Gerle Creek Sensitive Site Investigation and Mitigation Monitoring Plan Final Report

Sacramento Municipal Utility District

Hydro License Implementation • September 2016

Upper American River Project

FERC Project No. 2101

Powering forward. Together.

SMUD®

Table of Contents

Table of Tables, Figures, Attachments, and Appendices

1.0 INTRODUCTION

The Sacramento Municipal Utility District (SMUD) owns and operates the Upper American River Project (UARP or Project), a series of hydropower generation facilities in El Dorado and Sacramento counties, primarily within lands of the Eldorado National Forest. Located in the watersheds of the Rubicon River, Silver Creek, and the South Fork of the American River, the UARP consists of three major storage reservoirs (Loon Lake, Union Valley Reservoir, and Ice House Reservoir), eight smaller regulating or diversion reservoirs, and eight powerhouses. The authorized installed capacity of the UARP is 637.3 megawatts. The Project includes numerous recreation facilities containing over 700 campsites, five boat ramps, hiking paths, and bicycle trails at the reservoirs.

On July 23, 2014 the Federal Energy Regulatory Commission (FERC) issued a new license (FERC 2014) for SMUD to continue operation and maintenance of the UARP. The *Gerle Creek Sensitive Site Investigation and Mitigation Monitoring Plan Final Report* (*Report*) was prepared to fulfill requirements set forth in:

1. Article 401(b) of the FERC license;
2. Condition 2.B of the State Water Resources Control Board (SWRCB) section 401 Water Quality Certification (WQC)[1];
3. The U.S. Department of Agriculture Forest Service (USFS) section 4(e) Condition No. 28[2]; and
4. The *Gerle Creek Sensitive Site Investigation and Mitigation Monitoring Plan* (SSIMMP) (SMUD 2015a).

More specifically, this *Report* addresses requirements related to developing the information necessary to determine the appropriate magnitude of pulse flows in Gerle Creek below Loon Lake Reservoir Dam (the Loon Lake Dam reach, Figure 1).

2.0 BACKGROUND

Where certain WQC conditions and USFS section 4(e) conditions require SMUD to submit reports to the SWRCB or USFS, respectively, FERC included License Article 401(b) to require SMUD to file these same reports with FERC. Attachment 1 and Attachment 2 contain WQC Condition 2.B and USFS section 4(e) Condition 28, respectively, both of which contain reporting requirements covered by Article 401(b) and fulfilled by the preparation and filing of this *Report*.

---

[1] The SWRCB WQC is incorporated into the license as Appendix A.

[2] The USFS section 4(e) conditions are incorporated into the license as Appendix B.

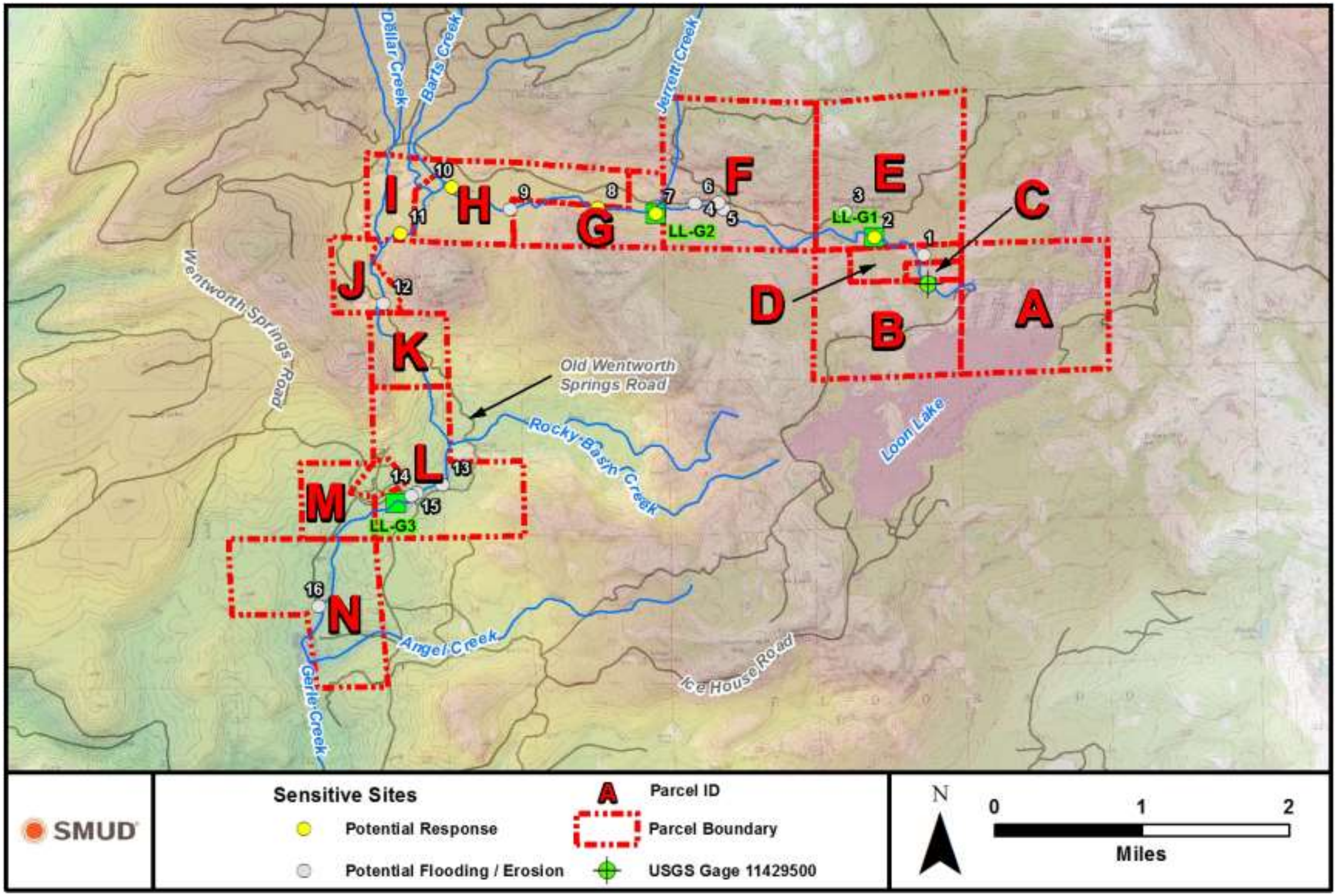


Figure 1. **Loon Lake Dam reach of Gerle Creek**

WQC Condition 2.B and USFS section 4(e) Condition 28 require SMUD to complete three items (collectively, pulse flow studies) within two years of license issuance and prior to implementing the pulse flows:

1. A sensitive site investigation;
2. Test pulse flow releases; and
3. An analysis of the potential impacts of the pulse flows on downstream features.

After the development of the *SSIMMP* in consultation with the resource agencies [i.e., SWRCB, USFS, California Department of Fish and Wildlife (CDFW), and the U.S. Fish and Wildlife Service (USFWS)], and subsequent approval by SWRCB, USFS, and CDFW, FERC approved the *SSIMMP* with modifications (FERC 2015a), including extending the schedule to allow the final report addressing the pulse flow studies to be filed with FERC by October 1, 2016. As stated in Article 401(a) of the license, upon FERC approval, a plan or measure becomes a requirement of the license, and SMUD shall implement the plan. Table 1 provides a timeline of key events and upcoming milestones supporting the completion of the pulse flow studies.

The first item, the sensitive site investigation, which includes post-test pulse flow release monitoring of geomorphic and riparian vegetation conditions, was completed as documented by this *Report*. The second item, the test pulse flow releases, were carried out as two separate tests completed in June 2016. The third item, the analysis of the potential impacts of the pulse flows on downstream features, was documented in the *Pulse Flow Test Recommendations* (SMUD 2016a, provided as Attachment **3**) and field-checked during the test pulse flow releases. WQC Condition 2.B and USFS section 4(e) Condition No. 28 require the completion of these three items for the USFS, with the concurrence of the SWRCB Deputy Director, to determine the appropriate magnitude of the pulse flows to reach the objectives of restoring the stream channel to a proper functioning condition.

Table 1. Timeline of key events and milestones of the pulse flow studies

Date Completed	Event
November 1, 2012	SMUD carried out a 3-day reconnaissance of the Loon Lake Dam Reach
April 4, 2013	SMUD met with USFS to discuss hydraulic modeling and alternatives to test pulse flow releases at the maximum of up to 740 cfs, or the maximum capacity of the outlet works, whichever is less
May 2013	SMUD acquired LiDAR mapping of topography around the Loon Lake Dam Reach for use in developing geometric input to the hydraulic model
June 13, 2013	SMUD met with Rubicon Oversight Committee users to discuss potential impacts of pulse flows to the trail, and to present an approach for sensitive site investigation; USFS agreed with no release of pulse flows if hydraulic modeling shows such flows would cause damage
July 11 2013	SMUD released for resource agency review the initial *Framework of the Plan for Sensitive Site Investigations and Pulse Flow Testing*
August 1, 2013	SMUD met with resource agencies to discuss *Framework of the Plan for Sensitive Site Investigations and Pulse Flow Testing*
October 4, 2013	SWRCB issued final Section 401 WQC for the UARP

Date Completed	Event
November 5, 2013	SMUD and resource agencies participated in a site visit
November 26, 2013	SMUD released for resource agency review the Final *Framework of the Plan for Sensitive Site Investigations and Pulse Flow Testing*
February 12, 2014	SMUD received initial comments from USFS on the *Framework*
March 10, 2014	SMUD received comments from CDFW and SWRCB on the *Framework*
March 27, 2014	Monthly License Implementation Meeting where resource agencies' comments on the *Framework* were discussed
July 23, 2014	FERC issued order to SMUD issuing license for the UARP
September 25, 2014	SMUD and consultation group discussed scheduling a site meeting
October 13, 2014	SMUD released draft *Sensitive Site Investigations and Mitigation Monitoring Plan* (*SSIMMP*) to the consultation group
October 22, 2014	SMUD and resource agencies participated in site meeting to discuss elements of the draft *SSIMMP*
November 14, 2014	SMUD deployed pressure transducers to measure stage hydrographs during the spring 2015 snowmelt runoff for use in calibrating the hydraulic model
November 24, 2014	SMUD hosted meeting with resource agencies to discuss objectives addressed by draft *SSIMMP*
December 18, 2014	SMUD received comments from consultation group on draft *SSIMMP*
January 8, 2015	SMUD and consultation group participated in a meeting to discuss comments on the draft *SSIMMP*
January 23, 2015	SMUD released revised *SSIMMP* to the resource agencies for 90-day review and comment
May 4, 2015	SMUD and resource agencies met with a facilitator to discuss comments on revised SSIMMP and agree on a final *SSIMMP*
May 6, 2015	Continuation of unfinished meeting started on May 4, 2015
May 21, 2015	SMUD filed the *SSIMMP* with FERC
June 4, 2015	SMUD retrieved pressure transducers (see 14 Nov 2014 deployment)
June 18, 2015	FERC issued order modifying and approving the *SSIMMP*
October 6, 2015	SMUD met with resource agencies for field meeting to approve the survey plan at sensitive site LL-G2
November 6, 2015	SMUD completed pre-test pulse flow release monitoring at LL-G2 and bathymetric surveys (for geometric inputs to the hydraulic model)
February 5, 2016	SMUD distributed *Hydraulic Modeling Overview* to Technical Workgroup
February 22, 2016	SMUD hosted Technical Workgroup to explain development of the hydraulic model, model testing, model limitations, and uncertainty analyses
March 2016	SMUD communicated plans for the test pulse flow releases to the various private property landowners
April 22, 2016	SMUD distributed the draft *Pulse Flow Test Recommendations* to the resource agencies and private property landowners

Date Completed	Event
April 28, 2016	Monthly License Implementation Meeting where SMUD and the resource agencies and private property landowners discussed the test pulse flow release recommendations
May 12, 2016	SMUD met with resources agencies to discuss the basis for establishing the maximum flow during the test pulse flow releases
May 16, 2016	SMUD distributed the final *Pulse Flow Test Recommendations* to the resource agencies and private property landowners
May 2016	SMUD addressed concerns expressed by private property landowners regarding the test pulse flow releases
June 3, 2016	SMUD completed the initial 2 day test pulse flow release, with on-site participation from resource agencies and private property landowners
June 15, 2016	SMUD met with resource agencies to discuss observations during initial test pulse flow release and to agree on flows for the 5-day test pulse flow release
June 17, 2016	Resource agencies approve *Pulse Flow Test Recommendations*
June 27, 2016	SMUD completed 5-day test pulse flow release
July 1, 2016	SMUD completed post-test pulse flow release monitoring at LL-G2
July 22, 2016	SMUD releases *Results of Pulse Flow Studies in Gerle Creek below Loon Lake Dam* to resource agencies for 45-day review
September 5, 2016	End of 45-day review for resource agencies to comment on the *Results of Pulse Flow Studies*
September 6, 2016	SMUD met with resource agencies to discuss their comments and private landowner concerns
September 14, 2016	USFS met with affected private landowners to discuss their concerns
September 30, 2016	SMUD filed with FERC the *Gerle Creek Sensitive Site Investigation and Mitigation Monitoring Plan Final Report*

The following sections present the results and findings of the three items comprising the pulse flow studies. To align the layout of the *Report* with the chronological progression of the pulse flow studies, the results of the third item are presented first (Section 3.0), followed by the results of the second item (Section 4.0), then the results of the first item (Section 5.0). Interpretations based on the results are provided in Section 6.0, and conclusions on the appropriate magnitude of pulse flows in Gerle Creek downstream of Loon Lake Dam are presented in Section 7.0.

3.0 RESULTS OF THE EFFECTS AND POTENTIAL IMPACTS OF THE PULSE FLOWS ON DOWNSTREAM FEATURES

Because of concerns regarding the potential for the pulse flows to impact downstream features (i.e., bridges, campgrounds, day-use areas, and private property), SMUD developed a hydraulic model to simulate water-surface elevations associated with various test pulse flow releases along Gerle Creek downstream of Loon Lake Dam. The primary objective of the model was to evaluate the potential for flooding impacts without having to directly observe such impacts during the test pulse flow releases.

On February 5, 2016 SMUD distributed the *Gerle Creek SSIMMP Hydraulic Model Overview* (SMUD 2016b, provided as Attachment 4) to a technical workgroup of resource agency staff with hydraulic modeling experience. On February 22, 2016 SMUD hosted a meeting with this technical workgroup to discuss the *Overview,* demonstrate the hydraulic simulations, and address the workgroup's questions. The meeting resulted in the workgroup expressing support for the development and testing (including uncertainty analyses) of the model, and concurring with the simulated water-surface profiles, simulated inundation extents, and inferred potential impacts over a range of pulse flows.

Water-surface elevations for flows ranging from 5 to 630 cfs (the maximum capacity of the outlet works at Loon Lake Dam, with a full reservoir) were simulated and compared to field-measured threshold elevations at the potential flooding/erosion sites presented in the *SSIMMP.* The comparisons were provided in the *Pulse Flow Test Recommendations.* The comparisons indicated potential for flooding impacts at Sensitive Site 4 on Parcel F (Figure 1) during pulse flow releases as low as 125 cfs, and at five sites for a release of 600 cfs. These findings were: (1) shared with affected private property landowners, and (2) used to initiate consultation with the resource agencies. SMUD (2016a) presented the approach (subsequently approved by the resource agencies) for how the hydraulic modeling results would be used with input from the private property landowners to carry out a test pulse flow release to establish the maximum release during a subsequent 5-day test pulse flow release.

The hydraulic modeling indicated that a pulse flow release of 630 cfs could not be released without likely flooding downstream features. Because of limitations of the model, the simulated water-surface profiles were used to identify potential impacts, but actual impacts were to be carefully evaluated during test pulse flow releases.

4.0 RESULTS OF TEST PULSE FLOW RELEASES

The potential impacts of the pulse flows on downstream features described in the previous section led to an agreement between SMUD, the resource agencies, and the private property landowners to carry out two test pulse flow releases. The purpose of the initial test was to observe any downstream impacts and to identify the maximum pulse flow release. The private property landowners of Parcel F (see Figure 1) communicated to SMUD that they could accept minor flooding of their property during the pulse flow releases, but that they could not establish their flooding tolerance without first observing the degree of flooding that occurs during a set of progressively increasing test pulse flow releases.

Given this input, and coupled with the ramping rate constraints provided in WQC Condition 3 and USFS section 4(e) Condition No. 29, test pulses were progressively increased during the initial test so that SMUD, the resource agencies, and the private property landowners could observe the flooding and agree on a maximum release. The agreed upon maximum release was used to establish the peak (day 3) and the shoulders (days 1, 2, 4, and 5) of the subsequent 5-day test pulse flow release.

Both the pulse flow conditions (WQC Condition 2.B and USFS section 4(e) Condition No. 28) and the ramping rate conditions (WQC Condition 3 and USFS section 4(e) Condition No. 29) specify that for compliance purposes, the point of flow measurement is the USGS gage (11429500) located approximately 0.3 miles downstream of Loon Lake Reservoir Dam. SMUD operates and maintains this gaging station for the USGS, so stage and flow records are provisional until approved by the USGS after the end of the water-year; since water-year 2016 has not yet elapsed, flows presented in this *Report* are provisional.

Prior to the initial test, SMUD installed graduated staff gages at sensitive sites where potential flooding impacts were a concern. These staff gages provided a consistent visual reference of inundation depths during test pulse flow releases.

Since the test was conducted well after the main spring runoff period, little additional surface flow was added to the releases from Loon Lake. Low accretion flows were ideal for the test pulse flow releases because once test pulse flows reached steady-state conditions, the flow measured at the USGS gage could be used to represent flow everywhere in the Loon Lake Dam reach.

4.1 Initial Test

The initial test pulse flow release began on June 2, 2016 and continued into June 3. SMUD, the USFS, and private property landowners were on-site during the test pulse flow release. In the late afternoon of June 2, the release reached a nearly steady flow of approximately 395 cfs (Figure 2 and Table 2), fluctuating between 384 cfs and 401 cfs at the gaging station. No adverse flooding impacts were observed at any of the sensitive sites during these flows. By the early morning of June 3 flows had reached a steady state throughout the reach and were measured at about 390 cfs, which was slightly less than the previous afternoon. At this time flooding impacts were observed at Parcel F (Figure 3), and the property owner requested the test be terminated. However, earlier in the morning, prior to communication with the private property landowner, SMUD had increased the release to approximately 500 cfs. SMUD honored the landowner’s request to terminate the test with the understanding that the flooding impacts would temporarily increase while the 500 cfs release passed through their property. Subsequently, this landowner wrote to SMUD to request that the peak flow be limited to 300 cfs because of the observed flooding impacts (private landowner correspondence is provided in Attachment 5). In addition to the landowner’s flooding concerns at Parcel F, SMUD also observed erosion of the gravel road approach to the north abutment of a bridge on Parcel H under the 500 cfs release (Figure 4). The eroded area covered approximately 50 square-feet, and the erosion depths were less than 0.5 feet. Given the low permissible velocity of 2.5 feet per second for fine gravels (Fischenich 2001) similar to the material comprising the road approach, the potential for continued erosion during overtopping flows is high. The El Dorado County Road entering the USFS campground at Wentworth Springs (Parcel E) was inundated to a depth of approximately 1.3 feet at 500 cfs (Figure 5). Such inundation is counter to the El Dorado County Department of Transportation's 2010 *Operations and Maintenance Plan for the Rubicon Trail*, which seeks to drain the trail surface to prevent or reduce sediment discharge to waters of the state (such as Gerle Creek). According to the July 2013 *Rubicon Trail Monitoring Protocol*, if County staff observe flowing depths of at least 4 inches on the trail, the County can initiate a temporary closure of the Trail. Finally, the private property landowner for Parcel D expressed concern about mobilization and transport of wood impairing crossings on the property and requested in written communication to SMUD that the peak be limited to 385 cfs, or preferably to 300 cfs (Attachment 5). SMUD progressively decreased flows on June 3 in compliance with the ramping rates, until the minimum streamflow was restored by about 6 PM.

Table 2. Initial test flow hydrograph as recorded at USGS gaging station 11429500

Time	Flow (cfs)	Time	Flow (cfs)
6/2/16 07:45	55	6/3/16 09:45	489
6/2/16 09:45	163	6/3/16 11:20	271
6/2/16 11:15	163	6/3/16 11:45	271
6/2/16 12:20	273	6/3/16 12:20	161
6/2/16 13:30	273	6/3/16 12:45	158
6/2/16 14:30	400	6/3/16 13:20	104
6/2/16 18:00	377	6/3/16 14:00	104
6/3/16 07:30	387	6/3/16 14:45	42
6/3/16 08:05	506	6/3/16 15:35	42
6/3/16 08:30	492	6/3/16 18:00	28

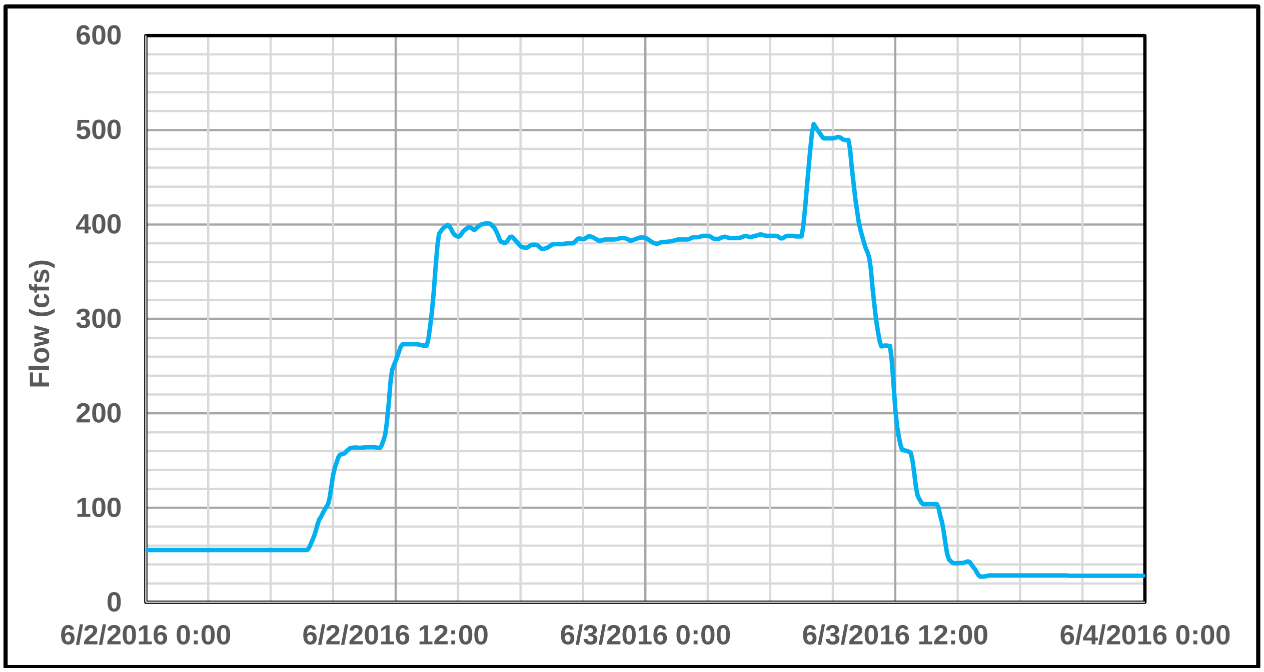


Figure 2. Initial test flow hydrograph as recorded at USGS gaging station 11429500

Figure 3. Flooding of Parcel F, 6/3/16, at about 375 cfs

Figure 4. **Erosion of bridge approach on Parcel H, 6/3/16, at about 500 cfs**

Figure 5. **Flooding of county road entering Wentworth Springs Campground, 6/2/16, at about 375 cfs**

As a result of the initial test, SMUD prepared a recommended release flow hydrograph for the 5-day test that considered the competing interests of: (1) minimizing flooding impacts and, (2) maximizing anticipated geomorphic and riparian objectives. The recommended peak of the 5-day flow hydrograph was 375 cfs. While this flow was observed to cause flooding and erosion impacts to private property, previous analyses carried out in support of UARP relicensing (DTA and Stillwater Sciences 2005) showed conditions of incipient motion at flows of 86 cfs, 149 cfs, and 326 cfs for the three cross sections at LL-G2. SMUD's recommended peak flow sought to provide (1) the anticipated geomorphic benefits associated with bed surface mobilization and sorting of spawning gravel, and (2) inundation of riparian vegetation, with only minor and limited-duration flooding and erosion impacts. The recommended flow for the other 4 days of the 5-day test was 300 cfs. This flow was based primarily on requests of the private property landowners and the ratio of peak flow to shoulder flow for the WET water-year pulse flow schedule in WQC Condition 2.B and USFS section 4(e) Condition No. 28.

Only the WET water-year schedule was considered because the recommended hydrograph exceeded the AN (Above Normal) and BN (Below Normal) schedules (see Attachment 1 and Attachment 2), so flooding impacts are not expected except during WET water-year types.

SMUD's recommended release flow hydrograph for the 5-day test was presented to the resource agencies in a meeting on June 15, 2016. The resource agencies approved SMUD's recommended 5-day test flow hydrograph, but commented that additional future test pulses may need to be considered depending on the results of the post-test pulse flow release monitoring.

4.2 5-Day Test

The 5-day test began at noon on June 22, 2016 and continued through noon on June 27, 2016. SMUD and private property landowners were on-site for this test. Figure 6 and Table 3 illustrate the flow hydrograph during this test.

