caples Meadow XS-3 looking at the bed.
Photo A-31. Caples Creek at Girl Scout Access XS-1 looking upstream.

Photo A-32. Caples Creek at Girl Scout Access XS-1 looking downstream.
Photo A-33. Caples Creek at Girl Scout Access XS-1 looking at the left bank.

Photo A-34. Caples Creek at Girl Scout Access XS-1 looking at the right bank.
Photo A-35. Caples Creek at Girl Scout Access XS-1 looking at the bed.


Photo A-38. Caples Creek at Girl Scout Access XS-2 looking at the left bank.

Photo A-40. Caples Creek at Girl Scout Access XS-2 looking at the bed.
Photo A-41. Caples Creek at Girl Scout Access XS-3 looking upstream.

Photo A-42. Caples Creek at Girl Scout Access XS-3 looking downstream.
Photo A-43. Caples Creek at Girl Scout Access XS-3 looking at the left bank.

Photo A-44. Caples Creek at Girl Scout Access XS-3 looking at the right bank.
Photo A-45. Caples Creek at Girl Scout Access XS-3 looking at the bed.

Photo A-46. Caples Creek at Jake Schneider Meadow XS-B looking upstream.
Photo A-47. Caples Creek at Jake Schneider Meadow XS-B looking downstream.

Photo A-48. Caples Creek at Jake Schneider Meadow XS-B looking at the left bank.
Photo A-49. Caples Creek at Jake Schneider Meadow XS-B looking at the right bank.

Photo A-50. Caples Creek at Jake Schneider Meadow XS-B looking at the bed.
Photo A-51. Caples Creek at Jake Schneider Meadow XS-C looking upstream.

Photo A-52. Caples Creek at Jake Schneider Meadow XS-C looking downstream.
Photo A-53. Caples Creek at Jake Schneider Meadow XS-C looking at the left bank.

Photo A-54. Caples Creek at Jake Schneider Meadow XS-C looking at the right bank.
Photo A-55. Caples Creek at Jake Schneider Meadow XS-C looking at the bed.

Photo A-56. Caples Creek at Jake Schneider Meadow XS-2 looking upstream.
Photo A-57. Caples Creek at Jake Schneider Meadow XS-2 looking downstream.

Photo A-58. Caples Creek at Jake Schneider Meadow XS-2 looking at the left bank.
Photo A-59. Caples Creek at Jake Schneider Meadow XS-2 looking at the right bank.

Photo A-60. Caples Creek at Jake Schneider Meadow XS-2 looking at the bed.
Photo A-61. Oyster Creek below Highway 88 XS-7 looking upstream.

Photo A-62. Oyster Creek below Highway 88 XS-7 looking downstream.
Photo A-63. Oyster Creek below Highway 88 XS-7 looking at the left bank.

Photo A-64. Oyster Creek below Highway 88 XS-7 looking at the right bank.
Photo A-65. Oyster Creek below Highway 88 XS-7 looking at the bed.

Photo A-66. Oyster Creek below Highway 88 XS-6 looking upstream.
Photo A-67. Oyster Creek below Highway 88 XS-6 looking downstream.

Photo A-68. Oyster Creek below Highway 88 XS-6 looking at the left bank.
Photo A-69. Oyster Creek below Highway 88 XS-6 looking at the right bank.

Photo A-70. Oyster Creek below Highway 88 XS-6 looking at the bed.
Photo A-71. Oyster Creek below Highway 88 XS-5 looking upstream.

Photo A-72. Oyster Creek below Highway 88 XS-5 looking downstream.
Photo A-73. Oyster Creek below Highway 88 XS-5 looking at the left bank.

Photo A-74. Oyster Creek below Highway 88 XS-5 looking at the right bank.
Photo A-75. Oyster Creek below Highway 88 XS-5 looking at the bed.

Photo A-76. South Fork American River below Kyburz Diversion Dam XS-1 looking upstream.
Photo A-77. South Fork American River below Kyburz Diversion Dam XS-1 looking downstream.

Photo A-78. South Fork American River below Kyburz Diversion Dam XS-1 looking at the left bank.
Photo A-79. South Fork American River below Kyburz Diversion Dam XS-1 looking at the right bank.

Photo A-80. South Fork American River below Kyburz Diversion Dam XS-1 looking at the bed.
Photo A-81. South Fork American River below Kyburz Diversion Dam XS-2 looking upstream.

Photo A-82. South Fork American River below Kyburz Diversion Dam XS-2 looking downstream.
Photo A-83. South Fork American River below Kyburz Diversion Dam XS-2 looking at the left bank.

Photo A-84. South Fork American River below Kyburz Diversion Dam XS-2 looking at the right bank.
Photo A-85. South Fork American River below Kyburz Diversion Dam XS-2 looking at the bed.

Photo A-86. South Fork American River below Kyburz Diversion Dam XS-3 looking upstream.
Photo A-87. South Fork American River below Kyburz Diversion Dam XS-3 looking downstream.

Photo A-88. South Fork American River below Kyburz Diversion Dam XS-3 looking at the left bank.
Photo A-89. South Fork American River below Kyburz Diversion Dam XS-3 looking at the right bank.

Photo A-90. South Fork American River below Kyburz Diversion Dam XS-3 looking at the bed.
Photo A-91. Silver Fork American River at Forgotten Flat XS-1 looking upstream.

Photo A-92. Silver Fork American River at Forgotten Flat XS-1 looking downstream.
Photo A-93. Silver Fork American River at Forgotten Flat XS-1 looking at the left bank.

Photo A-94. Silver Fork American River at Forgotten Flat XS-1 looking at the right bank.
Photo A-95. Silver Fork American River at Forgotten Flat XS-1 looking at the bed.

Photo A-96. Silver Fork American River at Forgotten Flat XS-2 looking upstream.

Photo A-98. Silver Fork American River at Forgotten Flat XS-2 looking at the left bank.
Photo A-99. Silver Fork American River at Forgotten Flat XS-2 looking at the right bank.

Photo A-100. Silver Fork American River at Forgotten Flat XS-2 looking at the bed.
Photo A-101. Silver Fork American River at Forgotten Flat XS-3 looking upstream.

Photo A-102. Silver Fork American River at Forgotten Flat XS-3 looking downstream.
Photo A-103. Silver Fork American River at Forgotten Flat XS-3 looking at the left bank.

Photo A-104. Silver Fork American River at Forgotten Flat XS-3 looking at the right bank.
Photo A-105. Lower Echo Creek XS-0b at Left Channel looking upstream.

Photo A-106. Lower Echo Creek XS-0b at Left Channel looking downstream.
Photo A-107. Lower Echo Creek XS-0b at Left Channel looking at the left bank.

Photo A-108. Lower Echo Creek XS-0b at Left Channel looking at the right bank.
Photo A-109. Lower Echo Creek XS-0b at Left Channel looking at the bed.

Photo A-110. Lower Echo Creek XS-0b at Right Channel looking upstream.
Photo A-111. Lower Echo Creek XS-0b at Right Channel looking downstream.

Photo A-112. Lower Echo Creek XS-0b at Right Channel looking at the left bank.
Photo A-113. Lower Echo Creek XS-0b at Right Channel looking at the right bank.

Photo A-114. Lower Echo Creek XS-0b at Right Channel looking at the bed.
Photo A-115. Lower Echo Creek XS-1 at Left Channel looking upstream.

Photo A-116. Lower Echo Creek XS-1 at Left Channel looking downstream.
Photo A-117. Lower Echo Creek XS-1 at Left Channel looking at the left bank.

Photo A-118. Lower Echo Creek XS-1 at Left Channel looking at the right bank.
Photo A-119. Lower Echo Creek XS-1 at Left Channel looking at the bed.

Photo A-120. Lower Echo Creek XS-1 at Right Channel looking upstream.
Photo A-121. Lower Echo Creek XS-1 at Right Channel looking downstream.

Photo A-122. Lower Echo Creek XS-1 at Right Channel looking at the left bank.
Photo A-123. Lower Echo Creek XS-1 at Right Channel looking at the right bank.

Photo A-124. Lower Echo Creek XS-1 at Right Channel looking at the bed.
Photo A-125. Lower Echo Creek XS-2 at Left Channel looking upstream.

Photo A-126. Lower Echo Creek XS-2 at Left Channel looking downstream.
Photo A-127. Lower Echo Creek XS-2 at Left Channel looking at the left bank.

Photo A-128. Lower Echo Creek XS-2 at Left Channel looking at the right bank.
Photo A-129. Lower Echo Creek XS-2 at Left Channel looking at the bed.

Photo A-130. Lower Echo Creek XS-2 at Right Channel looking upstream.
Photo A-131. Lower Echo Creek XS-2 at Right Channel looking downstream.

Photo A-132. Lower Echo Creek XS-2 at Right Channel looking at the left bank.
Photo A-133. Lower Echo Creek XS-2 at Right Channel looking at the right bank.

Photo A-134. Lower Echo Creek XS-2 at Right Channel looking at the bed.
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