Table 3. 5-day flow hydrograph as recorded at USGS gaging station 11429500

Time	Flow (cfs)	Time	Flow (cfs)
6/22/16 08:15	28	6/25/16 12:00	386
6/22/16 11:45	340	6/25/16 12:45	309
6/22/16 12:45	313	6/27/16 12:00	310
6/24/16 11:30	313	6/27/16 16:00	29
6/24/16 12:15	387	--	--

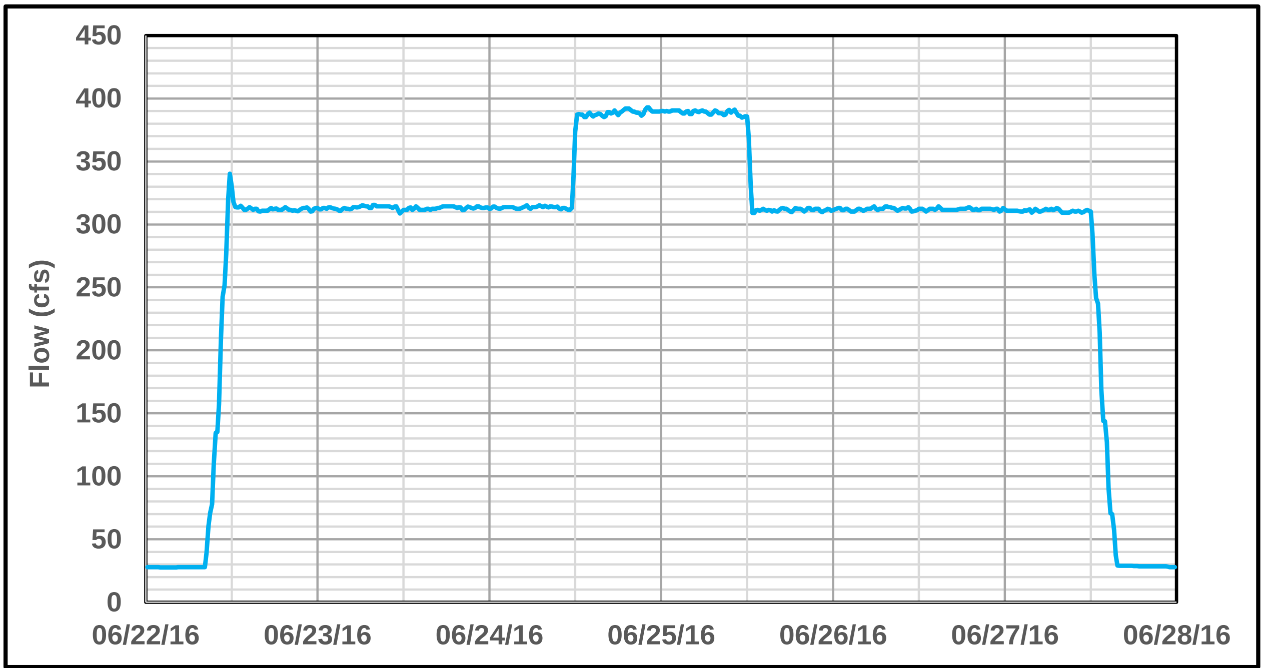


Figure 6. Flow hydrograph as recorded at USGS gaging station 11429500

SMUD observed and recorded conditions during each day of the test. Because of minor variations in flow during releases, SMUD slightly exceeded the targeted flows to ensure that the targeted values were actually achieved (Table 3). During the afternoon of June 22nd with pulse flows around 300 cfs, no flooding impacts were observed at the sensitive sites along the Loon Lake Dam reach. In the early afternoon on June 23rd the El Dorado County road into the USFS campground at Wentworth Springs was inundated to a depth of about 0.5 feet (Figure 7). In the late morning of June 24th, the private property landowner of Parcel F expressed concern about a flooded trail on their property, and flooding depths were observed to be less than 0.5 feet (Figure 8). In summary, no major flooding or erosion impacts were observed during the first two days of the test.


06.23.2016

Figure 7. Flooding of county road into Wentworth Springs Campground, at about 300 cfs


06.24.2016

Figure 8. Flooding trail on Parcel F, at about 300 cfs

On the morning of June 25th, after flows had been raised around noon on June 24th to the target of 375 cfs, additional flooding was observed along the El Dorado County road into the USFS campground at Wentworth Springs (Figure 9). More sections of the road were inundated, and flooding depths increased to a maximum of about 0.8 feet. At a group camp on private property (Parcel F), flooding depths of up to about 0.6 feet were observed (Figure 10). Erosion of the gravel road approach to the north abutment of a bridge on Parcel H was observed, possibly threatening the integrity of this crossing (Figure 11). The eroded area covered approximately 50 square-feet, and the erosion depths increased over erosion during the initial test to less than one foot. Given the low permissible velocity of 2.5 feet per second for fine gravels (Fischenich 2001) similar to the material comprising the road approach, the potential for continued erosion during overtopping flows is high. No other flooding or erosion impacts were observed at the peak flow of 385 cfs.

Figure 9. Flooding of county road into Wentworth Springs Campground, at about 375 cfs

Figure 10. **Flooding of Parcel F, at about 375 cfs**

Figure 11. **Erosion of bridge approach on Parcel H, at about 375 cfs**

Flows were reduced to 310 cfs around noon on June 25th. On June 26th, inundation depths returned to levels noted during the first two days of the test. Observations on the morning of June 27th confirmed the consistency of the observations from the previous day.

Based on observations and measurements made during the 5-day test, flooding impacts to downstream features at about 300 cfs were confirmed to be relatively minor, with greater flooding and erosion impacts occurring during the peak of about 375 cfs. The results of the test pulse flow releases indicate that unintended flooding and erosion impacts are unlikely during the pulse flow releases prescribed in WQC Condition 2.B and USFS section 4(e) Condition 28 for BN and AN water-year types.

5.0 RESULTS OF THE SENSITIVE SITE INVESTIGATION

Observations and measurements made during the test pulse flow releases provide direct information to quantify the potential flooding and erosion impacts to downstream features; however, post-test monitoring data were needed to evaluate whether geomorphic and riparian vegetation objectives were achieved at potential response sites LL-G1 and LL-G2 (Figure 1). The *SSIMMP* provides a description of the approved monitoring methods and metrics.

Surveys of geomorphic conditions at LL-G1 and LL-G2 were carried out during the summer of 2003 as a component of the UARP relicensing studies (DTA and Stillwater Sciences 2005) and riparian vegetation was mapped for the relicensing during the summer of 2003 (DTA 2004). Because of the elapsed time since the relicensing surveys and mapping, pre-test pulse flow release surveys and mapping were completed August 2015 through November 2015 to confirm, and update if necessary, baseline conditions. Monitoring was repeated after the test pulse flow releases in June 2016 to assess change relative to the baseline conditions.

While the geomorphic and riparian vegetation monitoring was targeted to LL-G1 and LL-G2 (SMUD 2015a), the monitoring methods were judged impractical at LL-G1 (consistent with considerations provided in the *SSIMMP*) because the site was flooded out by backwater from beaver dams. Thus, the pre- and pulse-test pulse flow release geomorphic and riparian vegetation monitoring focused only on LL-G2.

SMUD was successful in relocating some of the relicensing cross section end-pins and longitudinal profile benchmarks set at LL-G2 during the 2003 surveys. Enough monuments were re-established (Appendix A) that surveying the recovered pins and benchmarks allowed the elevations surveyed in 2003 to be converted from a local datum to the National Geodetic Vertical Datum of 1929 (NGVD29). This conversion provided a means for direct comparisons of the 2003 surveys to the pre-test pulse flow release (2015) and post-test pulse flow release (2016) surveys, both of which reference elevations to NGVD29.

After re-establishing the LL-G2 site, SMUD walked the reach and considered alignments, locations, and lateral extents for establishing permanent cross sections in addition to the three established during the relicensing for both the geomorphic survey and riparian mapping. During the October 6, 2015 field meeting, SMUD presented proposed cross section locations to the resource agencies to obtain agency input and agreement. It was agreed that the full geomorphic and riparian vegetation monitoring would occur at eight of the cross sections; only geometric surveys would occur at the remaining 14 cross sections to support development of a detailed hydraulic model at LL-G2. The results of the discussion are summarized in Table 4. Because of hydraulic modeling needs for cross sections to be perpendicular to flow direction, the cross section alignments in the overbanks were adjusted as determined appropriate when setting the control at each section (Figure 12). These adjustments are relatively minor and generally maintain the cross sections within the Riparian Study Areas around the vegetation transects (Figure 13). Cross section 8 approximately represents the downstream extent of the LL-G2 site delineated during relicensing, but in the event that pulse flows mobilized/breached the large woody debris (LWD) jam at cross section 7, six additional cross sections were surveyed downstream to provide a stable downstream boundary for the hydraulic model. Other than the LWD jams noted in Table 4, no other LWD were observed to be obstructing streamflow.

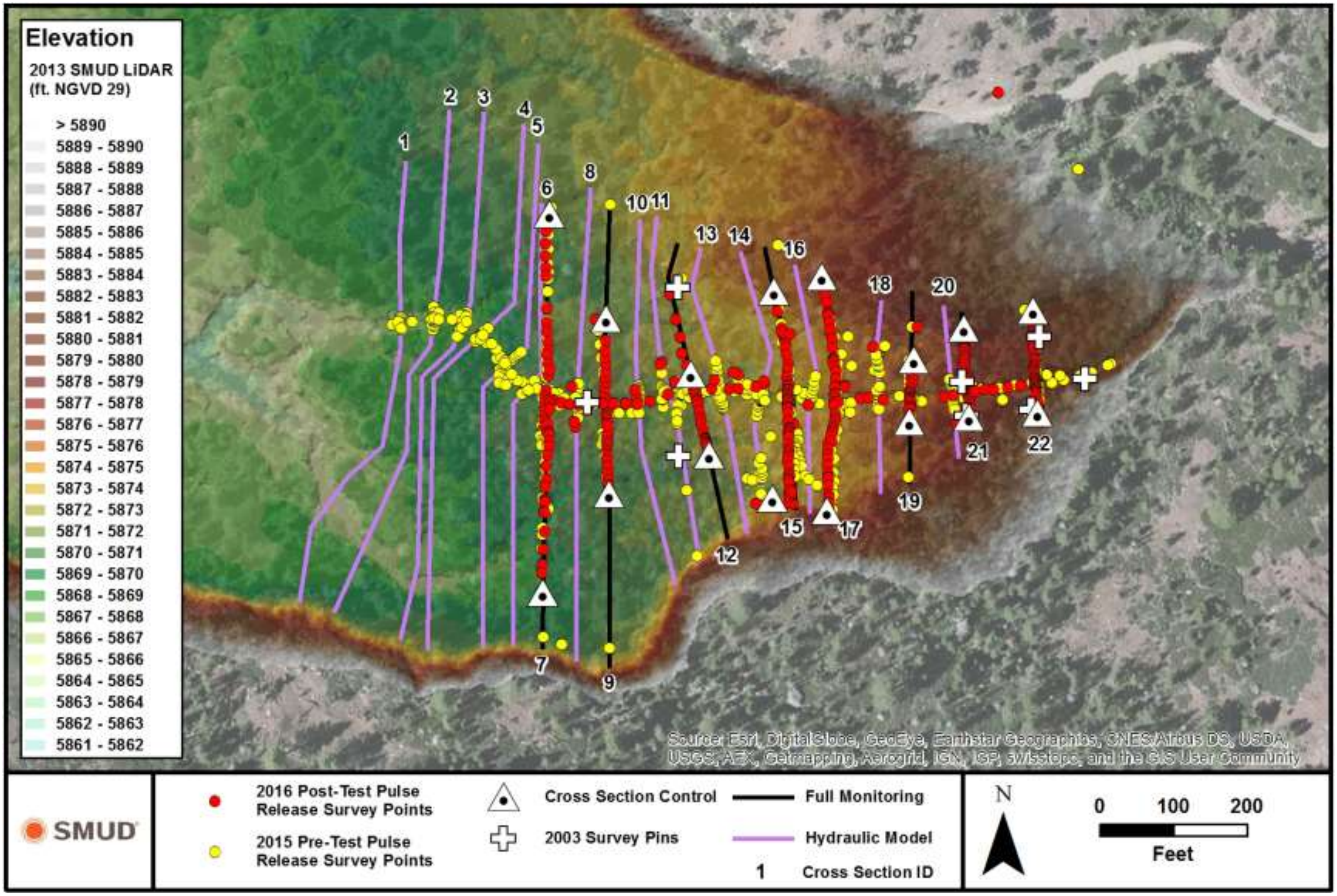
Table 4. Cross sections established at sensitive site LL-G2

ID	Station (ft.)[1]	Purpose	Selection Rationale
1	-2+43	Hydraulic model	Riffle
2	-1+98	Hydraulic model	LWD jam
3	-1+58	Hydraulic model	Riffle
4	-1+28	Hydraulic model	Pool
5	-0+72	Hydraulic model	Breached LWD jam
6	-0+31	Hydraulic model	Pool d/s of LWD jam
7	0+00	Full monitoring	LWD jam, broad floodplain, side channels
8	0+43	Hydraulic model	Pool u/s of LWD jam
9	0+81	Full monitoring	Run into pool u/s LWD jam, broad floodplain, side channel
10	1+25	Hydraulic model	Run upstream of left bank split into side channel
11	1+69	Hydraulic model	Run
12	2+04	Full monitoring	Riffle, lower relicensing section, riffle, side channel
13	2+39	Hydraulic model	Riffle at the d/s end of mid-channel island
14	2+97	Hydraulic model	Riffle u/s of breached LWD jam
15	3+35	Full monitoring	Pool, broad floodplain, side channels
16	3+63	Hydraulic model	Riffle d/s of LWD jam
17	3+96	Full monitoring	LWD jam and multiple floodplain channels
18	4+57	Hydraulic model	Run into pool u/s of LWD jam
19	5+01	Full monitoring	Riffle, narrow floodplain, side channel
20	5+59	Hydraulic model	Riffle
21	5+79	Full monitoring	Plane bed, middle relicensing section, narrow floodplain
22	6+74	Full monitoring	Plane bed, upper relicensing section, narrow floodplain

Note:

[1] Relative to Station 0+00 set at cross section 7

Coordinates and elevations for the pins set at the monitoring sections are provided in Appendix A. Pre- and post-test pulse flow release geomorphic and riparian vegetation monitoring focused on the full monitoring sections; the hydraulic model sections were surveyed only once during the pre-test pulse flow release monitoring.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 12. **Geomorphic monitoring cross sections at LL-G2**

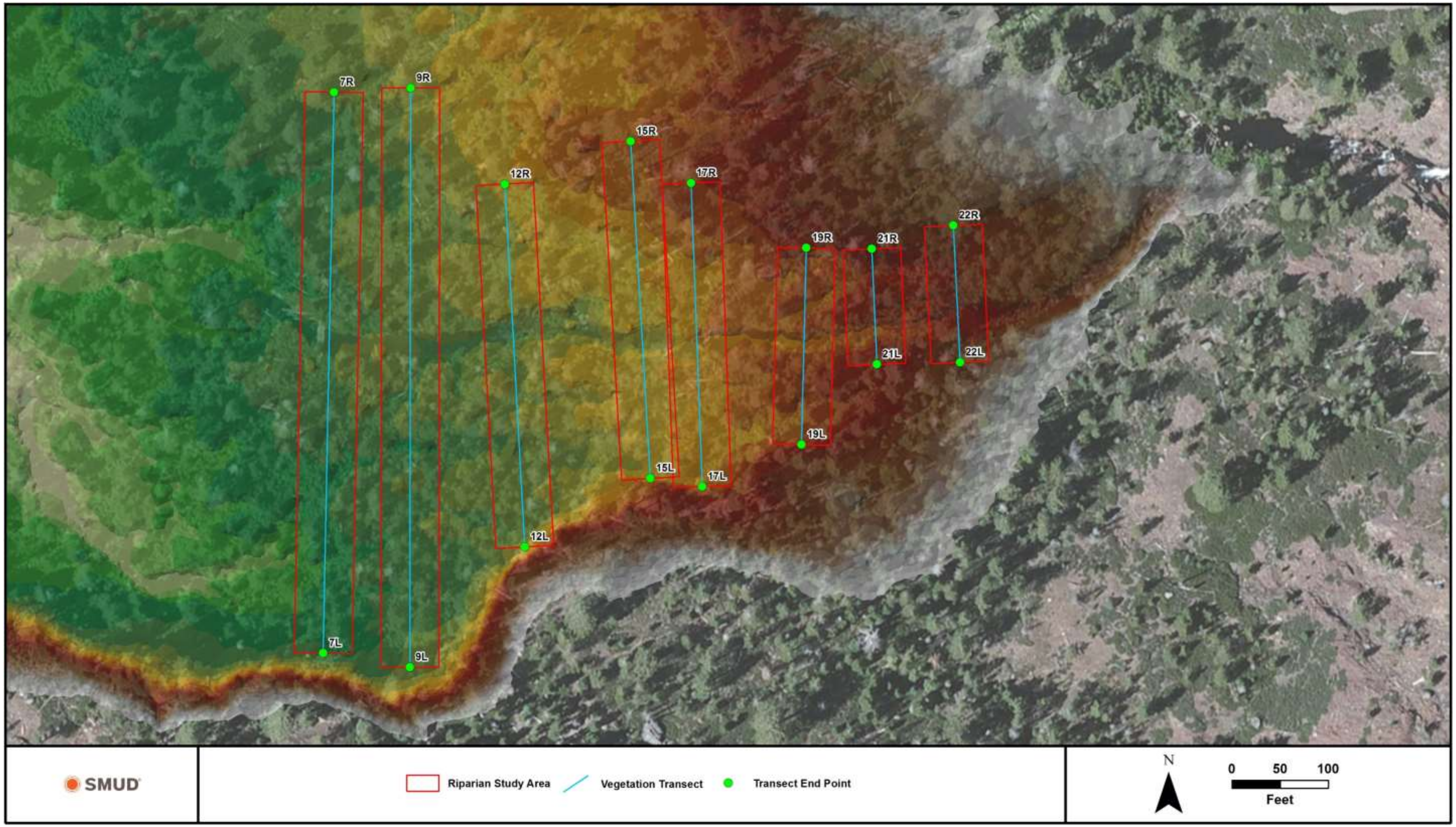


Figure 13. **Riparian vegetation transects and associated riparian study areas at LL-G2**

5.1 Pre-Test Pulse Flow Release Monitoring

Pre-test pulse flow release geomorphic and riparian vegetation baseline conditions were established during the summer and fall of 2015 consistent with the *SSIMMP*. Monitoring was targeted to sensitive sites LL-G1 and LL-G2, but LL-G1 was flooded out because beaver dams backwatered the site (Figure 14), so collection of useful information could not be completed safely (i.e., water depths exceeding wadeable depths) or practically at this site. Thus, the pre-test pulse flow release monitoring focused on sensitive site LL-G2.

Figure 14. Facing upstream at beaver-induced inundation through LL-G1, August 18, 2015

5.1.1 Geomorphic Monitoring

The geomorphic monitoring at LL-G2 included longitudinal bed and bank profiles, cross section geometry, bed surface gradations, and photograph points.

5.1.1.1 Longitudinal Bed and Bank Profiles

The longitudinal bed profile through LL-G2 noticeably steepens upstream of about cross section 17 (Station 3+96). Because of this change, slopes were calculated between (1) cross section 7 at station 0+00 and cross section 17, (2) cross section 17 and cross section 22 at station 6+74, and (3) cross section 7 and cross section 22. The slopes calculated from the pre-test pulse flow release monitoring were compared to the slopes calculated by DTA and Stillwater Sciences (2005) from the 2003 relicensing survey (Table 5). Pre-test pulse flow release slopes were calculated by fitting linear regression lines through the points on the profile, excluding the tops of LWD jams. The station and elevation measurements for the longitudinal profile are provided in Appendix B.

Table 5. Pre-test pulse flow release longitudinal bed slopes (percent)

Location	Station	2003 Survey	2015 Survey
XS 7 to XS 17	0+00 to 3+96	0.50	0.58
XS 17 to XS 22	3+96 to 6+74	1.73	1.82
XS 7 to XS 22	0+00 to 6+74	1.28	1.26

The calculated slopes in Table 5 and the profiles provided in Figure 15 show the longitudinal bed profile is very similar between the 2003 and 2015 surveys. The minor local variations are most likely caused by differences in the surveyed locations and the effects of the coarse bed material and bedforms (e.g., pools and steps). The LWD jam at XS 17 appears to have lost some material, as indicated by the almost 3-foot decrease in elevation at the top of the jam.

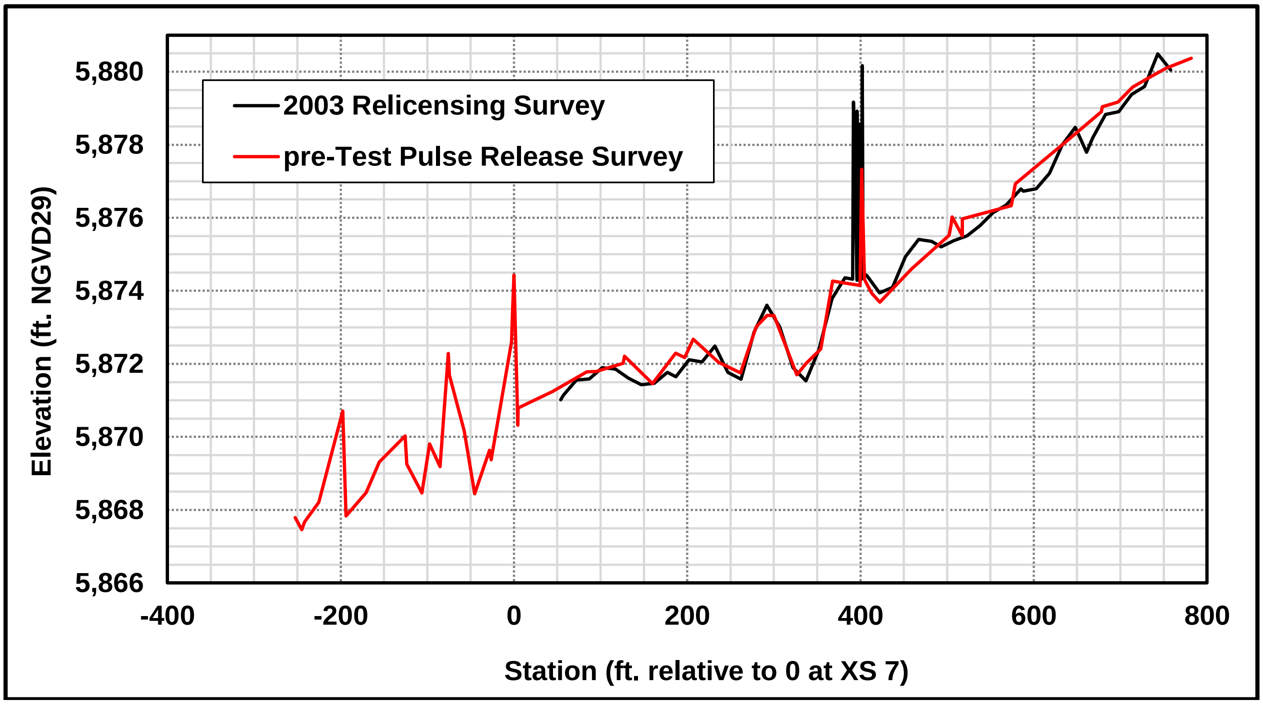


Figure 15. Pre-test pulse flow release longitudinal bed slopes

The surveys on which the longitudinal bank profiles are based focused on the top-of-bank (TOB) alignment because the banks were so low (typically only one to two feet in height) and stable (consistent with the observations and assessments noted in DTA and Stillwater Sciences (2005)). Indications of unstable banks (e.g., surface erosion, slumping/mass wasting, fractures/tension cracks, or undermined riparian vegetation falling into the channel) were not observed, so no areas of unstable banks were mapped. No bank profiles are available in DTA and Stillwater Sciences (2005), so there is nothing to compare to the pre-test pulse flow release surveys; however, the pre-test pulse flow release bank profiles are compared to the post-test pulse flow release bank profiles in Section 5.2.1.1, and details of the profiles are provided in Appendix B.

5.1.1.2 Cross Section Geometry

The cross section geometry was surveyed at each of the eight monitoring cross sections. The bankfull channel area (*A*), bankfull top width (*W*), and hydraulic depth (*d*) were calculated using the surveys and field observations; the values associated with the 2003 survey are transferred from Table 4.1-1 in DTA and Stillwater Sciences (2005). Figures illustrating the surveyed geometry are provided in Appendix C; an example for cross section 12 (the lower relicensing section) is provided in Figure 16.

Table 6. Cross section bankfull geometry

	Area (*A*) (sq.-ft.)		**Top Width (*W*) (ft.)**		**Hydraulic Depth (*d*) (ft.)**	
ID	**2003**	**2015**	**2003**	**2015**	**2003**	**2015**
7	--	48	--	27	--	1.8
9	--	33	--	32	--	1.0
12	56	36	51	35	1.1	1.0
15	--	82	--	27	--	3.0
17	--	68	--	49	--	1.4
19	--	52	--	27	--	1.9
21	49	37	38	23	1.3	1.6
22	86	29	54	27	1.6	1.1

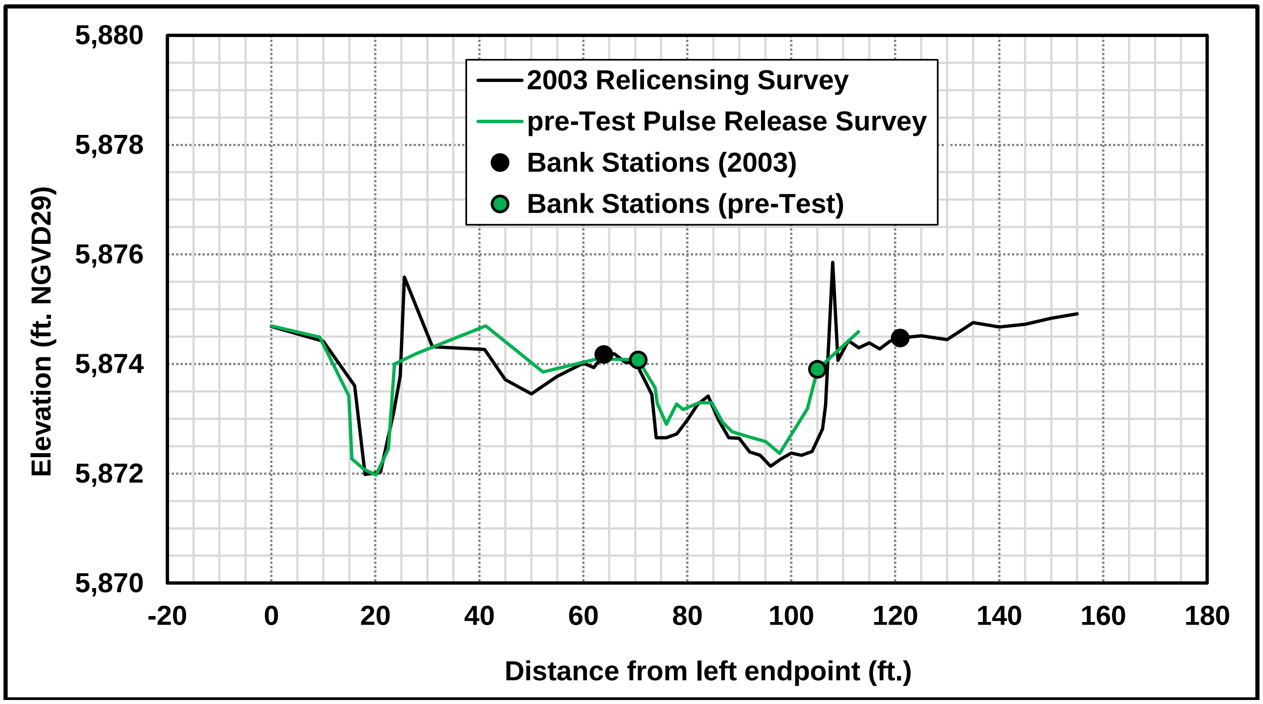


Figure 16. **Cross section geometry at cross section 12 (lower relicensing section)**

Table 6 suggests substantial changes in geometric conditions at the three cross sections surveyed in 2003 during the relicensing studies. However, review of the relicensing data (DTA and Stillwater Sciences 2005) raises concerns about the geometric properties reported at these three cross sections. For example, at cross section 12, the locations of the bankfull estimators (bank stations) were reported at stations 64 and 121 as presented on Figure 16, providing a bankfull top width of 56 feet. The bankfull width of 56 feet is not supported by the 2003 site photographs (DTA and Stillwater Sciences 2005, Appendix F, Photo Number 515 and 517, which show a channel lined with dense riparian vegetation that appears notably similar to observations made during the 2015 surveys), and could not be confirmed during the 2015 survey (Appendix E, Figures 45 and 46, which show very similar dense riparian vegetation lining both banks and limiting channel width to about 35 feet). The 2003 width is also inconsistent with the range of 10 to 40 feet reported for the Loon Lake Dam Reach of Gerle Creek, and with the typical width of 20 feet reported for Gerle Creek through LL-G2, in the *Riparian Vegetation and Wetlands Technical Report* (DTA 2004). As shown in Figure 16, the surveyed geometry also does not support an apparent 36-percent reduction in the bankfull area between the two surveys. Similar issues were noted at cross section 21 (Figure 17) and cross section 22 (Figure 18), where apparent reductions in bankfull area of 24-percent and 66-percent, respectively, are not supported by the 2015 surveys. Regardless of the origin of the apparent change, the apparent changes in geometric properties shown in Table 6 are not supported by the geometric surveys illustrated in Figure 16, Figure 17, and Figure 18.

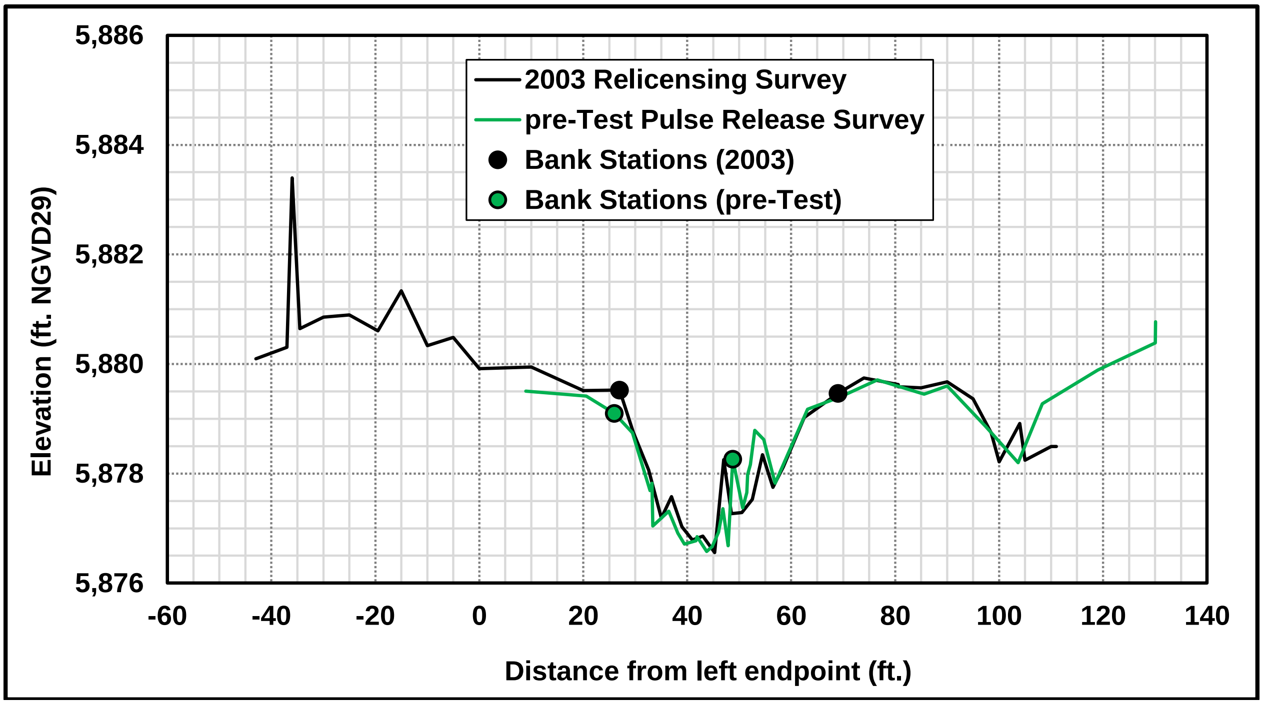


Figure 17. Cross section geometry at cross section 21 (middle relicensing section)

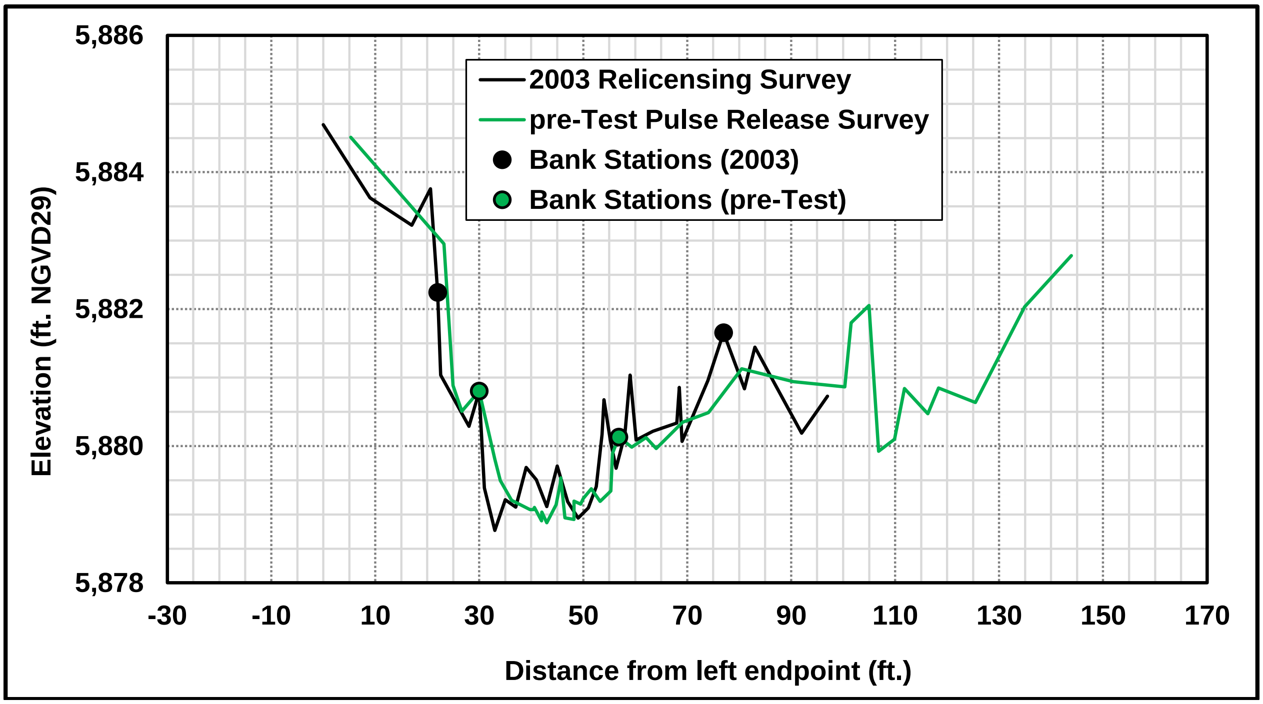


Figure 18. Cross section geometry at cross section 22 (upper relicensing section)

5.1.1.3 Bed Surface Gradations

The bed surface gradation was characterized at each of the eight monitoring sections using pebble counts (Wolman 1954). The size of the intermediate axis of each particle was measured using a gravelometer to a half-phi scale, and sizes were recorded as the largest opening on which a particle could be retained. The gradations were used to calculate the standard quantiles D_{84}, D_{50}, and D_{16}, where the subscript number is the percentage of the sample finer than the diameter D. The D_{50} (median) describes the central tendency of the gradation whereas the D_{84} and D_{16} describe the spread of the coarser and finer tails of the distribution, respectively. The quantiles are provided in Table 7 and Figure 19. Table 7 shows the values from the relicensing studies (DTA and Stillwater Sciences 2005), with an important distinction that the values for the upper and lower sections (cross section IDs 22 and 12, respectively) appear to have been transposed in the 2005 report based on field observations and photographs (DTA and Stillwater Sciences 2005, Appendix F, Photo Number 497 and 516, which clearly shows a coarser bed surface at the upper site than at the lower site); Table 7 reflects corrected values. Furthermore, the quantiles provided in Table 4.1-1 in DTA and Stillwater Sciences (2005) nearly match the gradation curves provided in Appendix H of that report, but are inconsistent with quantiles calculated from the pebble count summary in Appendix G of that report, so both sets of quantiles are presented in Table 7. The 2003 quantiles calculated from the pebble count summary in Appendix G of DTA and Stillwater Sciences (2005) are used here as the basis of comparisons (including Figure 19) because the method of calculation is consistent with the calculations using the pre- and post-test pulse flow release monitoring data.

Table 7. Bed surface gradation quantiles

ID	D_{84} (mm)			D_{50} (mm)			D_{16} (mm)		
	2003[1]	2003[2]	2015	2003[1]	2003[2]	2015	2003[1]	2003[2]	2015
7	--	--	102	--	--	53	--	--	28
9	--	--	102	--	--	61	--	--	35
12	148	167	150	40[3]	67	77	17	18	41
15	--	--	168	--	--	96	--	--	53
17	--	--	213	--	--	101	--	--	59
19	--	--	212	--	--	104	--	--	48
21	172	203	261	74	73	117	14	17	57
22	170	190	231	90	92	113	40	39	57

Notes:

[1] Values copied from Table 4.1-1 in DTA and Stillwater Sciences (2005), and generally consistent with gradation curves in Appendix H (p. H-15) of DTA and Stillwater Sciences (2005)

[2] Values calculated from LL-G2 pebble count summary in Appendix G (p. G-17) of DTA and Stillwater Sciences (2005)

[3] Value appears to be a typographical error in Table 4.1-1 as Appendix H shows a value of about 71 mm

Table 7 shows coarsening of the bed surface at the three sections sampled in both 2003 and 2015. The greatest changes are mostly in the D_{16} values, indicating the finer tail of the gradation has coarsened more than the median or coarser tail. The table also shows a general trend of downstream fining, where the gradations are coarser at the upstream end of the site and finer at the downstream end. This trend is consistent with the influence of decreasing longitudinal bed slope presented in Section 5.1.1.1.

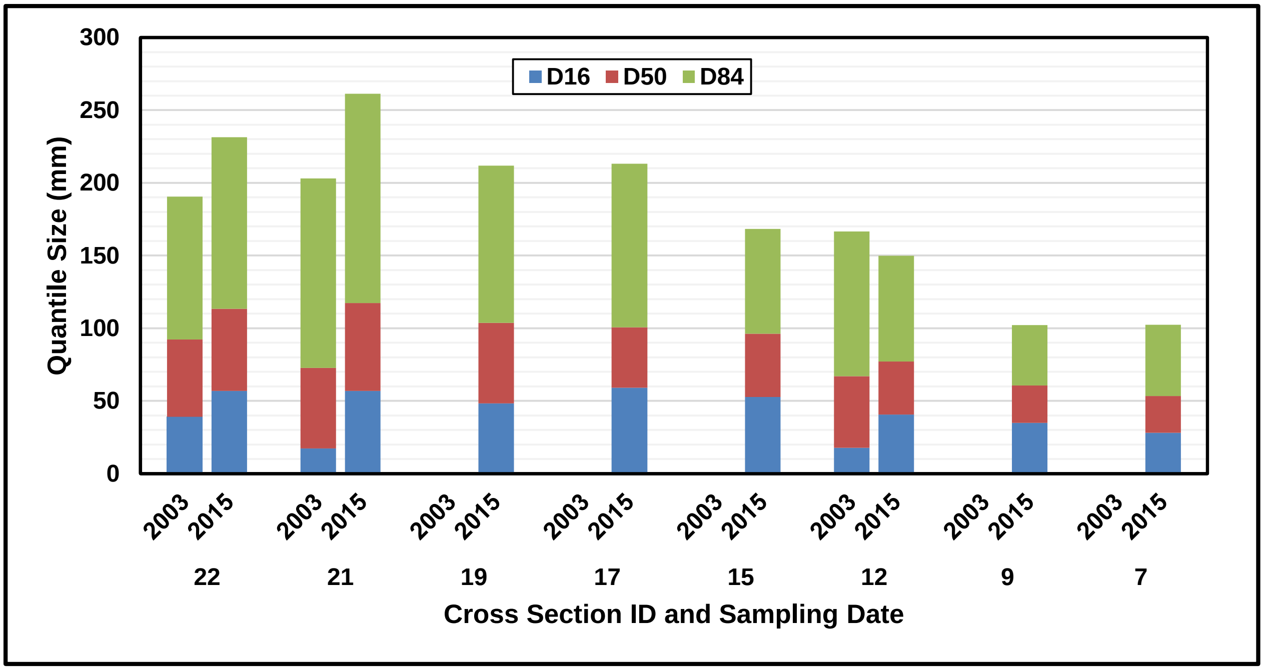


Figure 19. Bed surface gradation quantiles

Gradation plots and tabular summaries are provided in Appendix D; Figure 20 is an example gradation plot from cross section 12.

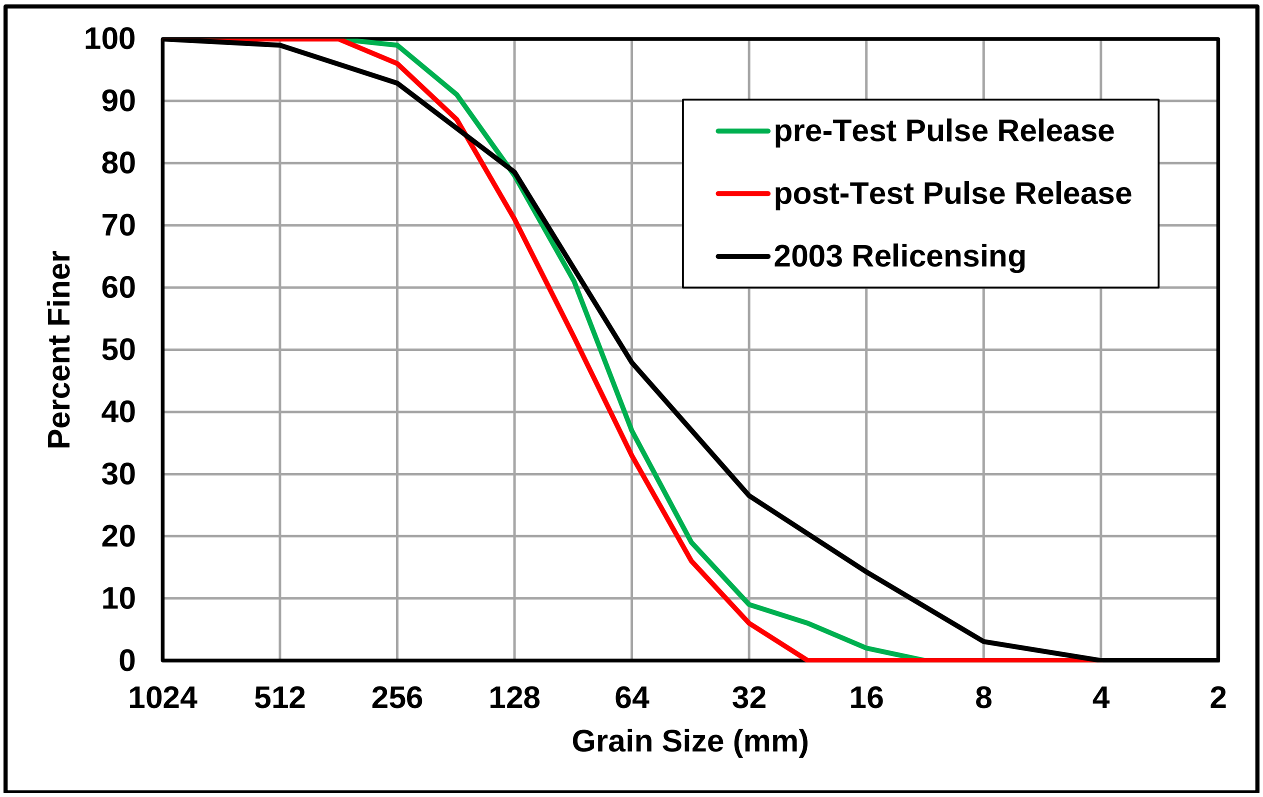


Figure 20. **Bed surface gradation plot at cross section 12**

A volumetric subsurface bed material sample was collected in the channel near the right bank between cross section 8 and cross section 9. The sample, weighing approximately 100 lbs., was delivered to a geotechnical lab for processing (drying and sieving) to determine the gradation. The sample was collected to evaluate the degree of hydraulic sorting of the bed surface and to provide a reference for the gradation of bedload if and when the bed surface is fully mobilized. It was assumed that the single subsurface sample represented the subsurface material underlying the bed through the whole LL-G2 site. The D_{84} was 35.6 mm, the D_{50} was 10.5 mm, and the D_{16} was 1.2 mm. The gradation curve is shown with the surface gradations for cross section 9 in Appendix D; tabular information is also provided in Appendix D.

5.1.1.4 Photograph Points

Photograph points were established along each of the monitoring sections to facilitate visual comparison of the geomorphic conditions over time. The pre-test pulse flow release photographs were taken in November 2015; the photographs are provided in Appendix E. Table 8 shows photograph point locations where comparisons of pre- and post-test pulse flow release conditions are valuable; differences in leaf-out of the vegetation between the 2015 and 2016 surveys inhibit meaningful comparisons at some of the locations.

Table 8. Summary of geomorphology monitoring photograph points

ID	Location on Cross Section[1]						
	LPIN	**LB**	**U/S**	**D/S**	**RB**	**RPIN**	**Others**
7	✓	✓	✓	✓	✓	✓	✓
9	✓	✓	✓	✓	✓	✓	✓
12	✓	✓	✓			✓	
15		✓	✓		✓		
17		✓	✓	✓	✓		
19	✓	✓	✓	✓	✓		
21	✓	✓	✓	✓	✓	✓	
22	✓	✓	✓	✓	✓	✓	

Note:
[1] Left and right based on a downstream-facing perspective. LPIN – facing riverward from the left pin; LB – riverward from the left bank; U/S – facing upstream at the section; D/S – facing downstream at the section; RB – facing riverward from the right bank; RPIN – facing riverward from the right pin; Others – additional locations such as side channels

5.1.2 Riparian Vegetation Monitoring

The riparian vegetation monitoring included data collection within both the Riparian Study Areas and the Greenline Study Areas. These data included photo-documentation at established photograph points. A detailed description of the monitoring results in the Riparian and Greenline Study Areas follows.

5.1.2.1 Riparian Study Areas

Eight vegetation transects were established within LL-G2 as described in Section 5.0, corresponding to the eight full monitoring cross sections (IDs 7, 9, 12, 15, 17, 19, 21, and 22). As agreed upon during the October 6, 2015 field meeting between SMUD and the resource agencies, the vegetation transects were established with the intent to encompass the entire width that had the potential to be influenced by the test pulse flow releases. Where possible, the placement of transect endpoints was based on topographical changes and shifts in vegetation communities from riparian areas to communities associated with uplands. However, as noted in the *Riparian Vegetation and Wetlands Technical Report* (DTA 2004), multiple wetlands occur adjacent to this reach of Gerle Creek, which in some cases made it difficult to differentiate riparian vegetation versus adjacent aquatic features. Thus, observations of other physical attributes, such as topography/elevation shifts and historical shelving and banking, were used to assist in justification of the transect endpoint locations where clear vegetation shifts were not evident. The rationale for each transect end point is included in Appendix F. Riparian Study Areas were established at each of the eight vegetation transects, and included the area 30 feet upstream and 30 feet downstream of the vegetation transect (Figure 13), as defined in the *SSIMMP*.

Eight distinct vegetation community types were identified within the eight Riparian Study Areas (Figure 21) using *A Manual of California Vegetation, Second Edition* (Sawyer et al. 2009):

1. *Abies concolor* Forest Alliance;
2. *Alnus incana* Shrubland Alliance;
3. *Cornus sericea* Shrubland Alliance;
4. *Glyceria elata* Herbaceus Alliance;
5. *Phleum alpinum-Juncus xiphioides;*
6. *Pinus contorta* ssp. *murrayana* Forest Alliance;
7. *Populus tremuloides* Forest Alliance; and
8. *Populus trichocarpa* Forest Alliance.

Alnus incana Shrubland Alliance was the most abundant vegetation community type observed within the Riparian Study Areas surveyed, accounting for 77 percent of the total area surveyed. *Cornus sericea* Shrubland Alliance accounted for 12 percent of the total surveyed area. The remaining six vegetation community types observed individually accounted for 4 percent or less of the vegetation communities observed. As shown on Figure 21, 35 individual vegetation community polygons were mapped within the Riparian Study Areas.

Within each vegetation community type all plant species were identified and the Braun-Blanquet (1932) cover class was recorded for each species. The dominant and co-dominant species recorded in each vegetation community polygon are provided in Table 9. A complete list of plant species and cover classes recorded in each vegetation community polygon is provided in Appendix F.

Figure 21. **Vegetation community types within the Riparian Study Areas**

Table 9. Summary of pre-test pulse flow release mapping within the Riparian Study Areas

Polygon	Vegetation Community	Species	Cover Estimate Category
7L-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Pinus contorta	Dominant
		Calamagrostis canadensis	Co-Dominant
		Carex aquatilis	Co-Dominant
		Carex vesicaria	Co-Dominant
		Poa pratensis	Co-Dominant
7R-1	*Glyceria elata* Herbaceous Alliance	*Carex aquatilis*	Dominant
		Glyceria elata	Dominant
		Poa pratensis	Dominant
7R-2	*Phleum alpinum - Juncus xiphioides*	*Phleum alpinum*	Dominant
		Juncus xiphioides	Co-Dominant
		Muhlenbergia filiformis	Co-Dominant
		Solidago canadensis	Co-Dominant
7R-3	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Poa pratensis	Dominant
		Pinus contorta	Co-Dominant
		Prunella vulgaris	Co-Dominant
		Veratrum californicum	Co-Dominant
9L-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Pinus contorta	Dominant
		Cornus sericea	Co-Dominant
		Juncus xiphioides	Co-Dominant
		Poa pratensis	Co-Dominant
		Pteridium aquilinum	Co-Dominant
		Spiraea splendens	Co-Dominant
9R-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Pinus contorta	Dominant
		Poa pratensis	Dominant
		Elymus sp.	Co-Dominant
		Prunella vulgaris	Co-Dominant
12L-1	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Poa pratensis	Dominant
		Carex vesicaria	Co-Dominant
		Juncus xiphioides	Co-Dominant
		Pinus contorta	Co-Dominant
12L-2		*Pinus contorta*	Dominant

Polygon	Vegetation Community	Species	Cover Estimate Category
	Pinus contorta ssp. *murrayana* Forest Alliance	*Abies concolor*	Co-Dominant
		Populus trichocarpa	Co-Dominant
12L-3	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Pinus contorta	Dominant
		Athyrium filix-femina	Co-Dominant
		Spiraea splendens	Co-Dominant
12R-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Poa pratensis	Dominant
		Muhlenbergia filiformis	Co-Dominant
		Pinus contorta	Co-Dominant
		Prunella vulgaris	Co-Dominant
12R-2	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Pinus contorta	Dominant
		Alnus incana	Co-Dominant
		Poa pratensis	Co-Dominant
		Spiraea splendens	Co-Dominant
15L-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Carex vesicaria	Dominant
		Poa pratensis	Dominant
		Cornus sericea	Co-Dominant
		Juncus xiphioides	Co-Dominant
		Pinus contorta	Co-Dominant
		Spiraea splendens	Co-Dominant
15R-1	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Pinus contorta	Dominant
		Poa pratensis	Co-Dominant
		Poaceae sp.	Co-Dominant
15R-2	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Poa pratensis	Dominant
		Pinus contorta	Co-Dominant
		Prunella vulgaris	Co-Dominant
15R-3	*Populus tremuloides* Forest Alliance	*Calamagrostis canadensis*	Dominant
		Populus tremuloides	Dominant
		Elymus sp.	Co-Dominant
		Poa pratensis	Co-Dominant
		Veratrum californicum	Co-Dominant
15R-4		*Poa pratensis*	Dominant

Polygon	Vegetation Community	Species	Cover Estimate Category
	Pinus contorta ssp. *murrayana* Forest Alliance	*Abies concolor*	Co-Dominant
		Calamagrostis canadensis	Co-Dominant
		Pinus contorta	Co-Dominant
17L-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Poa pratensis	Dominant
		Carex vesicaria	Co-Dominant
		Juncus xiphioides	Co-Dominant
		Pinus contorta	Co-Dominant
		Spiraea splendens	Co-Dominant
17R-1	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Alnus incana	Co-Dominant
		Hosackia oblongifolia	Co-Dominant
		Pinus contorta	Co-Dominant
17R-2	*Alnus incana* Shrubland Alliance	*Poa pratensis*	Dominant
		Alnus incana	Co-Dominant
		Calamagrostis canadensis	Co-Dominant
		Pinus contorta	Co-Dominant
		Prunella vulgaris	Co-Dominant
17R-3	*Pinus contorta* ssp. *murrayana* Forest Alliance	*Pinus contorta*	Dominant
		Poa pratensis	Dominant
		Lonicera conjugialis	Co-Dominant
		Prunella vulgaris	Co-Dominant
19L-1	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Pinus contorta	Dominant
19L-2	*Pinus contorta* ssp. *murrayana* Forest Alliance	*Abies concolor*	Dominant
		Pinus contorta	Co-Dominant
		Populus trichocarpa	Co-Dominant
19L-3	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Athyrium filix-femina	Co-Dominant
		Calocedrus decurrens	Co-Dominant
		Cornus sericea	Co-Dominant
		Spiraea splendens	Co-Dominant
19R-1	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Pinus contorta	Dominant
		Alnus incana	Co-Dominant
		Glyceria elata	Co-Dominant
		Poa pratensis	Co-Dominant

Polygon	Vegetation Community	Species	Cover Estimate Category
		Spiraea splendens	Co-Dominant
19R-2	*Populus trichocarpa* Forest Alliance	*Populus trichocarpa*	Dominant
		Elymus sp.	Co-Dominant
		Pinus contorta	Co-Dominant
		Poa pratensis	Co-Dominant
19R-3	*Populus tremuloides* Forest Alliance	*Pinus contorta*	Dominant
		Elymus sp.	Co-Dominant
		Poa pratensis	Co-Dominant
		Populus tremuloides	Co-Dominant
		Prunella vulgaris	Co-Dominant
19R-4	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Carex vesicaria	Co-Dominant
		Elymus sp.	Co-Dominant
		Pinus contorta	Co-Dominant
		Prunella vulgaris	Co-Dominant
21L-1	*Alnus incana* Shrubland Alliance	*Cornus sericea*	Dominant
		Abies concolor	Co-Dominant
		Alnus incana	Co-Dominant
		Athyrium filix-femina	Co-Dominant
		Pinus contorta	Co-Dominant
		Spiraea splendens	Co-Dominant
21R-1	*Populus trichocarpa* Forest Alliance	*Populus trichocarpa*	Dominant
		Elymus sp.	Co-Dominant
		Lonicera conjugialis	Co-Dominant
		Pinus contorta	Co-Dominant
		Prunella vulgaris	Co-Dominant
21R-2	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Pinus contorta	Dominant
		Juncus xiphioides	Co-Dominant
		Populus trichocarpa	Co-Dominant
22L-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Spiraea splendens	Dominant
		Cornus sericea	Co-Dominant
22L-2	*Abies concolor* Forest Alliance	*Abies concolor*	Dominant
		Calocedrus decurrens	Co-Dominant
		Quercus vaccinifolia	Co-Dominant
		Spiraea splendens	Co-Dominant
22R-1		*Cornus sericea*	Dominant

Polygon	Vegetation Community	Species	Cover Estimate Category
	Cornus sericea Shrubland Alliance	*Pinus contorta*	Dominant
		Alnus incana	Co-Dominant
		Juncus xiphioides	Co-Dominant
22R-2	*Populus trichocarpa* Forest Alliance	*Populus trichocarpa*	Dominant
		Abies concolor	Co-Dominant
		Pinus contorta	Co-Dominant
		Poa pratensis	Co-Dominant
		Spiraea splendens	Co-Dominant
22R-3	*Pinus contorta* ssp. *murrayana* Forest Alliance	*Pinus jeffreyi*	Dominant
		Abies concolor	Co-Dominant
		Elymus sp.	Co-Dominant
		Pinus contorta	Co-Dominant

Age classes of all dominant and co-dominant woody plant species observed were recorded within each vegetation community polygon according to the age classification per *Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation* (Burton et al. 2011) and approximate percent vegetation cover observed in each of the herb, shrub, and tree layers for each vegetation community mapped was recorded (Appendix F).

5.1.2.2 Greenline Study Areas

The Greenline Study Areas follow both banks between approximately cross section 12 and approximately cross section 21 (Figure 22). The Greenline Study Areas were established at this location to span a representative subset of the geomorphic features through the site. These features included: (1) the plane-bed upper portion of the reach, (2) a LWD jam, and (3) multiple riffles, runs and pools. The Greenline Study Areas encompass the area located within three feet on either side of the Greenline and extending approximately 409 feet along each bank. The Greenline Study Area survey began on the right bank of Gerle Creek, proceeding downstream along the Greenline using the step transect approach described in the *SSIMMP*. The vegetation communities observed and all dominant plant species observed at each step were recorded. Once complete, Gerle Creek was crossed and the process repeated on the left side of the bank proceeding upstream. The total number of steps and percent composition of each vegetation community within each Greenline Study Area transect is provided in Table 10.

On the left bank, *Cornus sericea* Alliance was the most commonly encountered vegetation community and had the highest percent composition observed (69.7). *Alnus incana* Alliance had the second highest percent composition observed (25.5). All remaining vegetation communities recorded individually accounted for two percent or less of the percent composition observed in the left bank Greenline Study Area.

On the right bank, *Cornus sericea* Alliance was the vegetation community with the highest percent composition observed (59.8), and *Alnus incana* Alliance had the second highest percent composition (22.6). All the remaining vegetation communities recorded accounted for eight percent or less of the percent composition observed in the right bank Greenline Study Area.

Table 10. Summary of pre-test pulse flow release vegetation communities within the Greenline Study Areas

Vegetation Community	Left Bank Step Count	Left Bank Percent Composition	Right Bank Step Count	Right Bank Percent Composition
Alnus incana Alliance	37	25.5	37	22.6
Carex vesicaria Alliance	0	0.0	6	3.7
Cornus sericea Alliance	101	69.7	98	59.8
Glyceria elata Alliance	3	2.1	3	1.8
Hosackia oblongifolia	0	0.0	2	1.2
Juncus xiphioides	0	0.0	14	8.5
Spiraea splendens	1	0.7	1	0.6
Boulders	0	0.0	2	1.2
Cobbles	3	2.1	0	0.0
Woody Debris	0	0.0	1	0.6

The total number of steps and percent composition of the dominant plant species within each Greenline Study Area transect are provided in Table 11.

On the left bank, the most dominant plant species encountered was *Cornus sericea*, having the highest percent composition observed (85.5). *Alnus incana* had the second highest percent composition observed (71.7), followed by *Pinus contorta* (46.2) and *Glyceria elata* (22.1). All remaining species recorded individually accounted for 13 percent or less, and were not considered dominant species.

On the right bank, *Cornus sericea* was the most dominant plant species observed with a percent composition of 80.0. *Alnus incana* had the second highest percent composition (49.7), followed by *Pinus contorta* (42.8), *Juncus xiphioides* (27.6), and woody debris (24.1). All remaining species recorded individually accounted for 19 percent or less.

Figure 22. **Greenline Study Areas at LL-G2**

Table 11. Dominant plant species in the Greenline Study Areas, pre-test pulse flow release

Dominant Species	Left Bank Step Count	Left Bank Percent Composition	Right Bank Step Count	Right Bank Percent Composition
Abies concolor	1	0.7	0	0.0
Alnus incana	104	71.7	72	49.7
Athyrium filix-femina	15	10.3	0	0.0
Calocedrus decurrens	2	1.4	0	0.0
Carex aquatilis	0	0.0	1	0.7
Carex vesicaria	0	0.0	17	11.7
Cornus sericea	124	85.5	116	80.0
Glyceria elata	32	22.1	27	18.6
Hosackia oblongifolia	9	6.2	20	13.8
Juncus xiphioides	4	2.8	40	27.6
Juniperus grandis	0	0.0	2	1.4
Lupinus polyphyllus	1	0.7	0	0.0
Phleum alpinum	0	0.0	1	0.7
Pinus contorta	67	46.2	62	42.8
Poa pratensis	0	0.0	5	3.4
Populus trichocarpa	1	0.7	0	0.0
Prunella vulgaris	0	0.0	1	0.7
Ribes nevadense	1	0.7	0	0.0
Rosa sp.	1	0.7	0	0.0
Senecio triangularis	2	1.4	0	0.0
Solidago canadensis	0	0.0	4	2.8
Sorbus sp.	2	1.4	0	0.0
Spiraea splendens	19	13.1	23	15.9
Boulder	0	0.0	2	1.4
Cobbles	3	2.1	0	0.0
Woody debris	15	10.3	35	24.1

5.1.2.3 Photograph Points

Photograph points were established for each of the eight Riparian Study Areas to facilitate visual comparison of the riparian vegetation conditions over time. Eight photographs were taken for each Riparian Study Area, four of which were taken on each side of the creek (left and right). Photos for each side of each Riparian Study Area included:

1. facing across the creek channel from the bank

2. facing toward the study area from the bank
3. facing toward the creek from the transect end point
4. facing away from the creek from the transect end point

Photograph points were also established for the end points of the Greenline Study Area on both sides of the bank (Figure 22), which were permanently marked with rebar and labeled cap. Upstream and downstream photographs were taken at each permanent monument, totaling eight photographs.

The pre-test pulse flow release photographs for both the Riparian Study Areas and Greenline Study Areas were taken in October 2015 and the photographs are provided in Appendix G.

5.2 Post-Test Pulse Flow Release Monitoring

Post-test pulse flow release geomorphic and riparian vegetation conditions were monitored immediately following the 5-day test pulse flow release during June 2016. LL-G1 was still flooded out because of the influence of beaver dams (Figure 23), so collection of useful information at LL-G1 could not be completed safely (depths still in excess of wadeable conditions) or practically. Accordingly, the post-test pulse flow release monitoring focused on sensitive site LL-G2. Except for the LWD jams noted in Table 4, no new downed logs were observed obstructing streamflow at LL-G2.


06 22 2016

Figure 23. Facing upstream at beaver-induced inundation through LL-G1

5.2.1 Geomorphic Monitoring

The geomorphic monitoring included longitudinal bed and bank profiles, cross section geometry, bed surface gradations, and photograph points.

5.2.1.1 Longitudinal Bed and Bank Profiles

Bed slopes calculated from the longitudinal surveys are compared in Table 12.

Table 12. Pre-test pulse flow release longitudinal bed slopes (percent)

Location	Station	2003 Survey	2015 Survey	2016 Survey
XS 7 to XS 17	0+00 to 3+96	0.50	0.58	0.56
XS 17 to XS 22	3+96 to 6+74	1.73	1.82	1.59
XS 7 to XS 22	0+00 to 6+74	1.28	1.26	1.13

Comparing the calculated slopes in Table 12 to the profiles provided in Figure 24 illustrates the similarity in the bed profile across surveys. Minor local variations caused by differences in the surveyed locations and the effects of the coarse bed material and bedforms (e.g., pools and steps) do not indicate reach-scale adjustments in response to the test pulse flow releases. The LWD jam at XS 17 (station 3+96) appears to have retained some additional debris after the test pulse flow releases, but the relatively small change could also be due to surveying different positions on the jam.

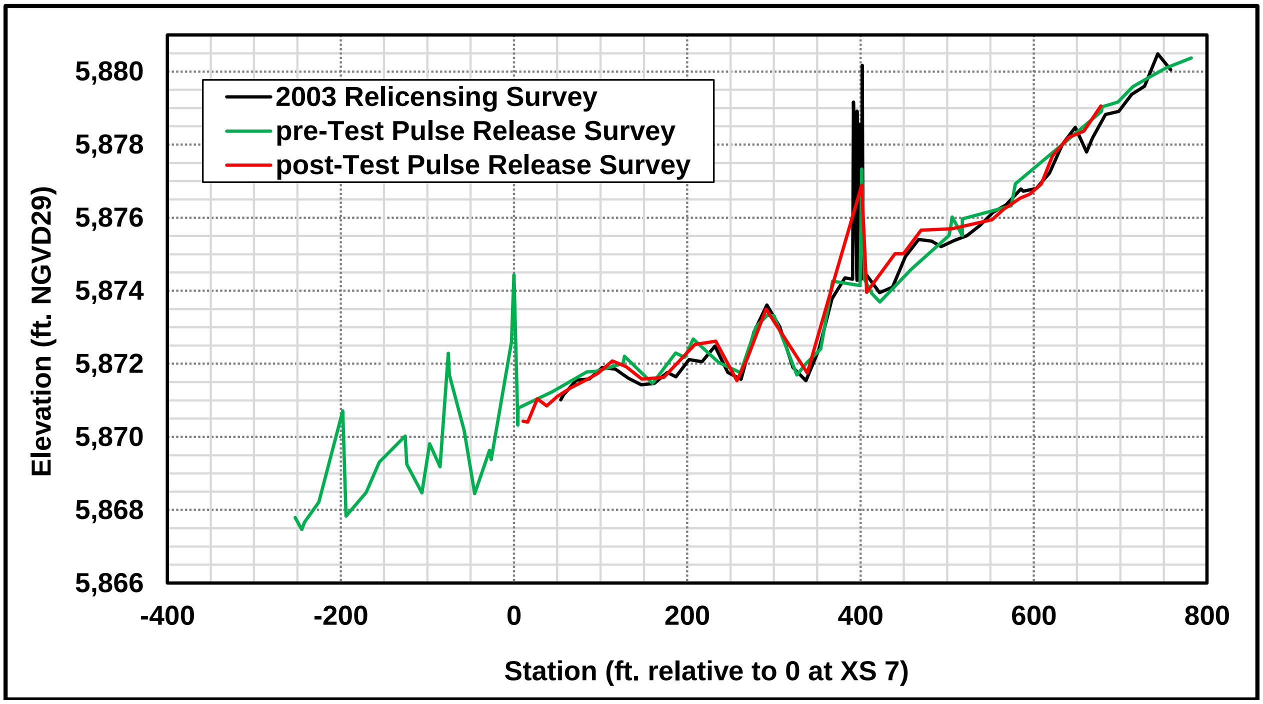


Figure 24. Pre-test pulse flow release longitudinal bed slopes

The longitudinal TOB profiles (Figure 25 and Figure 26) show the absence of substantial changes to bank heights, which is consistent with the similarity in the bed profiles (Table 12 and Figure 24). As with the pre-test pulse flow release surveys of the banks, no indicators of unstable banks were observed.

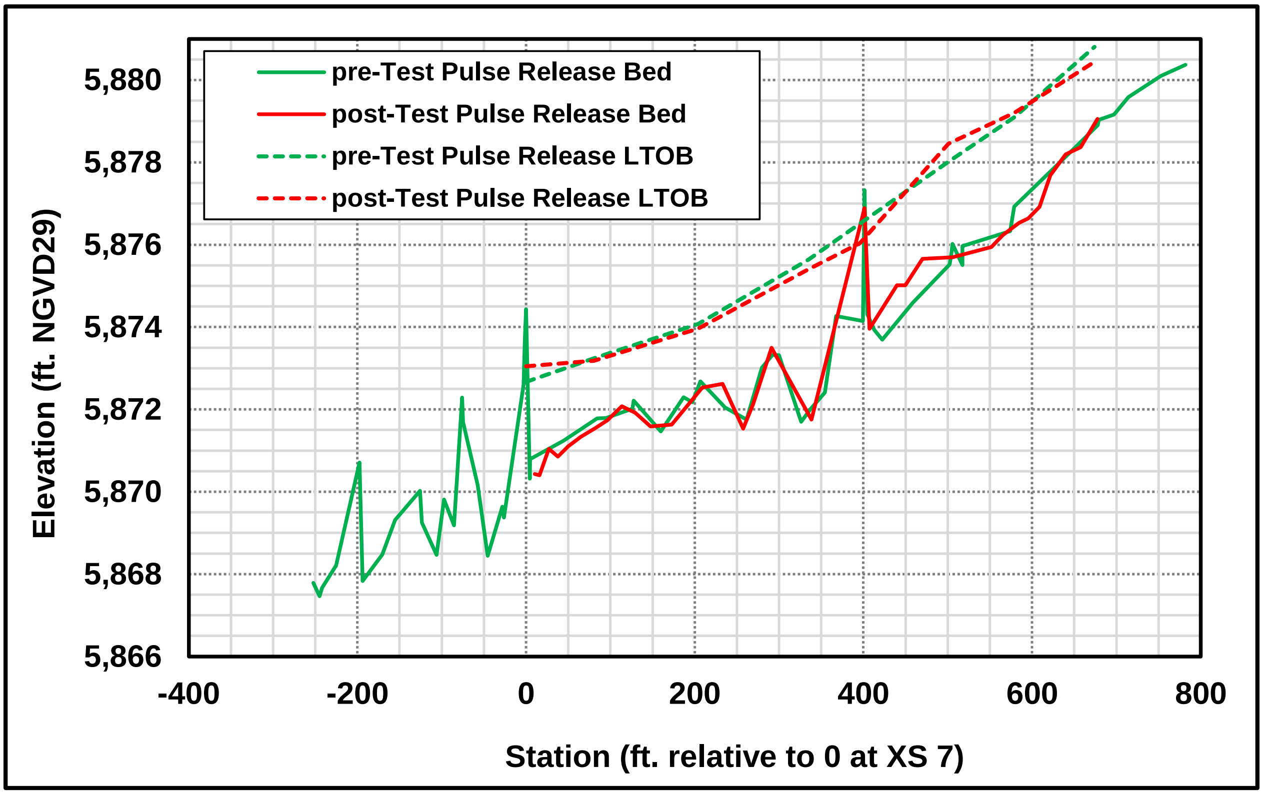


Figure 25. **Comparison of pre- and post-test pulse flow release longitudinal left TOB profile**

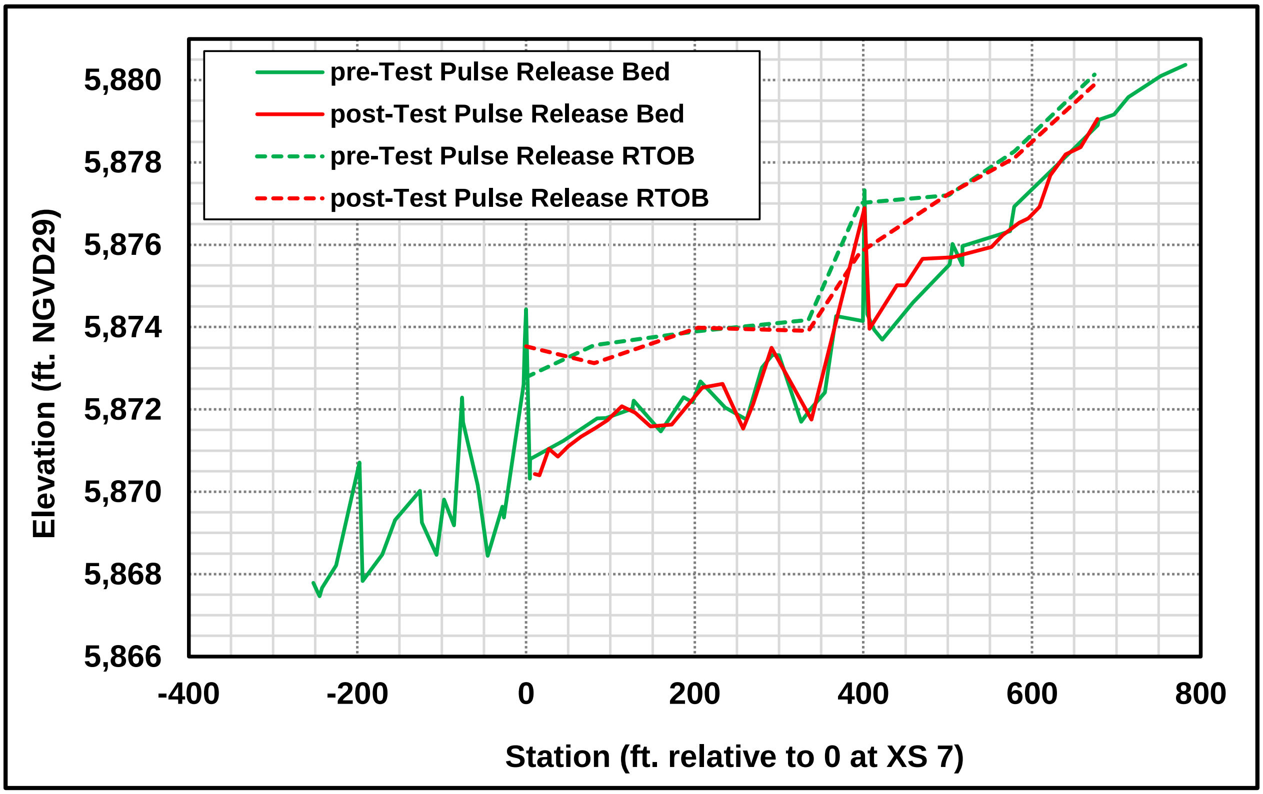


Figure 26. **Comparison of pre- and post-test pulse flow release longitudinal right TOB profile**

5.2.1.2 Cross Section Geometry

The bankfull channel area (*A*), bankfull top width (*W*), and hydraulic depth (*d*) were calculated from the surveyed geometry of each of the eight monitoring sections (Table 13). Figures of cross section surveys are provided in Appendix C; Figure 27 provides and an example from cross section 12 (the lower relicensing section).

Table 13. **Cross section bankfull geometry**

ID	Area (A) (sq.-ft.)			Top Width (W) (ft.)			Hydraulic Depth (d) (ft.)		
	2003	2015	2016	2003	2015	2016	2003	2015	2016
7	--	48	50	--	27	36	--	1.8	1.4
9	--	33	34	--	32	30	--	1.0	1.1
12	56	36	41	51	35	36	1.1	1.0	1.1
15	--	82	86	--	27	30	--	3.0	2.9
17	--	68	--	--	49	--	--	1.4	--
19	--	52	49	--	27	25	--	1.9	1.9
21	49	37	44	38	23	20	1.3	1.6	2.2
22	86	29	32	54	27	26	1.6	1.1	1.2

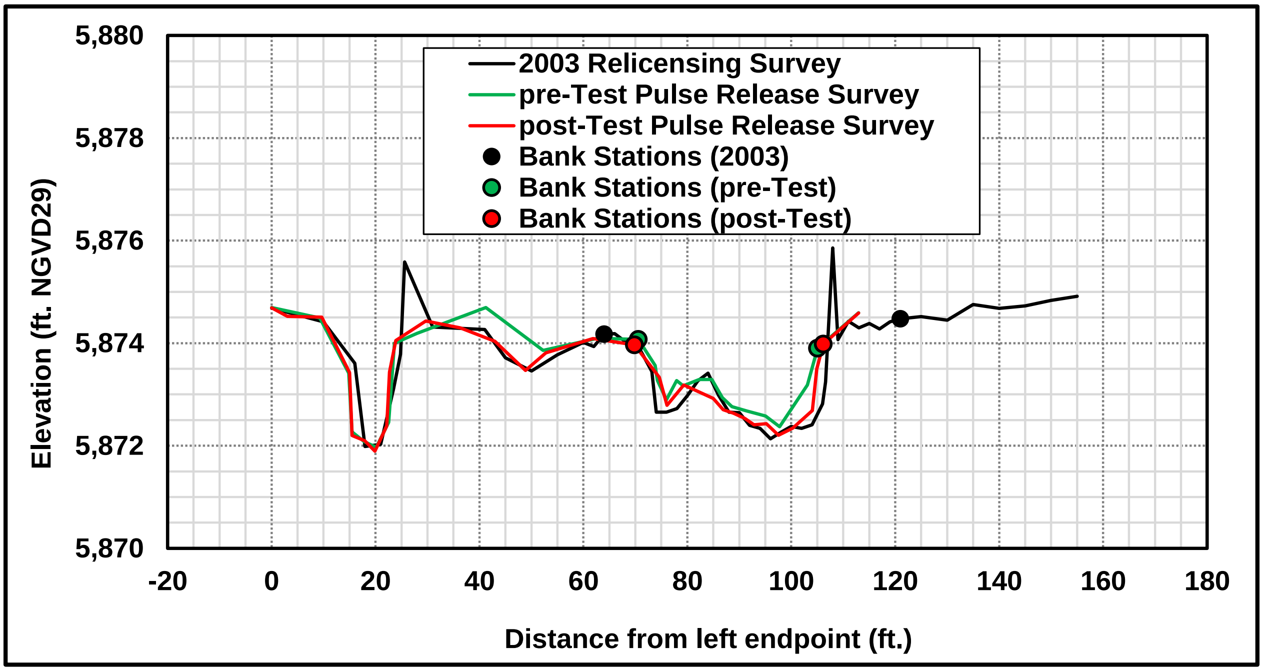


Figure 27. **Cross section geometry at cross section 12 (lower relicensing section)**

Table 13 shows *A* increased after the test pulse flow releases at six of the eight cross sections, and at half of these sections, the increases were greater than 10 percent. The apparent width increase at cross section 7 is not supported by the photographs (Appendix E, Figures 9 and 10), but rather, attributed to difficulties in differentiating natural bank material from debris along the upstream face of the LWD jam. *W* increased at four sections and decreased at three sections, and three of the changes exceeded 10 percent. Table 13 shows *d* increased at four sections and decreased at two sections, with only two of the changes greater than 10 percent.

5.2.1.3 Bed Surface Gradations

Quantiles of the bed surface gradations are provided in Table 14 and Figure 28. The comments provided in Section 5.1.1.3 about the relicensing data (DTA and Stillwater Sciences 2005) apply to Table 14 and Figure 28. Gradation plots and tabular summaries are provided in Appendix D.

Table 14. Bed surface gradation quantiles

ID	D_{84} (mm)			D_{50} (mm)			D_{16} (mm)		
	2003	2015	2016	2003	2015	2016	2003	2015	2016
7	--	102	88	--	53	49	--	28	32
9	--	102	108	--	61	60	--	35	35
12	167	150	169	67	77	87	18	41	45
15	--	168	--[1]	--	96	--[1]	--	53	--[1]
17	--	213	--[1]	--	101	--[1]	--	59	--[1]
19	--	212	186	--	104	96	--	48	48
21	203	261	249	73	117	113	17	57	64
22	190	231	235	92	113	106	39	57	57

Note:
[1] Flow depths were too great to safely sample these locations

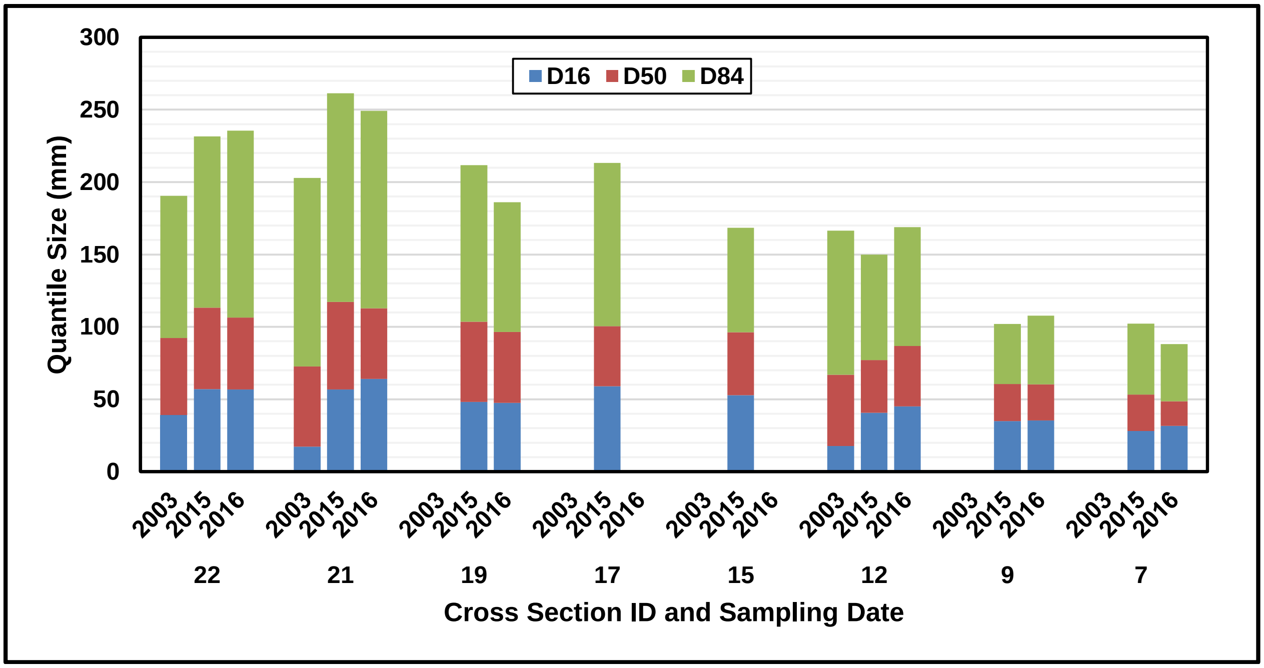


Figure 28. Bed surface gradation quantiles

The results in Table 14 and Figure 28 indicate that the bed surface gradations have not changed appreciably before and after the test pulse flow releases. Half of the D_{84} values decreased, five of six D_{50} values decreased, and all six D_{16} values either didn't change or increased; however, in most cases the magnitude of these changes was less than 10 percent, and in all cases it was less than 15 percent.

5.2.1.4 Photograph Points

As described in Section 5.1.1.4, photographs at established photo points are provided in Appendix E; and points of meaningful comparison between the pre- and post-test pulse flow release monitoring are provided in Table 8.

5.2.2 Riparian Vegetation Monitoring

Riparian vegetation monitoring was repeated in June 2016 following the same methodologies described in Section 5.1.2 and in the *SSIMMP*, targeting the data collection within both the Riparian Study Areas and the Greenline Study Areas. These data included photo-documentation at established photograph points. During the 5-day test pulse flow release, the edge of water was flagged along the vegetation transects; only the right edge of water was accessible. During the geomorphic monitoring, the flagged locations were surveyed and later used to estimate the inaccessible left edges of water. A surface was created and intersected with the LiDAR mapping to estimate the inundation extents. As shown in Figure 29, the majority of each Riparian Study Areas were inundated during the test pulse flow releases. The water surface elevation at LL-G2 differed by about 0.2 feet between the 300 cfs release and the 375 cfs release, so the inundation extent is expected to have been similar over the 5-day test. The riparian vegetation was likely inundated for the full five days of the test.

5.2.2.1 Riparian Study Areas

The eight Riparian Study Areas (Figure 21) were re-visited following the test pulse flow releases. No substantial changes were recorded during the survey that warranted mapping new boundaries for any of the existing vegetation community polygons mapped in 2015. No additional vegetation community polygons were mapped in 2016.

Within each vegetation community type all plant species were identified and the Braun-Blanquet (1932) cover class was recorded for each species. The dominant and co-dominant species recorded in each vegetation community polygon are provided in Table 15. Appendix F presents a complete list of plant species and cover classes recorded in each vegetation community polygon.

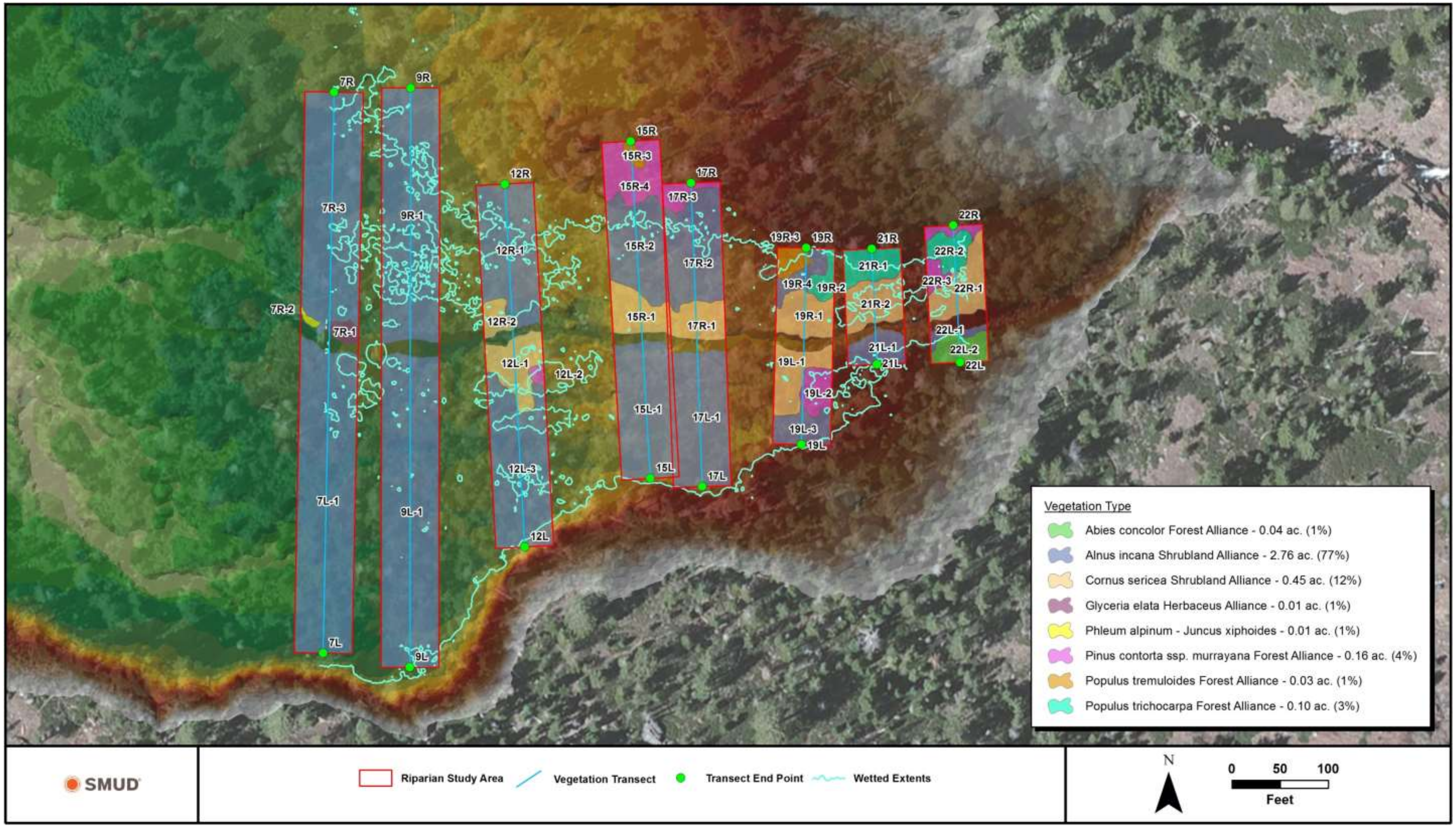


Figure 29. **Maximum wetted extents during the 375 cfs peak of the 5-day test pulse flow release**

Table 15. Summary of post-test pulse flow release mapping within the Riparian Study Areas

Polygon	Vegetation Community	Species	Cover Estimate Category
7L-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Pinus contorta	Dominant
		Carex vesicaria	Co-Dominant
		Glyceria elata	Co-Dominant
		Phleum alpinum	Co-Dominant
		Pteridium aquilinum	Co-Dominant
		Veratrum californicum	Co-Dominant
7R-1	*Glyceria elata* Herbaceous Alliance	*Carex vesicaria*	Co-Dominant
		Glyceria elata	Co-Dominant
7R-2	*Phleum alpinum - Juncus xiphioides*	*Juncus xiphioides*	Dominant
		Phleum alpinum	Dominant
7R-3	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Veratrum californicum	Dominant
		Glyceria elata	Co-Dominant
		Pinus contorta	Co-Dominant
		Poa pratensis	Co-Dominant
		Senecio triangularis	Co-Dominant
9L-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Pinus contorta	Dominant
		Cornus sericea	Co-Dominant
		Glyceria elata	Co-Dominant
		Pteridium aquilinum	Co-Dominant
9R-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Pinus contorta	Dominant
		Veratrum californicum	Dominant
		Elymus glaucus	Co-Dominant
		Glyceria elata	Co-Dominant
		Poa pratensis	Co-Dominant
12L-1	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Carex vesicaria	Co-Dominant
		Glyceria elata	Co-Dominant
		Juncus xiphiodes	Co-Dominant
		Pinus contorta	Co-Dominant
12L-2		*Pinus contorta*	Dominant

Polygon	Vegetation Community	Species	Cover Estimate Category
	Pinus contorta ssp. *murrayana* Forest Alliance	*Abies concolor*	Co-Dominant
		Populus trichocarpa	Co-Dominant
12L-3	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Pinus contorta	Dominant
		Athyrium filix-femina	Co-Dominant
		Carex vesicaria	Co-Dominant
		Glyceria elata	Co-Dominant
		Spiraea splendens	Co-Dominant
12R-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Camassia quamash	Co-Dominant
		Glyceria elata	Co-Dominant
		Melica sp.	Co-Dominant
		Phleum alpinum	Co-Dominant
		Pinus contorta	Co-Dominant
		Poa pratensis	Co-Dominant
		Veratrum californicum	Co-Dominant
12R-2	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Pinus contorta	Dominant
		Alnus incana	Co-Dominant
		Glyceria elata	Co-Dominant
15L-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Carex vesicaria	Dominant
		Glyceria elata	Dominant
		Camassia quamash	Co-Dominant
		Cornus sericea	Co-Dominant
		Pinus contorta	Co-Dominant
15R-1	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Pinus contorta	Dominant
		Camassia quamash	Co-Dominant
		Glyceria elata	Co-Dominant
		Poa pratensis	Co-Dominant
15R-2	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Poa pratensis	Dominant
		Glyceria elata	Co-Dominant
		Pinus contorta	Co-Dominant
		Veratrum californicum	Co-Dominant

Polygon	Vegetation Community	Species	Cover Estimate Category
15R-3	*Populus tremuloides* Forest Alliance	*Poa pratensis*	Dominant
		Populus tremuloides	Dominant
		Veratrum californicum	Dominant
		Elymus glaucus	Co-Dominant
15R-4	*Pinus contorta* ssp. *murrayana* Forest Alliance	*Poa pratensis*	Dominant
		Abies concolor	Co-Dominant
		Melica sp.	Co-Dominant
		Pinus contorta	Co-Dominant
		Rumex acetosella	Co-Dominant
		Veratrum californicum	Co-Dominant
17L-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Glyceria elata	Dominant
		Carex vesicaria	Co-Dominant
		Juncus xiphioides	Co-Dominant
		Pinus contorta	Co-Dominant
		Senecio triangularis	Co-Dominant
		Spiraea splendens	Co-Dominant
17R-1	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Alnus incana	Co-Dominant
		Carex vesicaria	Co-Dominant
		Hosackia oblongifolia	Co-Dominant
		Pinus contorta	Co-Dominant
17R-2	*Alnus incana* Shrubland Alliance	*Alnus incana*	Co-Dominant
		Carex vesicaria	Co-Dominant
		Circaea alpina	Co-Dominant
		Pinus contorta	Co-Dominant
		Veratrum californicum	Co-Dominant
17R-3	*Pinus contorta* ssp. *murrayana* Forest Alliance	*Pinus contorta*	Dominant
		Circaea alpina	Co-Dominant
		Lonicera conjugialis	Co-Dominant
		Melica sp.	Co-Dominant
		Veratrum californicum	Co-Dominant
19L-1	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Pinus contorta	Dominant
19L-2		*Abies concolor*	Dominant

Polygon	Vegetation Community	Species	Cover Estimate Category
	Pinus contorta ssp. *murrayana* Forest Alliance	*Pinus contorta*	Dominant
19L-3	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Athyrium filix-femina	Co-Dominant
		Calocedrus decurrens	Co-Dominant
		Cornus sericea	Co-Dominant
		Spiraea splendens	Co-Dominant
19R-1	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Pinus contorta	Dominant
		Alnus incana	Co-Dominant
		Glyceria elata	Co-Dominant
		Spiraea splendens	Co-Dominant
19R-2	*Populus trichocarpa* Forest Alliance	*Hosackia oblongifolia*	Dominant
		Populus trichocarpa	Dominant
		Pinus contorta	Co-Dominant
		Senecio triangularis	Co-Dominant
19R-3	*Populus tremuloides* Forest Alliance	*Pinus contorta*	Dominant
		Populus tremuloides	Dominant
		Anaphalis margaritacea	Co-Dominant
		Circaea alpina	Co-Dominant
		Melica sp.	Co-Dominant
19R-4	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Carex vesicaria	Co-Dominant
		Glyceria elata	Co-Dominant
		Pinus contorta	Co-Dominant
21L-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Cornus sericea	Dominant
		Abies concolor	Co-Dominant
		Athyrium filix-femina	Co-Dominant
		Pinus contorta	Co-Dominant
		Spiraea splendens	Co-Dominant
21R-1	*Populus trichocarpa* Forest Alliance	*Populus trichocarpa*	Dominant
		Abies concolor	Co-Dominant
		Hosackia oblongifolia	Co-Dominant
		Lupinus polyphyllus	Co-Dominant
		Pinus contorta	Co-Dominant
		Prunella vulgaris	Co-Dominant

Polygon	Vegetation Community	Species	Cover Estimate Category
		Viola glabella	Co-Dominant
21R-2	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Pinus contorta	Dominant
		Juncus xiphioides	Co-Dominant
		Populus trichocarpa	Co-Dominant
22L-1	*Alnus incana* Shrubland Alliance	*Alnus incana*	Dominant
		Spiraea splendens	Co-Dominant
22L-2	*Abies concolor* Forest Alliance	*Abies concolor*	Dominant
		Calocedrus decurrens	Co-Dominant
		Lonicera conjugialis	Co-Dominant
		Quercus vaccinifolia	Co-Dominant
		Spiraea splendens	Co-Dominant
22R-1	*Cornus sericea* Shrubland Alliance	*Cornus sericea*	Dominant
		Pinus contorta	Dominant
		Alnus incana	Co-Dominant
		Juncus xiphioides	Co-Dominant
22R-2	*Populus trichocarpa* Forest Alliance	*Populus trichocarpa*	Dominant
		Abies concolor	Co-Dominant
		Cornus sericea	Co-Dominant
		Pinus contorta	Co-Dominant
		Spiraea splendens	Co-Dominant
22R-3	*Pinus contorta* ssp. *murrayana* Forest Alliance	*Pinus jeffreyi*	Dominant
		Abies concolor	Co-Dominant
		Pinus contorta	Co-Dominant

No substantial changes in species composition were observed within the Riparian Study Areas between the pre- and the post-test pulse flow release monitoring. However, minor changes in species composition were observed, primarily among herbaceous species. Changes in species composition and cover classes among dominant and co-dominant herbaceous species occurred in 28 of the 35 vegetation community polygons surveyed. Among woody dominant and co-dominant species (trees and shrubs), changes in species composition and cover classes were observed in only 6 of the 35 vegetation community polygons surveyed. Differences in phenology between the two monitoring periods may account for some of these changes. None of these changes were substantial enough to warrant a re-classification or re-mapping of any vegetation community polygon within the Riparian Study Areas. Further comparisons of species composition and abundance are provided in Section **Error! Reference source not found.**.

Age classes of all dominant and co-dominant woody plant species observed were recorded within each vegetation community polygon according to age classification per *Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation* (Burton et al. 2011) (Appendix F). Because the age class data collection methods in the *SSIMMP* do not include actual counts of individual plants in each age class, the data are not useful for quantifying changes in recruitment or age class distribution over time. Further discussion of the age class data is provided in Section 6.2.1.

Approximate percent vegetative observed in each of the herb, shrub, and tree layers for each vegetation community mapped was recorded (Appendix F). No substantial changes were observed between the pre- and the post-test pulse flow release riparian vegetation monitoring in either the age class dataset or the vegetation layer dataset. Table 16 below shows a summary of total vegetative cover for the herb, shrub, and tree layers by year (2015 and 2016). As the data in Table 16 indicate, total vegetative cover was very similar between the two monitoring events.

Table 16. Average Percent Cover of Vegetation Layers

Year	Average Percent Cover of Herb Layer	Average Percent Cover of Shrub Layer	Average Percent Cover of Tree Layer
2015	51.2	42.0	39.9
2016	51.9	41.1	40.1

5.2.2.2 Greenline Study Areas

The Greenline Study Areas (Figure 22) were revisited following the test pulse flow releases. The total number of steps and percent composition of each vegetation community observed within each Greenline transect is provided in Table 17.

Table 17. Summary of post-test pulse flow release vegetation communities within the Greenline Study Areas

Veg Type	Left Bank Step Count	Left Bank Percent Composition	Right Bank Step Count	Right Bank Percent Composition
Alnus incana Alliance	38	26.2	37	22.6
Carex vesicaria Alliance	0	0.0	8	4.9
Cornus sericea Alliance	102	70.3	102	62.2
Hosackia oblongifolia	0	0.0	1	0.6
Juncus xiphioides	0	0.0	12	7.3
Phleum alpinum Alliance	0	0.0	2	1.2
Spiraea splendens	2	1.4	0	0.0

Boulder	0	0.0	1	0.6
Cobbles	3	2.1	0	0.0
Woody debris	0	0.0	1	0.6

No substantial changes in vegetation community composition of the Greenline Study Area were observed between the pre- and post-test pulse flow release monitoring. On the left bank, *Cornus sericea* Alliance was the most commonly encountered vegetation community and had the highest percent composition observed (70.3). *Alnus incana* Alliance had the second highest percent composition observed (26.2). Both of these vegetation communities increased in prevalence by less than one percent compared to the pre-test pulse flow release monitoring results. All remaining vegetation communities recorded individually accounted for two percent or less of the left bank Greenline Study Area. None of these vegetation communities changed by more than three percent compared to the pre-test pulse flow release monitoring results.

On the right bank, *Cornus sericea* Alliance was the vegetation community with the highest percent composition observed (62.2), and *Alnus incana* Alliance had the second highest percent composition (22.6). *Cornus sericea* Alliance increased in prevalence by 2.4 percent, and no change in prevalence was observed in *Alnus incana* Alliance. All remaining vegetation communities recorded individually accounted for seven percent or less of the right bank Greenline Study Area. None of these vegetation communities changed by more than eight percent compared to the pre-test pulse flow release monitoring.

The total number of steps and percent composition of the dominant plant species within each Greenline transect are provided in Table 18.

Table 18. Dominant plant species in the Greenline Study Areas, post-test pulse flow release

Dominant Species	Left Bank Step Count	Left Bank Percent Composition	Right Bank Step Count	Right Bank Percent Composition
Abies concolor	1	0.7	0	0.0
Alnus incana	107	73.8	71	49.0
Athyrium filix-femina	11	7.6	0	0.0
Calocedrus decurrens	2	1.4	0	0.0
Camassia quamash	3	2.1	0	0.0
Carex vesicaria	0	0.0	21	14.5
Cornus sericea	124	85.5	122	84.1
Glyceria elata	9	6.2	18	12.4
Hosackia oblongifolia	3	2.1	17	11.7
Juncus xiphioides	2	1.4	42	29.0
Juniperus grandis	0	0.0	2	1.4
Lonicera conjugialis	1	0.7	0	0.0
Phleum alpinum	0	0.0	11	7.6
Pinus contorta	70	48.3	63	43.4
Ribes nevadense	1	0.7	0	0.0
Salix lasiandra	0	0.0	1	0.7
Senecio triangularis	2	1.4	0	0.0
Spiraea splendens	16	11.0	16	11.0
Boulder	0	0.0	1	0.7
Cobbles	3	2.1	0	0.0
Woody debris	16	11.0	34	23.4

On the left bank, the most dominant plant species most commonly encountered was *Cornus sericea*, having the highest percent composition observed (85.5). *Alnus incana* had the second highest percent composition observed (73.8), followed by *Pinus contorta* (48.3 percent). The prevalence of *Alnus incana* and *Pinus contorta* decreased by approximately two percent compared to the pre-test pulse flow release monitoring results. No observable change in the prevalence of *Cornus sericea* was recorded. All remaining species were recorded as dominant along 11 percent or less of the left bank Greenline Study Area. No substantial changes in prevalence were recorded for any of these species.

On the right bank, the dominant species most commonly observed was *Cornus sericea*, with a percent composition of 84.1. The prevalence of *Cornus sericea* along the right bank decreased by approximately four percent compared to the pre-test pulse flow release monitoring. *Alnus incana* had the second highest percent composition (49.0), followed by *Pinus contorta* (43.4), *Juncus xiphioides* (29.0), and woody debris (23.4). A change of approximately one percent was recorded for each of these species. All remaining species were recorded as dominant along 14 percent or less of the right bank Greenline Study Area. No substantial changes in prevalence were recorded for any of these species.

5.2.2.3 Photograph Points

Photograph points were revisited within the riparian study areas and Greenline Study Areas in June 2016 and the photographs are provided in Appendix G.

6.0 INTERPRETATIONS OF MONITORING RESULTS

The results presented in Section 3.0 through Section 5.0 document the completion of the three items comprising the pulse flow studies for the Loon Lake Dam reach of Gerle Creek (i.e., (1) a sensitive site investigation, (2) test pulse flow releases, and (3) an analysis of the potential impacts of the pulse flows on downstream features). The goal of the pulse flow studies was to determine the appropriate magnitude of the pulse flows to reach the objectives of restoring the stream channel to a proper functioning condition. The results cannot be used to conclusively determine whether this goal has been achieved, so the following interpretations provide context. In the Loon Lake Dam reach of Gerle Creek, as opposed to other reaches in the UARP, the objectives for pulse flows recognize the importance of the recreational brown trout fishery in addition to the native rainbow trout (CDFG 2007). Thus, where appropriate, habitat preferences of rainbow trout and brown trout provide context for assessing the condition of the channel and floodplain. Regarding the riparian vegetation, assessment of monitored riparian vegetation provided a basis for evaluating proper functioning condition for vegetation.

Potentially the key challenge in developing, implementing, and interpreting the pulse flow studies, and specifically the results of the sensitive site investigation, has been defining quantifiable values that could be used to deterministically evaluate whether the tested pulse flow releases achieved the desired objectives, or at least moved the existing conditions in the direction of the desired state (i.e., a proper functioning condition). Despite repeated consultations with the resource agencies on this issue, and numerous discussions to establish such valuess, such quantifiable values were never identified. This foreseen and discussed problem of not establishing values is now manifest – deciding whether the test pulse flow releases, which were of lower magnitude for WET water-year types than the regime provided in the WQC Condition 2.B and USFS section 4(e) Condition No. 28, have achieved objectives or progressed the Loon Lake Dam reach of Gerle Creek toward these objectives. Similarly, an unresolved issue, which was discussed most recently during the September 7, 2016 meeting between SMUD and the resource agencies, is whether the pulse flows were intended to (1) affect change to channel and floodplalin geomorphology and riparian vegetation, or (2) achieve/maintain a desired condition. The distinction is important because under the former, change alone could either degrade or enhance existing conditions; under the latter, maintaining any desirable existing conditions could preclude the need for change. The interpretations offered in the following sections consider these possibilities in evaluating the success of the test pulse flow releases.

6.1 Interpretation of Geomorphic Monitoring Results

Hydraulic geometry relationships were used to provide a reference for comparing the surveyed channel morphology. Habitat preferences of rainbow trout and brown trout were considered to evaluate the suitability of the bed surface gradation. The sediment balance was considered in the context of the bed surface gradations and the sediment delivery from Jarrett Creek. The potential for mobilized fines to impede upstream passage of brown trout from Gerle Creek Reservoir into Gerle Creek was also considered. Finally, though it was never considered in the original License Conditions, the ability of the pulse flows to remove or alter beaver dams that function as key hydraulic controls was assessed.

6.1.1 Bankfull Channel Geometry

The channel geometry shows relative consistency between the 2003 survey, the pre-test pulse release survey, and the post-test pulse release survey. While a documented objective of the pulse flows was to redefine the stream channel, the longitudinal profile (Table 5) and cross section geometry show relative consistency before and after the test pulse releases. The absence of extensive change (i.e., redefining the stream channel) may be attributed to an appropriately-sized channel rather than an insufficient pulse flow magnitude. One way to address this is to evaluate hydraulic geometry relationships that provide estimates of bankfull channel geometry as a function of either discharge or contributing drainage area. A recent publication of regional hydraulic geometry relationships throughout the U.S. (Bieger et al. 2015), shows that the relationships developed for the Pacific Mountain System physiographic division, which encompasses the UARP, are based primarily on previous work of Castro and Jackson (2001). Bieger et al. (2015) note that their hydraulic geometry relationships, which relate bankfull cross section area, width, and depth to drainage area, are less reliable than those that relate these parameters to discharge. Since Castro and Jackson (2001) developed relationships as a function of bankfull discharge, they were selected for use. A flood frequency analysis following the Bulletin 17B procedures (IACWD 1982) was used to estimate the unimpaired bankfull flow (Q_{bf}, estimated as equivalent to the 1.5-year average annual recurrence interval) based on average daily unimpaired flows for water-years 1975 through 2001 as developed during the relicensing proceeding (DTA and Hannaford 2005). The 90 percent confidence intervals about this estimate were also calculated and used to provide ranges for the bankfull channel area (A), bankfull top width (W), and bankfull hydraulic depth (d) (Table 19).

Table 19. LL-G2 surveyed channel geometry compared to bankfull hydraulic geometry

	Q_{bf} (cfs)	A (sq. ft.)	W (ft.)	d (ft.)
2015 pre-test pulse flow release surveyed geometry (Table 6)				
Maximum	--	82	49	3.0
Average	--	*48*	*31*	*1.6*
Minimum	--	29	23	1.0
2016 post-test pulse flow release surveyed geometry (Table 13)				
Maximum	--	86	36	2.9
Average	--	*48*	*29*	*1.7*
Minimum	--	32	20	1.1
Hydraulic geometry calculations based on Castro and Jackson (2001)				
95-percent confidence interval bankfull flow	237	62	34	1.8
Median bankfull flow	*175*	*48*	*29*	*1.6*
5-percent confidence interval bankfull flow	124	35	25	1.4

Table 19 shows that the bankfull channel through LL-G2 exhibits geometric properties similar to expected properties for unregulated channels as calculated using the hydraulic geometry relationships. The relative similarity in geometric properties preceding and following the test pulse releases is therefore not unexpected given the pre-test pulse release geometry appears reasonably sized for the estimated unregulated bankfull flows (124 to 237 cfs) and the ability of the site to convey flow in excess of the bankfull channel capacity primarily in the overbanks and side channels. It appears that the pre- and post-test pulse release channel geometry at LL-G2 is consistent with expectations based on regional hydraulic geometry relationships, and the relatively minor change in bankfull geometry is not indicative of insufficient tested pulse flow releases. Moreover, the tested pulse flow releases did not appear to change bankfull channel geometry in a way that impaired the width, depth, and cross sectional area.

6.1.2 Bed Surface Gradation

The habitat suitability curve for the average size of substrate in rainbow trout spawning areas shows suitability between about 3 mm and 100 mm, with optimal conditions between 15 mm and 60 mm (Raleigh et al. 1984). Brown trout prefer gravel between 10 mm and 70 mm for spawning substrate, but utilize gravel from 3 mm to 100 mm (Raleigh et al. 1986). The median particle size of the bed surface as sampled during the 2003 survey was between 67 and 92 mm (Table 14). Median particle size of the bed surface as sampled during the pre-test pulse release survey ranged from 53 to 117 mm; the range was 49 to 113 mm during the post-test pulse release survey (Table 14). All three surveys show median bed surface in the gravel to cobble range; further, in no sample was the D_{16} less than 17 mm (the smallest D_{16} during the pre- and post-test pulse flow release monitoring was 28 mm), indicating that the bed surface does not contain quantities of finer substrate (less than 3 mm) that are widely recognized to impair spawning habitats (Raleigh et al. 1984). According to CDFG (2007) there is high interest in providing high quality rainbow trout and brown trout habitat in the Loon Lake Dam reach of Gerle Creek, and pulse flows are expected to improve habitat quality through sorting of spawning gravels. It appears that 2003, pre-, and post-test pulse release bed surface gradations provide suitable, and in cases optimal, spawning substrate for rainbow and brown trout. Therefore, releasing pulse flows with the intention of sorting spawning gravels is unnecessary because the test pulse flow releases appear to maintain the bed surface in a suitable and even optimal condition for rainbow trout and brown trout habitat and spawning.

The *Rationale Report* identifies part of the geomorphic objective of pulse flows as “provid[ing] for balanced sediment transport” (Channel Morphology Objective) and “ensur[ing] delivery and transport of sediment are balanced” (Sediment Transport Objective). Comparing the D_{50} of the bed surface to the D_{50} of the subsurface shows the surface is about five to 12 times coarser (relating all surface samples to the single subsurface sample, which was assumed to be representative of the subsurface channel bed through the whole LL-G2 site), with the ratio at cross section 9 (where the subsurface sample was collected) at about six. Such high armor ratios, even at the low end of the range of about five, indicate a heavily armored channel with sediment supply limitations prevailing (Hinton 2012; Bray and Church 1980; Parker 1990; Dietrich et al. 1989; Barry et al. 2004). The indication of an imbalanced sediment transport regime is consistent with expected sediment regime of the Loon Lake Dam reach of Gerle Creek. For example, it is reasonably expected that bed material load delivered to Loon Lake is not transported through the outlet works at the dam, and with the higher slope channel at LL-G2, the sediment balance is reasonably skewed in the direction of excess transport capacity. It is not reasonable, therefore, to expect that the pulse flows could decrease the transport capacity and increase the supply. Thus, based on the observed sediment gradations and the general understanding of the sediment balance in Gerle Creek below Loon Lake Dam, the pulse flows are unlikely to achieve these geomorphic objectives relating to balancing the sediment transport regime.

6.1.3 Jarrett Creek Sediment Supply

The *SSIMMP* includes a monitoring component to survey channel geometry and collect bed material samples in Jarrett Creek for use in empirically calculating sediment delivered into Gerle Creek. Jarrett Creek flows across a coarse-grained alluvial fan between the Wentworth Springs Road crossing and Gerle Creek. During the pre-test pulse flow release survey, the channel was walked in the downstream direction starting upstream of the crossing. The bedrock-controlled channel upstream of the crossing contained very little stored sediment. The single-thread, bedrock-confined channel at the crossing bifurcates multiple times into smaller and less well-defined channels, until finally toward the downstream end of the fan, there are no defined channels (at least within the extents of LL-G2). Absent a channel to survey, or from which to collect a bed material sample, the best estimate of the mean annual bed material delivery from Jarrett Creek into Gerle Creek is a nominal amount too low to measure reliably. Given the imbalance in the sediment transport regime noted in the previous section, any sediment contribution from Jarrett Creek will not mitigate this imbalance.

6.1.4 Gerle Creek Delta

During the pre- and post-test pulse flow release monitoring, the delta formed where Gerle Creek flows into Gerle Creek Reservoir was visited to check for evidence of geomorphic change that could impede upstream passage of brown trout. No evidence of geomorphic change was observed prior to or following the test pulse flow releases, indicating the tested pulse flows are expected to allow SMUD to comply with WQC Condition 5.D and USFS section 4(e) Condition No. 34. Further, in August 2015 FERC issued an order (FERC 2015b) approving SMUD's filing of the *Gerle Creek Fish Passage Plan* (SMUD 2015b), which provides for the preparation of a reservoir operation plan that includes provisions to modify the delta if future monitoring indicates geomorphic change (caused by drivers such as pulse flows) could impede upstream passage of brown trout.

6.1.5 Beaver Dams

The SSIMMP required mapping of the alignments and elevation profiles of selected beaver dams that function as key hydraulic controls, pending safe access. The requirement provided a means for evaluating the ability of the pulse flows to remove or alter these beaver dams. Only a single beaver dam was identified as a key hydraulic control – the dam located approximately 475 feet downstream from the lower end of LL-G1. Even though this dam is partially breached (Figure 30), it is still the primary driver of the backwater that inundates LL-G1. The alignment of the beaver dam was mapped and surveyed during the pre-test pulse flow release monitoring (Table 20 and Figure 31).

Figure 30. **Partially breached beaver dam downstream of LL-G1, facing the right bank**

Table 20. **Surveyed alignment of beaver dam downstream of LL-G1**

Easting (ft.)	Northing (ft.)	Station (ft.)	Elevation (ft., NGVD29)
7,037,894.89	2,134,256.94	0	6,130.28
7,037,902.58	2,134,261.91	9.2	6,130.67
7,037,910.67	2,134,264.15	17.5	6,129.43
7,037,913.84	2,134,265.11	20.9	6,127.95
7,037,916.83	2,134,267.02	24.4	6,127.54
7,037,922.81	2,134,268.79	30.6	6,128.50
7,037,927.02	2,134,270.30	35.1	6,129.40
7,037,929.98	2,134,272.78	39.0	6,129.89
7,037,932.84	2,134,275.18	42.7	6,130.61
7,037,939.80	2,134,280.05	51.2	6,130.63
7,037,951.10	2,134,284.97	63.5	6,130.54
7,037,962.64	2,134,286.65	75.2	6,130.63
7,037,973.16	2,134,277.76	89.0	6,130.69
7,037,987.75	2,134,283.63	104.7	6,130.69
7,037,993.94	2,134,287.45	112.0	6,130.60
7,038,004.39	2,134,292.65	123.6	6,130.79

Note: Easting and northing referenced to NAD83, State Plane, California Zone II, in units of feet (FIPS Zone 0402). Station 0 set to start of beaver dam along left bank.

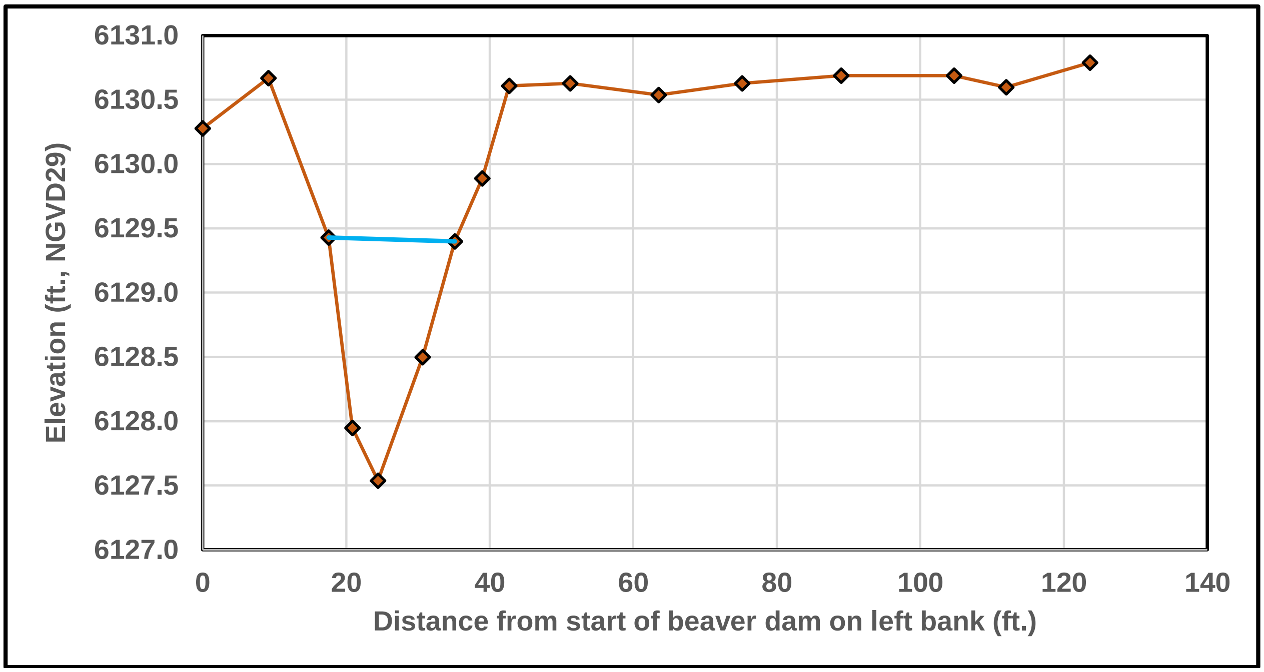


Figure 31. **Elevation profile of partially breached beaver dam downstream of LL-G1**

When the beaver dam was observed during the post-test pulse flow release monitoring, the dam was still present, confirming the pulse flows did not remove the dam. Further, there was no evidence that the pulse flows had altered the dam, and it was observed to still be backwatering LL-G1.

6.2 Interpretation of Riparian Vegetation Monitoring Results

While not a requirement of the *SSIMMP*, for consistency with the relicensing study (DTA 2004), the current condition of riparian vegetation was characterized using elements that closely conform to those used by USDI (1998) to assess proper functioning condition (PFC) of riparian areas. A complete evaluation of PFC considers aspects of the riparian vegetation, as well as hydrologic functions and erosion process, but DTA (2004) only considered the six vegetation items (Item 6 through Item 12) on the Standard Checklist (USDI 1998), so that is all that was done with the pre- and post-test pulse flow release monitoring data.

It is important to note that the field methods for the Riparian Vegetation Metrics presented in the *SSIMMP* do not directly address the vegetation attributes of Proper Functioning Condition (PFC); however, a combination of the collected data and qualitative observations by field personnel can be used to reasonably approximate a PFC assessment. An assessment of PFC Items 6 through 12 follows for the pre-test pulse flow release and post-test pulse flow release monitoring results.

6.2.1 PFC Standard Checklist Item 6

Item 6 of the *PFC User Guide* (USDI 1998) states: “There is diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)”. To respond “yes” to this item on the *PFC User Guide’s* Standard Checklist, seedlings and saplings must be present on the stream reach being assessed if woody vegetation is required in that system to achieve functionality (i.e. if a woody vegetation alliance were the only appropriate wetland/riparian vegetation type for the system). While woody vegetation would not necessarily be required throughout LL-G2 for the site to be considered functional, the field methods described in the *SSIMMP* only require the recording of age-classes of dominant or co-dominant woody species, not herbaceous species. Furthermore, the *SSIMMP* only requires the recording of the presence of woody species age classes (seedling, young, and mature), not a complete count of individual plants within each age class. Therefore, the presence or absence of seedlings and young individuals (as defined in the *SSIMMP*) of wetland/riparian woody plant species within LL-G2 is the only data-driven metric available to assess PFC Item 6.

During the pre-test pulse flow release monitoring in 2015, 22 of the 35 vegetation community polygons surveyed within the Riparian Study Areas contained seedlings or young individuals of dominant or co-dominant woody plant species rated as either FACW (facultative wetland) or OBL (obligate wetland) in the National Wetland Plant List for the Western Mountains, Valleys and Coast Region (Lichvar et. al. 2016). These 22 polygons account for 90.3 percent of the acreage of the Riparian Study Areas. During the post-test pulse flow release monitoring in 2016, 23 of the 35 polygons surveyed contained seedlings or young individuals of dominant or co-dominant woody plant species rated as either FACW or OBL. These 23 polygons account for 91.2 percent of the acreage of the Riparian Study Areas. Following the guidelines presented in the *PFC User Guide*, these statistics indicate that there were sufficiently diverse age-class distributions of riparian-wetland vegetation within the Riparian Study Areas during both monitoring events to satisfy PFC Item 6. While quantitative age class data was not collected, field observations also indicate that seedlings and saplings of woody riparian-wetland species were common throughout the Riparian Study Areas, and age class distributions were indicative of stable populations of riparian-wetland species.

6.2.2 PFC Standard Checklist Item 7

Item 7 of the *PFC User Guide* states: “There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)”. To respond “yes” to this item on the *PFC User Guide’s* Standard Checklist, at least two wetland-riparian species must be present on the reach being assessed. A summary of riparian-wetland species (rated FACW or OBL) diversity by vegetation community polygon is presented below in Table 21.

Table 21. Diversity of riparian-wetland species by vegation community polygons

Polygon	Vegetation Community	Acreage of Polygon	2015 Wetland Species Count	2016 Wetland Species Count
7L-1	*Alnus incana* Shrubland Alliance	0.44	18	12
7R-1	*Glyceria elata* Herbaceous Alliance	0.01	12	10
7R-2	*Phleum alpinum* - *Juncus xiphioides*	0.00	6	5
7R-3	*Alnus incana* Shrubland Alliance	0.33	6	15
9L-1	*Alnus incana* Shrubland Alliance	0.45	14	18
9R-1	*Alnus incana* Shrubland Alliance	0.36	16	17
12L-1	*Cornus sericea* Shrubland Alliance	0.07	9	13
12L-2	*Pinus contorta* ssp. *murrayana* Forest Alliance	0.01	1	4
12L-3	*Alnus incana* Shrubland Alliance	0.22	10	14
12R-1	*Alnus incana* Shrubland Alliance	0.19	13	15
12R-2	*Cornus sericea* Shrubland Alliance	0.02	8	10
15L-1	*Alnus incana* Shrubland Alliance	0.18	16	16
15R-1	*Cornus sericea* Shrubland Alliance	0.05	8	10
15R-2	*Alnus incana* Shrubland Alliance	0.13	7	16
15R-3	*Populus tremuloides* Forest Alliance	0.01	5	6
15R-4	*Pinus contorta* ssp. *murrayana* Forest Alliance	0.08	6	11
17L-1	*Alnus incana* Shrubland Alliance	0.19	13	12
17R-1	*Cornus sericea* Shrubland Alliance	0.05	6	8
17R-2	*Alnus incana* Shrubland Alliance	0.15	12	14
17R-3	*Pinus contorta* ssp. *murrayana* Forest Alliance	0.02	1	7
19L-1	*Cornus sericea* Shrubland Alliance	0.06	6	5
19L-2	*Pinus contorta* ssp. *murrayana* Forest Alliance	0.03	3	3
19L-3	*Alnus incana* Shrubland Alliance	0.05	7	8
19R-1	*Cornus sericea* Shrubland Alliance	0.06	10	10
19R-2	*Populus trichocarpa* Forest Alliance	0.02	9	11
19R-3	*Populus tremuloides* Forest Alliance	0.02	4	8
19R-4	*Alnus incana* Shrubland Alliance	0.03	8	9
21L-1	*Alnus incana* Shrubland Alliance	0.04	9	9
21R-1	*Populus trichocarpa* Forest Alliance	0.05	6	10
21R-2	*Cornus sericea* Shrubland Alliance	0.06	9	9
22L-1	*Alnus incana* Shrubland Alliance	0.01	5	4
22L-2	*Abies concolor* Forest Alliance	0.04	0	1
22R-1	*Cornus sericea* Shrubland Alliance	0.07	9	9
22R-2	*Populus trichocarpa* Forest Alliance	0.03	6	15
22R-3	*Pinus contorta* ssp. *murrayana* Forest Alliance	0.03	3	11

During the pre-test pulse flow release monitoring in 2015, the average number of riparian-wetland plant species (rated FACW or OBL) observed in the 35 vegetation community polygons surveyed was 8.0. Thirty two of the 35 vegetation community polygons contained at least two riparian-wetland plant species. These polygons accounted for 98.2 percent of the acreage of the Riparian Study Areas. During the post-test pulse flow release monitoring in 2016, the average number of riparian-wetland plant species observed in the 35 vegetation community polygons surveyed was 10.1. Thirty four of the 35 vegetation community polygons contained at least two riparian-wetland plant species. These polygons accounted for 99.0 percent of the acreage of the Riparian Study Areas. Only polygon 22L-2, classified as *Abies concolor* Forest Alliance, contained fewer than two riparian-wetland species during both survey efforts. However, this polygon occurs well above the floodplain of Gerle Creek, and has little potential for hosting riparian-wetland vegetation. Following the guidelines presented in the *PFC User Guide*, these statistics indicate that there was a sufficiently diverse composition of riparian-wetland vegetation within the Riparian Study Areas during both monitoring events to satisfy PFC Item 7.

6.2.3 PFC Standard Checklist Item 8

Item 8 of the *PFC User Guide* states: “Species present indicate maintenance of riparian-wetland soil moisture characteristics”. To respond “yes” to this item on the *PFC User Guide’s* Standard Checklist, plant species rated FACW or OBL must be present within the reach being assessed. While PFC Item 7 focused on the diversity of riparian-wetland species that were present within the Riparian Study Areas, PFC Item 8 focuses on whether the Riparian Study Areas were dominated by riparian-wetland plants.

During the pre-test pulse flow release monitoring in 2015, 26 of the 35 vegetation community polygons surveyed were dominated or co-dominated by plants rated FACW or OBL. These polygons accounted for 93.2 percent of the acreage of the Riparian Study Areas. With the exception of polygon 22L-2, polygons lacking FACW or OBL dominant or co-dominant species were primarily dominated by species rated FAC, which commonly occur in riparian and wetland conditions in the Sierra Nevada, including lodgepole pine (*Pinus contorta* ssp. *murrayana*), black cottonwood (*Populus trichocarpa*), Kentucky bluegrass (*Poa pratensis*), and double honeysuckle (*Lonicera conjugialis*) (Sawyer et. al. 2009). As stated in PFC Item 7, polygon 22L-2 does not occur in a landscape position where riparian-wetland vegetation would be expected to occur. This polygon was dominated by native upland trees and shrubs including incense cedar (*Calocedrus decurrens*), white fir (*Abies concolor*), huckleberry oak (*Quercus vaccinifolia*), and rose meadowsweet (*Spiraea splendens*).

During the post-test pulse flow release monitoring in 2016, 27 of the 35 vegetation community polygons surveyed were dominated or co-dominated by plants rated FACW or OBL. These polygons accounted for 93.6 percent of the acreage of the Riparian Study Areas. The species composition of polygons lacking FACW or OBL dominant or co-dominant species in 2016 was similar to that in 2015. During both monitoring events, a majority of the acreage and individual vegetation community polygons of the Riparian Study Areas were dominated by riparian-wetland species. This strongly indicates that riparian-wetland soil characteristics were maintained during both monitoring events.

6.2.4 PFC Standard Checklist Item 9

Item 9 of the *PFC User Guide* states: “Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events”. To respond “yes” to this item on the *PFC User Guide’s* Standard Checklist, riparian-wetland plant species must dominate the streambank plant communities. The Greenline Study Area component of the riparian vegetation monitoring most directly addresses this PFC item.

The two most dominant species along the greenline during the pre-test pulse flow release monitoring in 2015 were creek dogwood (*Cornus sericea*) and mountain alder (*Alnus incana*). Both of these species are rated FACW and are considered valuable for protecting and stabilizing stream banks due to their deep, extensive root systems (Sawyer et. al. 2009). In total, 97.4 percent of all sampling locations (steps) along the greenline were dominated by species rated FACW or OBL, which the *PFC User Guide* states are likely to have root masses capable of withstanding high-flow events. During the post-test pulse flow release monitoring in 2016, creek dogwood and mountain alder were again the most dominant species along the greenline. FACW and OBL species accounted for 97.1 percent of all sampling locations along the greenline in 2016. Figure 21 also shows that the vegetation communities mapped along the streambank within the Riparian Study Areas are almost exclusively *Cornus sericea* Shrubland Alliance and *Alnus incana* Shrubland Alliance. All of the vegetation community polygons located along the streambank were dominated by FACW and OBL species during both monitoring events. Following the guidelines presented in the *PFC User Guide*, these statistics indicate that the vegetation along the streambank within LL-G2 during both monitoring events had root masses capable of withstanding high streamflow events.

6.2.5 PFC Standard Checklist Item 10

Item 10 of the *PFC User Guide* states: “Riparian-wetland plants exhibit high vigor”. This item was not directly assessed during the 2015 and 2016 monitoring events. Furthermore, many riparian-wetland plant species were undergoing seasonal senescence during the pre-test pulse flow release monitoring in October 2015. Water stress cannot be reliably differentiated from normal senescence, so it may not be appropriate to make an assessment of plant vigor for the pre-test pulse flow release event. However, no riparian-wetland plant mortality or apparent water stress was observed during the post-test pulse flow release monitoring in 2016. Based on the condition of plants during the post-test pulse flow release monitoring, it can reasonably be assumed that there was no appreciable mortality of woody riparian-wetland plant species in 2015, since these would have likely still been apparent in 2016. Overall, there is no evidence that riparian-wetland plants within LL-G2 were unhealthy during either monitoring event; thus the response for this PFC item is “yes”.

6.2.6 PFC Standard Checklist Item 11

Item 11 of the *PFC User Guide* states: “Adequate riparian-wetland vegetative cover is present to protect banks and dissipate energy during high flows”. The preferred method of quantifying this metric presented in the *PFC User Guide* is a calculation of Greenline stability rating. A Greenline stability rating of seven or greater is considered adequate to respond “yes” to this item in the *PFC User Guide’s* Standard Checklist. The Greenline stability ratings were calculated following the methods presented in *Monitoring the Vegetation Resources in Riparian Areas* (Winward 2000). For species without a stability class listed in *Monitoring the Vegetation Resources in Riparian Areas,* stability classes were assigned based on the “Modified Winward” criteria presented in *Riparian Area Management: Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation* (USDI 2011). The results of the Greenline stability calculations are presented below in Table 22 and Table 23.

Table 22. Pre-test pulse flow release monitoring (2015) Greenline stability rating

Vegetation Type	Percent Composition	Stability Class	Stability Index
Alnus incana	23.95	8	1.92
Boulder	0.65	10	0.06
Carex vesicaria	1.94	2	0.04
Cobbles	0.97	10	0.10
Cornus sericea	64.40	7	4.51
Glyceria elata	1.94	8	0.16
Hosackia oblongifolia	0.65	5	0.03
Juncus xiphioides	4.53	8.5	0.39
Spiraea splendens	0.65	2	0.01
Woody debris	0.32	10	0.03
Total	**100**	**n/a**	**7.24**

Table 23. Post-test pulse flow release monitoring (2016) Greenline stability rating

Vegetation Type	Percent Composition	Stability Class	Stability Index
Alnus incana	24.27	8	1.94
Boulder	0.32	10	0.03
Carex vesicaria	2.59	2	0.05
Cobbles	0.97	10	0.10
Cornus sericea	66.02	7	4.62
Hosackia oblongifolia	0.32	5	0.02
Juncus xiphioides	3.88	8.5	0.33
Phleum alpinum	0.65	2	0.01
Spiraea splendens	0.65	2	0.01
Woody debris	0.32	10	0.03
Total	**100**	**n/a**	**7.15**

The 2015 and 2016 Greenline stability ratings were 7.24 and 7.15, respectively. As both of these ratings are greater than the threshold for streambank stability established in the *PFC User Guide*, “yes” is the appropriate response to PFC Item 11 for both monitoring events.

6.2.7 PFC Standard Checklist Item 12

Item 12 of the *PFC User Guide* states: “Plant communities are an adequate source of course and/or large woody material (for maintenance and recovery)”. To respond “yes” to this item on the *PFC User Guide’s* Standard Checklist, the stream reach being assessed must contain an adequate number of mature trees that are large enough to serve as hydrologic modifiers. This item was not directly assessed during the 2015 and 2016 monitoring events; however, LL-G2 contains a high number of large trees, primarily lodgepole pine, that would contribute to hydrologic modification should they fall into the stream.

6.2.8 Interpretation of PFC Standard Checklist Items 6 through 12

The evaluations of PFC Items 6 through 12 strongly indicate that riparian vegetation within LL-G2 has maintained proper functioning condition both before and after the test pulse flow releases. It is also important to note that a similar assessment of PFC was reported in the relicensing studies (DTA 2004, Table 5.1-1). DTA (2004) states current conditions for the Loon Lake Dam reach of Gerle Creek appeared to meet vegetative criteria for PFC. Thus, the tested pulse flow releases appear to allow for maintenance of PFC for riparian vegetation along the Loon Lake Dam reach of Gerle Creek.

6.2.9 Assessment of Change in Riparian Study Area Metrics

Section 5.2.2 discusses differences in the Riparian Study Area data between the two monitoring events. The following additional analyses were performed to quantify any changes that may have occurred in species composition, abundance, and diversity.

Table 21 summarizes the diversity of riparian-wetland species by vegetation community polygon for both monitoring events. On average, there was an increase of approximately 2.1 wetland species observed per vegetation community polygon in 2016 (standard deviation is approximately 3.3 species). Similarly, the total number of species observed per vegetation community polygon increased by approximately 1.7 species on average in 2016 (standard deviation is approximately 7.4 species). The data do not indicate any clear trends in plant diversity.

Change in species composition and abundance within a community can be described using a variety of dissimilarity indices. Table 24 below presents the results of two dissimilarity index calculations for the woody and herbaceous species components of each vegetation community polygon. These indices draw comparisons between the vegetation data collected during the pre-test pulse flow monitoring and the post-test pulse flow monitoring for each vegetation community polygon. Both dissimilarity indices range between zero and one, where zero indicates that the communities are identical and one indicates that the communities share no species. The Jaccard Index is based solely on the presence and absence of species, whereas the Morisita-Horn Index takes the abundance of each species into account. Species at high abundance weight the Morisita-Horn Index score more than species at low abundance. These indices were calculated based on methods presented in Numerical Ecology (Legendre and Legendre 1998). Analyses were performed in R 3.3.1 using the Vegan package (Oksanen et. al. 2016).

These results show that the woody species components of the vegetation community polygons are very similar between the two monitoring events. However, major differences in the herbaceous species component of the vegetation community polygons are apparent. This is likely due to the fact that the two monitoring events occurred in different seasons. It is also worth noting that the average Jaccard Index score is greater than the average Morisita-Horn Index score. This indicates that many of the changes in species composition occurred among species with low abundance values.

Table 24. **Vegetation Community Dissimilarity Indices**

Polygon	Woody Species		Herbaceous Species	
	Jaccard Dissimilarity	Morisita-Horn Dissimilarity	Jaccard Dissimilarity	Morisita-Horn Dissimilarity
7L-1	0.03	0.00	0.80	0.65
7R-1	0.25	0.14	0.83	0.52
7R-2	0.63	0.28	0.52	0.20
7R-3	0.02	0.00	0.75	0.50
9L-1	0.10	0.02	0.66	0.40
9R-1	0.00	0.00	0.83	0.67
12L-1	0.02	0.00	0.65	0.58
12L-2	0.04	0.00	0.94	0.97
12L-3	0.01	0.00	0.71	0.39
12R-1	0.04	0.00	0.83	0.62
12R-2	0.10	0.02	0.88	0.80
15L-1	0.15	0.04	0.71	0.36
15R-1	0.00	0.00	0.74	0.59
15R-2	0.06	0.00	0.65	0.17
15R-3	0.00	0.00	0.83	0.63
15R-4	0.02	0.00	0.65	0.22
17L-1	0.04	0.00	0.75	0.81
17R-1	0.00	0.00	0.57	0.21
17R-2	0.00	0.00	0.87	0.77
17R-3	0.00	0.00	0.90	0.81
19L-1	0.03	0.00	0.89	0.83
19L-2	0.38	0.13	0.44	0.12
19L-3	0.06	0.01	0.56	0.13
19R-1	0.02	0.00	0.57	0.32
19R-2	0.03	0.00	0.82	0.90
19R-3	0.27	0.08	0.84	0.72
19R-4	0.01	0.00	0.64	0.41
21L-1	0.19	0.07	0.55	0.15
21R-1	0.22	0.03	0.78	0.65
21R-2	0.02	0.00	0.54	0.16
22L-1	0.53	0.03	0.57	0.27
22L-2	0.19	0.04	0.66	0.38
22R-1	0.01	0.00	0.46	0.11
22R-2	0.13	0.02	0.79	0.79
22R-3	0.01	0.00	0.87	0.86
Average	**0.10**	**0.03**	**0.72**	**0.50**

Because the post-test pulse flow monitoring was conducted immediately after the test pulse flow as per the timeline in the *Pulse Flow Test Recommendations*, it is unlikely that any changes observed in the riparian vegetation data between the two monitoring studies are the result of the test pulse flow releases. This does not imply that pulse flows as conducted during the test would not, over time, have an influence on vegetation within LL-G2. Rather, because the vegetation communities within LL-G2 are adapted to and resilient to high-flow events, the effects of pulse flows on riparian vegetation within LL-G2 are unlikely to be detectable within the timescale of these studies.

7.0 CONCLUSIONS ON APPROPRIATE MAGNITUDE OF PULSE FLOWS IN GERLE CREEK BELOW LOON LAKE DAM

Following SMUD's providing the resource agencies a draft of these results to solicit comments and recommendations, a primary concern expressed by the SWRCB, USFS, and CDFW was that the magnitude of the maximum test pulse flow release of 375 cfs is insufficient to achieve the stated objectives. This concern does not appear to be based on agency interpretation of the results of the pulse flow studies, project specific information, or published, peer-reviewed scientific studies; rather, the concern appears based on generally applied assumptions that impacts often associated with some regulated watersheds are also impairing the channel morphology, aquatic habitat, and riparian vegetation through the Loon Lake Dam reach of Gerle Creek. However, during the numerous consultations over the years and through the course of the pulse flow studies, the resource agencies were unable to provide any quantitative values that could be used to deterministically evaluate the appropriate magnitude of the pulse flows.

Given this constraint, the flow magnitudes tested during the 5-day pulse flow release (Table 3 and Figure 6) represents the best balance between (1) maximizing resource objectives, and (2) minimizing unintended downstream flooding impacts to private landowners and roads. The previous sections of this *Report* document SMUD's completion of the pulse flow studies, which were developed over almost four years with input from resource agencies and private landowners, and ultimately approved by the resource agencies. The resource agencies, SMUD, and the private landowners agree no unintended flooding and erosion impacts are expected from the magnitude of the prescribed pulse flows for all water-year types except WET. The results provided in this *Report* suggest that Gerle Creek below Loon Lake Dam exhibits desired geomorphic and riparian vegetation conditions that demonstrate the channel and floodplain are properly functioning, and that the channel provides suitable, in some cases optimal, habitat for rainbow trout and brown trout. This position is reinforced by the uncertainties of (1) how and to what degree greater magnitude pulse flows in WET water-year types would further enhance resource objective in Gerle Creek below Loon Lake Dam, and (2) how such enhancements would outweigh private landowner's expressed and documented concerns to avoid greater flood-related impacts to their property.

8.0 LITERATURE CITED

Barry, J.J., J.M. Buffington, and J.G. King. 2004. *A general power equation for predicting bed load transport rates in gravel bed rivers.* Water Resources Research, Vol. 40: W10401. 22 p.

Bieger, K., H. Rathjens, P.M. Allen, and J.G. Arnold. 2015. *Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States.* Journal of the American Water Resources Association (JAWRA), Vol. 51(3): 842 – 858.

Bray, D.I. and M. Church. 1980. *Armored Versus Paved Gravel Beds.* American Society of Civil Engineers, Journal of Hydraulics Division, Vol. 106 (HY9): 1937 – 1940.

Burton, T.A., S.J. Smith, and E.R. Cowley. 2011. *Riparian area management: Multiple indicator monitoring (MIM) of stream channels and streamside vegetation. Technical Reference 1737-23. BLM/OC/ST-10/003+1737+REV*. U.S. Department of the Interior, Bureau of Land Management, Nation Operations Center, Denver, CO. 155 p.

Braun-Blanquet, J. 1932. <u>Plant Sociology: The Study of Plant Communities</u>. New York, U.S.

CDFG. 2007. *Rationale Report for Relicensing Settlement Agreement, Sacramento Municipal Utility District Upper American River Project FERC Project No. 2101, and Pacific Gas and Electric Company Chili Bar Project FERC Project No. 2155.* Prepared by California Department of Fish and Game. January 31, 2007. 310 p.

Castro, J.M., and P.L. Jackson. 2001. *Bankfull Discharge Recurrence Intervals and Regional Hydraulic Geometry Relationships: Patterns in the Pacific Northwest, USA.* Journal of the American Water Resources Association (JAWRA), Vol. 37(5): 1249 – 1262.

Dietrich, W.E., J.W. Kirchner, H. Ikeda, and F. Iseya. 1989. *Sediment supply and the development of the coarse surface layer in gravel-bedded rivers.* Nature, Vol. 340: 215 – 217.

DTA. 2004. *Riparian Vegetation And Wetlands Technical Report, Sacramento Municipal Utility District Upper American River Project FERC Project No. 2101, and Pacific Gas and Electric Company Chili Bar Project FERC Project No. 2155.* Prepared by Devine Tarbell & Associates, Inc. (DTA). October 2004, Version 2. 125 p.

DTA and Hannaford. 2005. *Hydrology Technical Report, Sacramento Municipal Utility District Upper American River Project FERC Project No. 2101, and Pacific Gas and Electric Company Chili Bar Project FERC Project No. 2155.* Prepared by Devine Tarbell & Associates, Inc. (DTA), and M. Hannaford. May 2005, Version 5. 274 p.

DTA and Stillwater Sciences. 2005. *Channel Morphology Technical Report, Sacramento Municipal Utility District Upper American River Project FERC Project No. 2101, and Pacific Gas and Electric Company Chili Bar Project FERC Project No. 2155.* Prepared by Devine Tarbell & Associates, Inc. (DTA), and Stillwater Sciences. April 2005, Version 2. 471 p.

El Dorado County. 2010. *Rubicon Trail 2010 Operations and Maintenance Plan Phase 1 Ground Operations*. The County of El Dorado, Department of Transportation. Placerville, California. 17 p.

El Dorado County. 2013. *Rubicon Trail Monitoring Protocol.* Prepared by the County of El Dorado, Community Development Agency, Transportation Division. July 2013. 5 p.

FERC. 2014. *Order Issuing New License.* Prepared by the U.S. Federal Energy Regulatory Commission (FERC). FERC Docket No. P-2101-084, Accession No. 20140723-3046. Filed July 23, 2014. 242 p.

FERC. 2015a. *Order Modifying and Approving Sensitive Site Investigation and Mitigation Monitoring Plan Pursuant to Article 401 (A).* Prepared by the U.S. Federal Energy Regulatory Commission (FERC). FERC Docket No. P-2101-105, Accession No. 20150618-3057. Filed June 18, 2015. 5 p.

FERC. 2015b. *Order Modifying and Approving Gerle Creek Fish Passage Plan Pursuant to Article 402.* Prepared by the U.S. Federal Energy Regulatory Commission (FERC). FERC Docket No. P-2101-114, Accession No. 20150805-3031. Filed August 8, 2015.

Fischenich, C. 2001. *Stability Thresholds for Stream Restoration Materials.* EMRRP Technical Notes Collection (ERCD TN-EMRRP-SR-29). U.S. Army Corps of Engineers, Engineer Research and Development Center, Environmental Laboratory. Vicskburg, Mississippi. 10 p.

Hinton, D.D. 2012. *Complexity of Bedload Transport in Gravel Bed Streams: Data Collection, Prediction, and Analysis.* A dissertation submitted to the faculty of Brigham Young University in partial fulfillment of the requirements for the degree of Doctor of Philosophy. Department of Civil and Environmental Engineering, Brigham Young University, December 2012. 100 p.

IACWD. 1982. *Guidelines for Determining Flood Flow Frequency, Bulletin #17B of the Hydrology Subcommittee.* Prepared by the Interagency Advisory Committee on Water Data (IACWD). U.S. Department of the Interior, Geological Survey, Office of Water Data Coordination, Reston, Virginia. Revised September 1981, editorial corrections March 1982. 194 p.

Lichvar, R.W., M. Butterwick, N.C. Melvin, and W.N. Kirchner. 2016. *The National Wetland Plant List: 2016 Wetland Ratings*. Phytoneuron 2016-30: 1-17. Retrieved from U.S. Army Corps of Engineers, Engineer Research and Development Center. Available Online: http://wetland_plants.usace.army.mil/.

Parker, G. 1990. *The ACRONYM Series of Pascal Programs for Computing Bedload Transport in Gravel Rivers.* University of Minnesota, St. Anthony Falls Hydraulic Laboratory, External Memorandum M-200. Minneapolis, Minnesota. 24 p.

Raleigh, R.F., T. Hickman, R.C. Solomon, and P.C. Nelson. 1984. *Habitat Suitability Information: Rainbow Trout.* U.S. Department of the Interior, Fish and Wildlife Service, Biological Report 82(10.60). January 1984. 76 p.

Raleigh, R.F., L.D. Zuckerman, and P.C. Nelson. 1986. *Habitat Suitability Index Models and Instream Flow Suitability Curves: Brown Trout.* U.S. Department of the Interior, Fish and Wildlife Service, Biological Report 82(10.124). Revised September 1986. 79 p.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colorado.

Sawyer, J.O., T. Keeler-Wolf, and J.M. Evens. 2009. A Manual of California Vegetation, Second Edition*.* California Native Plant Society Press. Sacramento, California.

SMUD. 2015a. *Gerle Creek Sensitive Site Investigation and Mitigation Monitoring Plan, Upper American River Project, FERC Project No. 2101.* Prepared by the Sacramento Municipal Utility District (SMUD), Hydro License Implementation. May 2015. 51 p.

SMUD. 2015b. *Gerle Creek Fish Passage Plan, Upper American River Project, FERC Project No. 2101.* Prepared by the Sacramento Municipal Utility District (SMUD), Hydro License Implementation. July 2015. 18 p.

SMUD. 2016a. *Pulse Flow Test Recommendations, Upper American River Project, FERC Project No. 2101.* Prepared by the Sacramento Municipal Utility District (SMUD), Hydro License Implementation. May 2016. 12 p.

SMUD. 2016b. *Gerle Creek SSIMMP Hydraulic Model Overview, Upper American River Project, FERC Project No. 2101.* Prepared by the Sacramento Municipal Utility District (SMUD), Hydro License Implementation. February 2016. 9 p.

USDI. 1998. *Riparian Area Management. A User Guide to Assessing Proper Functioning Condition and the Supporting Science for Lotic Areas. Technical Reference 1737-15*. Prepared by the U.S. Department of the Interior (USDI), Bureau of Land Management.

USDI. 2011. *Riparian Area Management: Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation*. Technical Reference 1737-23. BLM/OC/ST-10/003+1737+REV. U.S. Department of the Interior (USDI), Bureau of Land Management, National Operations Center. Denver, CO. 155 p.

Winward, A. H. 2000. *Monitoring the Vegetation Resources in Riparian Areas*. General Technical Report RMRS-GTR-47. United States Department of Agriculture, Forest Service, Rocky Mountain Research Station. Ogden, UT. 49 p.

Wolman, M.G. 1954. *A Method of Sampling Coarse River-Bed Material.* Transactions of the American Geophysical Union, Vol. 35(6): 951 – 956.

Attachment 1. SWRCB Section 401 Water Quality Certification, Condition 2.B, Pulse Flows in Gerle Creek below Loon Lake Reservoir Dam

The Licensee shall provide pulse flows timed to coincide with spring snowmelt runoff as specified in the five-day schedule outlined in Table 15 or as modified by the USFS with concurrence from the Deputy Director.

Table 15. Gerle Creek below Loon Lake Reservoir Dam Pulse Flows (cfs)

	BN	**AN**	**WET**
Day 1	125	200	600
Day 2	125	200	600
Day 3	180	250	740*
Day 4	125	200	600
Day 5	125	200	600

*Or maximum capacity of outlet works, whichever is less.

Within two years of license issuance and prior to implementing the pulse flows in Gerle Creek below Loon Lake Reservoir Dam, the Licensee shall complete the following items to develop the information necessary to determine the appropriate magnitude of pulse flows:

1. A sensitive site investigation to address the potential for stream bank erosion resulting from pulse flows, which includes additional permanent cross-sections to characterize the upper and middle geomorphology study sites LL-G1 and LL-G2[3]. Areas of unstable banks and downed logs obstructing streamflow shall be mapped. A professional riparian ecologist shall participate in the investigation.
2. Test pulse releases shall be made from the outlet works at different levels up to the prescribed 740 cfs or the maximum capacity of the outlet works, whichever is less, to determine the appropriate pulse flows for the desired channel conditions. The desired outcomes from the pulse flows are to redefine the stream channel, sort the spawning gravel and transport the bedload and fine material downstream.
3. Analysis of the effects and potential impacts of the pulse flows on downstream features including bridges, campgrounds, and day-use areas.

Once items 1 through 3 are complete, USFS, with the concurrence of the Deputy Director, may adjust the prescribed pulse flows if the results indicate adjustment is necessary to reach the objectives of restoring the stream channel to a proper functioning condition. The final pulse flows shall not exceed those described in the pulse flow schedule (Table 15). The pulse flows shall be measured at USGS gage 11429500, located approximately 0.3 miles downstream from Loon Lake Reservoir Dam.

---

[3] Study site designations and locations rea described in the *Channel Morphology Technical Report* (January 2005) prepared during the relicensing proceeding.

Attachment 2. USFS section 4(e), Condition 28, Pulse Flows in Gerle Creek Below Loon Lake Reservoir Dam

The licensee shall provide pulse flows timed to coincide with spring snowmelt runoff as specified in the following schedule based on month and water year type. The pulse flows shall be measured at USGS gage 11429500, located approximately 0.3 mile downstream from Loon Lake Reservoir Dam.

Gerle Creek Below Loon Lake Reservoir Dam Pulse Flows			
	BN	**AN**	**WET**
Day 1	125	200	600
Day 2	125	200	600
Day 3	180	250	740*
Day 4	125	200	600
Day 5	125	200	600

*Or maximum capacity of outlet works, whichever is less.

Prior to implementing the pulse flows in Gerle Creek below Loon Lake Reservoir Dam and within 2 years of license issuance, the licensee shall complete the following:

- A sensitive site investigation that includes additional permanent cross-sections that characterize the upper and middle Rosgen Level 3 analysis reaches. Areas of unstable banks and downed logs that are obstructing streamflow shall be mapped. A professional riparian ecologists shall participate in the investigation.
- Test pulse releases shall be made from the outlet works at different levels up to the prescribed 740 cfs or the maximum capacity of the outlet works, whichever is less, to determine the appropriate pulse flows for the desired channel conditions.
- Analysis of the effects of the pulse flows on downstream features including bridges, campgrounds, and day-use areas for potential impacts from the pulse flows.

Once the items are completed, [US]FS may adjust the prescribed pulse flows, if necessary, based on the results of the investigation and objectives of restoring the stream channel to a proper functioning condition. The final pulse flows shall not exceed those described in the pulse flow schedule.

Attachment 3. *Pulse Flow Test Recommendations* (SMUD 2016a)

Pulse Flow Test Recommendations

Sacramento Municipal Utility District

Hydro License Implementation • May 2016

Upper American River Project

FERC Project No. 2101

Powering forward. Together.

SMUD®

Table of Contents

Table of Tables and Figures

Introduction

On June 18, 2015, FERC issued an order modifying and approving the *Gerle Creek Sensitive Site Investigation and Mitigation Monitoring Plan (SSIMMP* or *plan)* (SMUD 2015). SMUD filed this *plan* with FERC pursuant to Article 401(a) of the Upper American River Project (UARP or Project) license (FERC 2014). The *plan* was also required by the Project's Water Quality Certification (WQC), Conditions 2.B and 8.G, and the U.S. Forest Service (USFS) 4(e) Conditions 28 and 31.[1] The pulse flow test recommendations presented herein address one of the components of the *plan*. Specifically, the *plan* requires SMUD to:

1) discuss with the resource agencies any potential flooding or erosion impacts that might be caused by the pulse flow tests, and
2) agree with the resource agencies on the magnitude of the initial test pulse release and potential subsequent releases.

During consultation with the resource agencies to develop the *plan*, the USFS made clear that flooding impacts to private property would be the only basis they would consider for reducing the magnitude of the pulse flow releases prescribed in the WQC and USFS 4(e) conditions; thus, potential flooding impacts were the primary consideration in evaluating the pulse flow test recommendations.

These pulse flow test recommendations are based on (1) observations of potential flooding made during the pre-test pulse release geomorphic monitoring carried out in the summer and fall of 2015, (2) on the application of a numerical hydraulic model used to evaluate potential flooding at sensitive sites, (3) consultation between SMUD and the resource agencies. Further details of both components are provided in the next sections of these recommendations.

Observations of Flooding Potential During pre-Test Pulse Release Monitoring

During the summer and fall of 2015, SMUD carried out geomorphic monitoring at the identified sensitive sites along the Loon Lake Dam reach of Gerle Creek. Since it has been nearly 20 years since a peak flow measured at the USGS gage below Loon Lake Reservoir Dam (USGS Gage No. 11429500) has exceeded 200 cfs (the minimum pulse flow prescribed in WQC Condition 2.B and USFS Section 4(e) Condition 28 for Below Normal[2] water year types), baseline conditions were established to characterize the effects of regulated hydrology on the geomorphology and riparian vegetation. Potential for flooding impacts at sensitive sites were noted, and are summarized here, progressing from upstream sites to downstream sites (Figure 1).

---

[1] The WQC and USFS 4(e) conditions were incorporated into the UARP license via Appendices A and B, respectively.

[2] Water year types are based on the water year forecast of unimpaired runoff in the American River below Folsom Lake published near the beginning of each month from February through May in the California Depart of Water Resources Bulletin 120 *Report of Water Conditions in California*. Further details on water year types are provided in WQC Condition 1 and USFS 4(e) Condition 27.

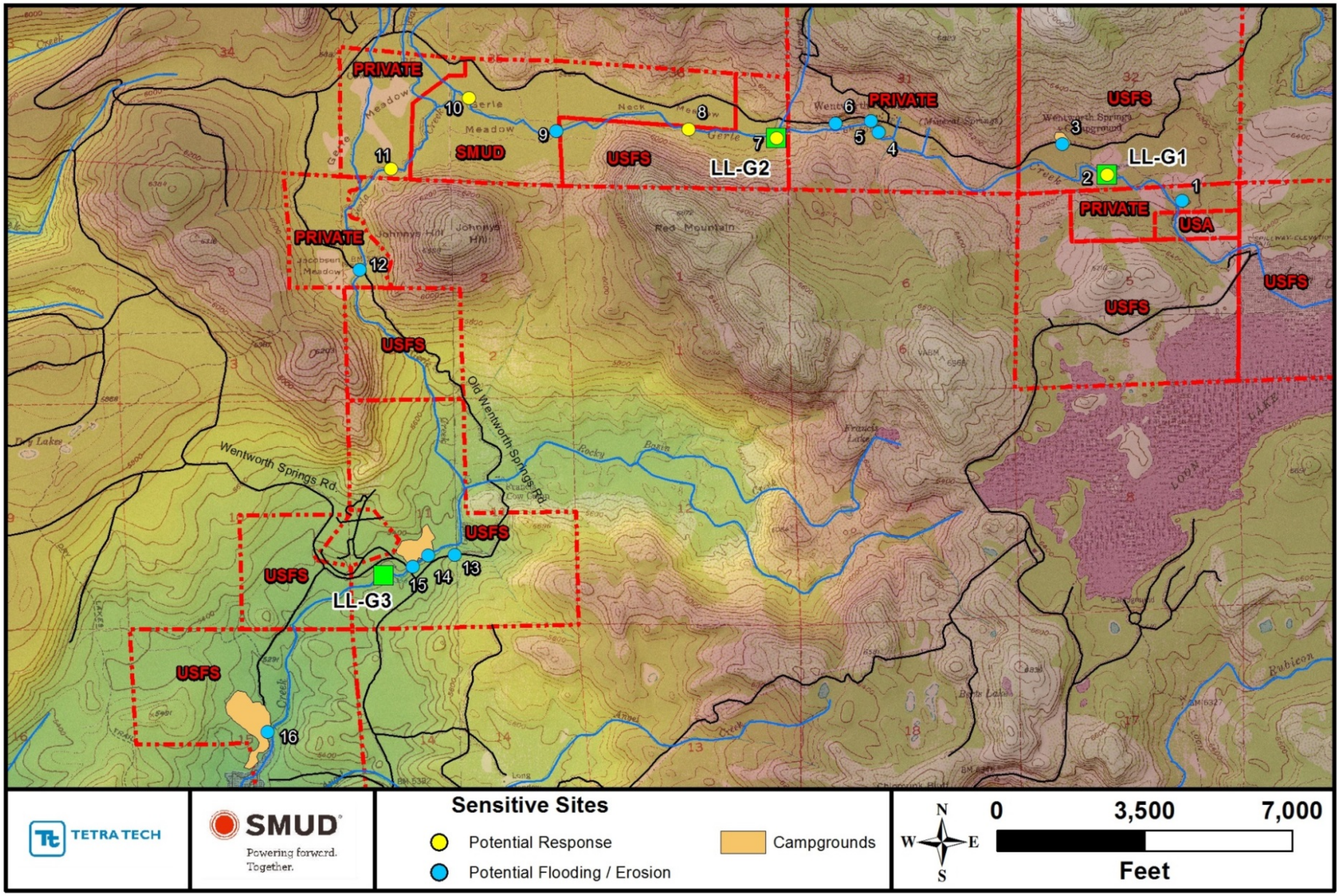


Figure 1. Sensitives Sites along the Loon Lake Dam Reach of Gerle Creek.

Family Camp on Private Property

The most upstream sensitive site (Site No. 1) is a family camp on private property. The riverward edge of the camp is located at the top of the right bank of Gerle Creek. The difference in elevation between the low-flow water-surface elevation and the top of bank was noted as approximately 4 feet. Because of the topographic confinement of the creek and the potential for backwater effects from downstream channel constrictions during high flows, this sensitive site was noted as at risk for flooding during pulse flows.

Wentworth Springs Campground

During development of the *SSIMMP* USFS staff expressed concern about potential flooding of the Wentworth Spring Campground (Sensitive Site No. 3). Campground facilities at risk of flooding include a vault toilet structure, a shed and hazardous waste disposal locker, picnic tables, and fire rings. Additionally, Old Wentworth Springs Road, which provides access to the campground, is low enough that it is sometimes inundated. A few camp sites with picnic tables and fire rings were observed to be within approximately 2 feet of the low-flow water-surface elevation. Gerle Creek is not topographically confined adjacent to the campground, so multiple flow paths through a swampy area have the potential to mitigate water-surface increases during pulse flows. However, a beaver dam was observed in this area, so potential for flood risk was noted.

Wentworth Springs

As Gerle Creek flows through Wentworth Springs, it passes by cabins on private property (Sensitive Site No. 4). In addition to the cabins, there is a group camp area with an outdoor stove and a picnic table. The cabin closest to the creek was approximately 3 feet above the low-flow water-surface elevation. The group camp appeared to be within about 1 foot of the low-flow water-surface elevation. This site was noted as the most susceptible to flooding during pulse releases.

Wentworth Springs Road

Downstream of Wentworth Springs, Gerle Creek is constricted as it flows along Old Wentworth Springs Road (Sensitive Sites Nos. 5 and 6). The lowest areas of the road were observed to be approximately 3 feet greater than the low-flow water-surface elevation, indicating the potential for pulse releases to inundate the road and affect access.

SMUD Bridge

Sensitive Site No. 9 is a bridge on SMUD's property that provides access to the land on the south side of the creek. The low chord of the bridge deck was estimated to be about 2 feet above the low-flow water-surface elevation, and the channel was approximately

30 feet wide. Pulse flows have the potential to inundate this bridge, and potentially wash out the bridge, both of which would limit access to the private property.

El Dorado County Bridge for Old Wentworth Springs Road over Gerle Creek

The recently constructed bridge (Site No. 12) was designed to provide a minimum of 3 feet of freeboard at the 2-percent annual chance exceedance (ACE) flow, and a minimum of 2 feet of freeboard at the 1-percent ACE flow (Ghimire 2010). The peak flows used in the design were 2,918 cfs for the 2-percent ACE flow and 4,003 cfs for the 1-percent ACE flow. Given the bridge design and observations of approximately 12 feet between the low chord of the bridge and the low-flow water-surface elevation, no flood impacts from the pulse releases are expected at this site.

Dispersed Camping Area near Airport Flat Campground

Site No. 13 is a dispersed camping area along the left bank of Gerle Creek. Unlike the Wentworth Springs Campground, no campground infrastructure was observed at this site. The riverward extent of this area was approximately 1 to 2 feet above the low-flow water-surface elevation, so pulse releases could limit the use of this site for camping.

Airport Flat Campground

The Airport Flat Campground (Site No. 14) includes two vault toilet structures, camping pads, picnic tables, grills, and fire rings. These facilities were observed to be more than approximately 10 feet above the low-flow water-surface elevation. The magnitude of this separation indicates no flood impacts from the pulse releases are expected at this site.

USFS Bridge for Wentworth Springs Road over Gerle Creek

The low chord of the USFS Bridge (Site No. 15) was estimated to be approximately 20 feet above the low-flow water-surface elevation. The bridge was designed in the late 1950s, so the USFS was unable to locate documentation of the hydraulic design. Staining on the concrete piers indicated typical high-water elevations are about 5 feet above the low-flow water-surface elevation. This site is immediately downstream from the Airport Flat Campground, so like it, no flood impacts from the pulse releases are expected at this bridge.

Simulated Water-surface Elevations at Sensitive Sites

On February 5, 2016, SMUD distributed by email to representatives of the consultation group an overview of the development, testing, and calibration of the numerical hydraulic model, as well as resulting uncertainty analyses and simulated water-surface profiles (SMUD 2016). A meeting between SMUD and these representatives was held on February 22, 2016. The objective of the meeting was to provide a small-group setting for consultation group representatives with hydraulic modeling experience to understand the model development, testing procedures, limitations, and applications such that all concerns could be addressed to provide confidence in the model. This confidence was important because the pulse flow test recommendations are based in part on the model results.

The HEC-RAS model was used to simulate water-surface profiles for shoulders (Days 1, 2, 4, and 5) and peaks (Day 3) of the 5-day pulse flow release hydrographs specified in the FERC license (WQC Condition 2.B and USFS 4(e) Condition 28). The profiles were used directly to assess potential for flooding at the sensitive sites. During the summer and fall baseline geomorphic monitoring, and consistent with methods presented in the *SSIMMP*, target elevations at each site were surveyed to establish threshold elevations for assessing flooding. Simulated water-surface elevations were compared to these threshold elevations. Table 1 summarizes this comparison and the corresponding potential impacts of flooding.

Private Landowner Input

As noted earlier in the observations of flooding potential and shown in Table 1, the private property near Wentworth Springs (Site 4) is most susceptible to flooding impacts during the pulse flow tests. SMUD shared the flooding potential with the landowners to ensure that the landowners understood the potential extent of flooding during the pulse flows (including the tests). The landowners expressed concern about the realistic possibility for fallen timber and debris to be mobilized during the pulse flow tests and for it to be transported to and accumulate on their property or in the vicinity, and perhaps to alter the extent of potential inundation. They stated that it is absolutely necessary to develop an agreement to clean-up debris left on their property as a result of the pulse flows (including the tests). Without such an agreement, the landowners strongly object to any and all pulse flow releases. SMUD has agreed to only clean up debris left on private property as a result of these test pulse flows.

Pulse Flow Test Recommendations

The following pulse flow test recommendations are based on joint considerations of (1) the key observations during the baseline geomorphic monitoring, (2) the potential flooding impacts simulated with the numerical hydraulic model, (3) the input from private landowners, and (4) consultation with the resource agencies, primarily during meetings on April 28, 2016 and May 12, 2016.

Timing of Pulse Flow Tests

Given the aggressive 2-year schedule available for completing the pulse flow testing, the recommended timing of the initial determination of the maximum acceptable release is the end of May 2016. Late-June is envisioned for the pulse flow tests.

Table 1. Potential Flooding of Sensitive Sites.

Site	Threshold Elev. (ft.)[1]	RAS XS	Simulated Water-Surface Elevation (ft.) [1, 2]									
			5 cfs	125 cfs	180 cfs	200 cfs	250 cfs	300 cfs	400 cfs	500 cfs	600 cfs	630 cfs
1	6,152.3	46158	6,148.7	6,150.1	6,150.4	6,150.5	6,150.8	6,151.1	6,151.6	6,152.0	6,152.4	6,152.5
3	6,131.8	42445	6,129.5	6,129.8	6,129.9	6,129.9	6,130.0	6,130.0	6,130.2	6,130.3	6,130.5	6,130.5
4[3]	6,019.4	37574	6,019.0	6,019.7	6,019.8	6,019.8	6,020.0	6,020.1	6,020.1	6,020.2	6,020.4	6,020.4
4[3]	6,011.6	36580	6,008.4	6,009.7	6,010.0	6,010.0	6,010.2	6,010.4	6,010.6	6,010.8	6,011.0	6,011.0
5	6,007.8	36257	6,004.0	6,005.7	6,006.1	6,006.2	6,006.5	6,006.7	6,007.2	6,007.5	6,007.9	6,008.0
6	5,996.5	35304	5,993.2	5,994.7	5,995.0	5,995.1	5,995.2	5,995.4	5,995.7	5,995.9	5,996.1	5,996.2
9	5,849.5	26241	5,848.0	5,848.8	5,849.1	5,849.3	5,849.5	5,849.7	5,850.1	5,850.4	5,850.7	5,850.8
12	5,837.6	17798	5,826.1	5,826.5	5,826.7	5,826.7	5,826.8	5,827.0	5,827.2	5,827.4	5,827.6	5,827.7
13	5,376.0	9308	5,375.3	5,375.5	5,375.6	5,375.6	5,375.7	5,375.8	5,375.9	5,376.1	5,376.3	5,376.3
14	5,373.0	8678	5,363.9	5,363.9	5,364.2	5,364.3	5,364.5	5,364.7	5,365.0	5,365.3	5,365.6	5,365.6
15	5,375.0	8018	5,356.0	5,356.3	5,356.4	5,356.5	5,356.6	5,356.7	5,357.0	5,357.2	5,357.4	5,357.4

Notes:

1 Elevations referenced to the National Geodetic Vertical Datum of 1929 (NGVD29)

2 Simulation resulting from best estimate of Manning's n-values, for the specified releases from the outlet works at Loon Lake Dam, including peak accretion flows with an ACE of 0.1 for Jarrett Creek, Barts and Dellar Creeks, and Rocky Basin Creek

3 The first site is the group camp area; the second site is the most riverward cabin

4 Red shading indicates expected inundation of the site; yellow shading indicates simulated water-surface elevations within 0.3-feet of the threshold elevation

Magnitude of Pulse Flow Tests

The magnitude of the pulse flow tests will be limited to the maximum release that does not cause unacceptable flooding impacts at the susceptible sites. The maximum release will be determined on-site collectively by SMUD, the affected landowners, and the resource agencies during the initial release scheduled for the week of May 31st (May 31 – June 3).

Pulse Flow Test Methods

While the hydraulic model is a valuable tool for assessing potential flood impacts, the simulated flood-flow water-surface profiles could not be calibrated (SMUD 2016), and further the profiles are subject to changing conditions along Gerle Creek that are not represented in the model. For example, beavers could build new dams or modify existing ones. Large woody debris could be mobilized and transported to break up existing jams or form new ones. To avoid unforeseen flooding impacts to the extent possible, SMUD recommends the following methods as a conservative approach for the pulse flow tests:

1. At the sensitive sites along Gerle Creek expected to be most susceptible to flooding impacts, deploy personnel to observe changing water-surface elevations during the tests. The personnel will be equipped with radios to communicate between each other and SMUD staff. Personnel will also have camera and survey rods to document water levels relative to threshold elevations.
2. The initial testing to determine the acceptable maximum release will start at 100 cfs. The travel time of flood pulses from the Wentworth Springs Campground to the Airport Flat Campground is expected to be between approximately 2.5 and 4 hours. Based on these relatively rapid travel times, the field personnel will be able to communicate safe passage of a pulse test. After SMUD, the affected private landowners, and the resource agencies collectively agree based on on-site observations and discussion that flooding impacts at susceptible sites are acceptable, the pulse will be ramped up to a greater flow (approximately 100-cfs increments, or as agreed upon on site during testing). This process will continue until the flooding impacts are collectively agreed to no longer be acceptable, at which point the initial test will stop, flows will be ramped back down to the required minimum instream flow, and the peak flow for the subsequent 5-day test will be limited to the maximum release agreed upon during the initial release.
3. Once the maximum release has been established, the magnitude will be compared to the 5-day schedules specified in WQC Condition 2.B and USFS 4(e) Condition 28. The following method will be used to implement a 5-day test with the greatest possible flows. The maximum release will first be compared to the shoulder flow of 125 cfs specified for Days 1, 2, 4, and 5 in the schedule for a Below Normal water year type.

   a. If the maximum release is less than 125 cfs, then it will be held for the duration of the 5-day schedule.
   b. If the maximum release is greater than 125 cfs, but less than the Below Normal water year type Day 3 peak of 180 cfs, then only the Day 3 flow will be limited to the maximum release with Days 1, 2, 4, and 5 held at 125 cfs.
   c. If the maximum release exceeds 180 cfs but is less than 200 cfs (the shoulder flow for the Above Normal water year type), then the maximum release will be held for 5 days.
   d. If the maximum release is between 200 and 250 cfs (the peak of the Above Normal water year type), then only the Day 3 flow will be limited to the maximum release with Days 1, 2, 4, and 5 held at 200 cfs.
   e. If the maximum release exceeds 250 cfs but is less than 600 cfs (the shoulder flow for the Wet water year type), then the maximum release will be held for 5 days.
   f. If the maximum release is between 600 and 740 cfs (or the maximum capacity of the outlet works, whichever is less; the peak of the Wet water year type), then only the Day 3 flow will be limited to the maximum release with Days 1, 2, 4, and 5 held at 600 cfs.

4. Immediately following the 5-day pulse flow test, SMUD will walk Sensitive Site No. 4 with the landowners to determine whether any debris that was transported onto the property during the test requires clean-up.
5. SMUD will commence the post-test pulse release geomorphic and riparian vegetation monitoring as soon after the 5-day test as the monitoring can be safely carried out and useful information collected. This monitoring will provide critical information for assessing whether the pulse flows achieve desired objectives.

Literature Cited

FERC. 2014. *Order Issuing New License, Sacramento Municipal Utility District Project No. 2101-084.* Issued July 23, 2014 by the U.S. Federal Energy Regulatory Commission (FERC). 242 p.

FERC. 2015. *Order Modifying and Approving Sensitive Site Investigation and Mitigation Monitoring Plan Pursuant to Article 401(a), Sacramento Municipal Utility District Project No. 2101-105.* Issued June 18, 2015 by the U.S. Federal Energy Regulatory Commission (FERC). 5 p.

Ghimire, C. 2010. *Gerle Creek Crossing Bridge Drainage Design Report, 77118.* County of El Dorado Department of Transportation Interoffice Memorandum. Dated November 23, 2010. 47 p.

SMUD. 2015. *Gerle Creek Sensitive Site Investigation and Mitigation Monitoring Plan, Upper American River Project, FERC Project No. 2101.* Sacramento Municipal Utility District (SMUD), Hydro License Implementation. Sacramento, California. 48 p.

SMUD. 2016. *Gerle Creek SSIMMP Hydraulic Model Overview, Upper American River Project, FERC Project No. 2101.* Sacramento Municipal Utility District (SMUD), Hydro License Implementation. Sacramento, California. 9 p.

Darold Perry

Subject: FW: SMUD - Gerle Creek SSIMMP Recommendations Regarding Loon Lake Test Pulse Flows REVISED

From: Lawson, Beth@Wildlife [mailto:Beth.Lawson@wildlife.ca.gov]
Sent: Friday, May 20, 2016 9:58 AM
To: Darold Perry; Thornburgh, Richard M -FS; Katy Parr (kparr@fs.fed.us); Gangl, Kristen@Waterboards; Milloy, Anna@Wildlife; Kim Morales; Hatton, Laurie@Wildlife
Cc: Tyler Belarde; Lauren A. Evans; Jon Bertolino
Subject: RE: SMUD - Gerle Creek SSIMMP Recommendations Regarding Loon Lake Test Pulse Flows REVISED

Darold,

A couple notes:

1. I understand and agree that in *this first round*, as written in this revision, we should see how the pulse flows water levels affect the private properties. After we know what those flows look like, I plan to brief my management about the effectiveness, public safety and property impacts observed during the initial pulse flows.

2. As a reminder, I suggest that we have a conference call after the first test flows and before the full 5-day pulse flow tests.

3. After the initial testing, we may make recommendations regarding the need to move minor infrastructure or discuss a woody-debris cleanup plan. If minor infrastructure is later moved or otherwise secured in some way, higher pulse flows ***could be*** tested before confirming what the final approved pulse flows will be in the license.

At this time though, I agree with going forward with the initial testing as described in this document.

Elizabeth Lawson, P.E.

Associate Hydraulic Engineer
California Department of Fish and Wildlife
1701 Nimbus Road, Suite A
Rancho Cordova, CA 95670
Phone: (916) 358-2875

From: Thornburgh, Richard M -FS [mailto:rthornburgh@fs.fed.us]
Sent: Friday, May 20, 2016 6:28 AM
To: Darold Perry
Cc: Parr, Katy -FS; Milloy, Anna@Wildlife; Lawson, Beth@Wildlife; Morales, Kimberly A -FS; Tyler Belarde; Lauren A. Evans; Jon Bertolino; Kristen@Waterboards Gangl
Subject: Re: SMUD - Gerle Creek SSIMMP Recommendations Regarding Loon Lake Test Pulse Flows REVISED

Darold - The revised plan is acceptable to the the Forest Service. We appreciate the dialogue last week and the effort to address concerns that were voiced.

Richard Thornburgh

Sent from my iPad

On May 19, 2016, at 6:02 PM, Gangl, Kristen@Waterboards <Kristen.Gangl@Waterboards.ca.gov> wrote:

> Hi Darold,
>
> The revised plan looks fine to me. I look forward to hearing how the tests go.
>
> Kristen Gangl
> 916-323-9389
>
> ---
>
> **From:** Darold Perry [mailto:Darold.Perry@smud.org]
> **Sent:** Monday, May 16, 2016 3:51 PM
> **To:** Thornburgh, Richard M -FS; Katy Parr (kparr@fs.fed.us); Gangl, Kristen@Waterboards; Milloy, Anna@Wildlife; Lawson, Beth@Wildlife; Kim Morales
> **Cc:** Tyler Belarde; Lauren A. Evans; Jon Bertolino
> **Subject:** SMUD - Gerle Creek SSIMMP Recommendations Regarding Loon Lake Test Pulse Flows REVISED
>
> Good Afternoon Folks,
>
> Please see attached for the revised subject document. This revision is intended to capture the discussions and agreements made during the phone conference of May 12th on the subject matter. We are asking for your concurrence that this is what was discussed so that SMUD and the various stakeholders can schedule the initial releases to determine the maximum flow. If we are to attempt these releases the week of the 31st, realistically we will need know by this Friday if your Agency agrees with the recommendations. Please let me know if you have any questions, and also reply to all when responding.
>
> Thank you.
>
> -Darold
>
> ---
>
> **From:** Darold Perry
> **Sent:** Friday, April 22, 2016 8:39 AM
> **To:** 'Alison Willy (Alison_Willy@fws.gov)'; 'Amy Kirsch (ALKB@pge.com)'; 'Anna Milloy (Anna.Milloy@wildlife.ca.gov)'; 'Bill Center (bclotus@innercite.com)'; 'Bill Deitchman (bill.deitchman@parks.ca.gov)'; 'Charis Parker (cparker@fs.fed.us)'; 'Chris Shutes (blancapaloma@msn.com)'; 'Craig Schmollinger (craig.schmollinger@edcgov.us)'; 'Dave Steindorf (dave@americanwhitewater.org)'; 'Elizabeth Lee (Elizabeth.Lee@waterboards.ca.gov)'; 'Ezra Becker (Ezra.Becker@pge.com)'; 'Hilde Schweitzer (hilde@amriver.us)'; 'Jim Eicher (jeicher@blm.gov)'; 'Jim Micheaels (jim.micheaels@parks.ca.gov)'; 'Katy Parr (kparr@fs.fed.us)'; 'Gangl, Kristen@Waterboards'; 'Nate Rangel (nate@raftcalifornia.com)'; 'Noah Triplett (noah.triplett@edcgov.us)'; 'R. Winston "Pete" Bell (pete@mokeriver.com)'; 'Rich Platt (rangeland47@comcast.net)'; 'Ron Stork (rstork@friendsoftheriver.org)'; 'Steven Bowes (Stephen_Bowes@nps.gov)'; 'Susan Monheit

(smonheit@waterboards.ca.gov)'; 'Theresa Simsiman (theresa@americanwhitewater.org)'; 'Vickie Sanders (vickie.sanders@edcgov.us)'; 'Thornburgh, Richard M -FS'; 'Stone, Hannah E -FS'
Cc: Amanda Beck; Chris Moffitt; David Hanson; Ethan Koenigs; Jon Bertolino; Mark Swisher; Sarah Madams; 'Marie Rainwater (marie@rainwater-associates.com)'; Tyler Belarde; Lauren A. Evans
Subject: SMUD - Gerle Creek SSIMMP Recommendations Regarding Loon Lake Test Pulse Flows

Good Morning Folks,

As described in the Gerle Creek SSIMMP, SMUD is required to provide recommendations regarding test pulse flows below Loon Lake reservoir to Resource Agencies, so that the test flow magnitude and release design can be agreed upon. These recommendations were developed based on the output of the numerical hydraulic model developed for the purpose, while considering the input from the private landowners along Gerle Creek who may be affected by these flows. These recommendations will be presented and discussed at the April 28th, 2016 License Implementation meeting, but in the meantime they are being provided so the Resource Agencies (and the private landowners) can have a chance to review beforehand. Please distribute to pertinent members of your staff so they can come prepared to ask questions, etc. Please let me know if you have any questions.

Thank you.

-Darold

Darold Perry
Supervisor
Hydro License Implementation
Sacramento Municipal Utility District
PO Box 1500 Pollock Pines, CA 95726-1500
w.530.647.5010 | m. 530.503.5646 | Darold.Perry@smud.org

SMUD
Powering forward.
Together.

Attachment 4. *Gerle Creek SSIMMP Hydraulic Model Overview* (SMUD 2016b)

Gerle Creek SSIMMP Hydraulic Model Overview

Hydro License Implementation • February 2016

Upper American River Project

FERC Project No. 2101

Powering forward. Together.

SMUD®

Table of Contents

Table of Tables, Attachments, and Figures

Introduction

This overview was prepared to (1) initiate an understanding of the hydraulic model SMUD developed to evaluate potential flooding impacts along Gerle Creek caused by pulse flows released from Loon Lake Dam, and (2) facilitate an upcoming discussion between SMUD and the resource agencies concerning the details of the model development and application of the model to simulate water-surface profiles for various pulse flows. SMUD prepared the hydraulic model as a component of implementing the *Gerle Creek Sensitive Site Investigation and Mitigation Monitoring Plan*, which was approved by FERC in an order issued June 18, 2015.

SMUD contracted Tetra Tech, Inc. to develop and apply the hydraulic model. Tetra Tech selected the U.S. Army Corps of Engineers' HEC-RAS software for the modeling. The HEC-RAS software is the industry standard for one-dimensional hydraulic analyses. Two components of the software were used: the steady-flow water-surface profile computations, and the unsteady-flow simulation.

The basic procedure in HEC-RAS for computing steady-flow, gradually-varied water-surface profiles is the solution of the one-dimensional energy equation using an iterative procedure called the standard-step method. Energy losses are evaluated by friction (i.e., Manning's equation) and contraction/expansion (i.e., coefficient multiplied by the change in velocity head). The computations of water-surface profiles can account for the effects of bridges, weirs, and other structures.

The hydraulic calculations for cross sections, bridges, and other hydraulic structures that HEC developed for the steady-flow component were incorporated into the unsteady-flow module. The unsteady-flow simulation solves partial-differential equations representing the physical laws that govern the flow of water in a channel, namely (1) the principle of conservation of mass (i.e., the continuity equation), and (2) the principle of conservation of momentum (I.e., the momentum equation).

Hydraulic Model Development

Geometric data, energy loss parameters, and boundary conditions are required inputs for the computation of water-surface profiles.

Geometric Inputs

1. Topographic inputs derived from two primary sources:
    a. May 2013 LiDAR mapping, 6.6 points/square-meter (bare earth), tested to meet 8.5-centimeter (0.28 ft.) $RMSE_z$
    b. Summer 2015 surveys of channel areas inundated during LiDAR mapping. Vertical control tied into SMUD's benchmarks (NGVD29, feet). Horizontal control tied to static GPS/GNSS observations. Surveys carried out using survey-grade Leica GPS/GNSS base station and rovers, and Topcon total stations.

2. Bank stations were set to the geomorphic top of bank. Where flow was divided across more than one channel, the right bank station was set at the right bank of the right-most channel and the left bank station was set at the left bank of the left-most channel.
3. Channel and overbank flow path alignments were digitized by eye using a GIS running ESRI ArcMap software to display the LiDAR mapping and aerial photography.
4. Cross section alignments were digitized using the LiDAR topography and the flow path alignments. The cross sections were doglegged where necessary to maintain a perpendicular orientation to the flow. The alignments were loaded into the GPS/GNSS equipment prior to the summer 2015 surveys to guide the surveyors.
5. Channel geometry was merged into the LiDAR mapping to produce cross section geometry that accurately represents the channel and floodplain. At some sections where channel geometry was not surveyed, bathymetric geometry was estimated by lowering the bed elevations by an amount similar to nearby surveyed channels.
6. Ineffective flow areas were used to store flow in areas where the downstream velocity component is expected to be near-zero or zero. Flow is not conveyed downstream in these areas unless they are not made permanent.
7. Blocked obstructions were used to prevent flow from accessing low areas, and to prevent storage in these areas.
8. Geometric inputs for the bridge on SMUD property (low- and high-chords of the bridge deck) were surveyed during summer 2015.
9. Beaver dams were simulated as inline structures consisting of broad crested weirs with weir coefficients of 2.6.

Energy Loss Parameters

1. Manning's n-values were based on (1) field observations, (2) *Table 5-6. Values of the Roughness Coefficient n* in Open Channel Hydraulics (Chow 1959), and (3) an empirical equation (Jarrett 1984) developed for mountainous streams (such as Gerle Creek). In general, channel normal channel values ranged from 0.03 to 0.08 as calculated using Jarrett (1984) over a range of flows. The lower bound was set to 0.03 and the upper bound was set to 0.08. Normal floodplain n-values were set to 0.10.
2. Expansion and contraction coefficients were based on recommended values in the *HEC-RAS Hydraulic Reference Manual* (Brunner 2010). For gradual transitions in section geometry, expansion and contraction coefficients were set to 0.3 and 0.1, respectively.

Boundary Conditions

1. Downstream boundary – normal depth slope of 0.018 feet per foot based on bed slope at the downstream end of the model
2. Upstream boundaries
    a. Steady-flow –

    i. Peak flows released from Loon Lake Dam (per Condition 2.B in Appendix A to the FERC License and Condition No. 28 in Appendix B to the FERC License), and
    ii. Peak accretion flows from Jerrett Creek, Barts and Dellar Creeks, and Rocky Basin Creek (based on flood frequency analyses using HEC-SSP to implement Bulletin 17B guidelines (IACWD 1982) on maximum average-daily accretion flows for March 1 through May 31 (defined here as the spring snowmelt runoff period) of 1974 through 2001 provided in the *Hydrology Technical Report* (DTA and Hannaford 2005) prepared during the relicensing studies).
  b. Unsteady-flow –
    i. Flow hydrograph from Loon Lake Dam (per Condition 2.B in Appendix A to the FERC License and Condition No. 28 in Appendix B to the FERC License), and
    ii. Lateral inflow hydrographs from Jerrett Creek, Barts and Dellar Creeks, and Rocky Basin Creek (shaped using freshet hydrographs from data in the *Hydrology Technical Report*).

Hydraulic Model Testing

1. Formal calibration and validation were not possible because the drought conditions during 2014 and 2015 did not allow for measurements of flows and corresponding water-surface elevations during flood events.
2. Low-flow water-surface elevations surveyed during the summer of 2015 were used to check locally that simulated water-surface elevations were reasonable.
3. Initial testing required resolution of all errors to ensure simulations would run to completion.
4. Cross sections were interpolated to reduce the effect of critical flow conditions in steep parts of the reach.
5. Compared simulated stage hydrographs to measured stage hydrographs, focusing on proper simulation of flow translation. Lacking flow measurements accompanying the measured stage hydrographs, attenuation effects could not be meaningfully assessed.
    a. SMUD deployed six pressure transducers along the Gerle Creek from mid-November 2014 through the end of May 2015.
    b. The pressure transducers measured stage and captured a Pineapple Express event between February 6, 2015 and February 11, 2015. No flows were measured along the channel or in tributaries.
    c. Three stage peaks were recorded, showing translation times of about 4.5 to 3.25 to 2.5 hours (from the earliest to latest peak, respectively) between the Wentworth Springs Campground (WWSCG) and the new bridge for Old Wentworth Springs Road (OWWSBR).

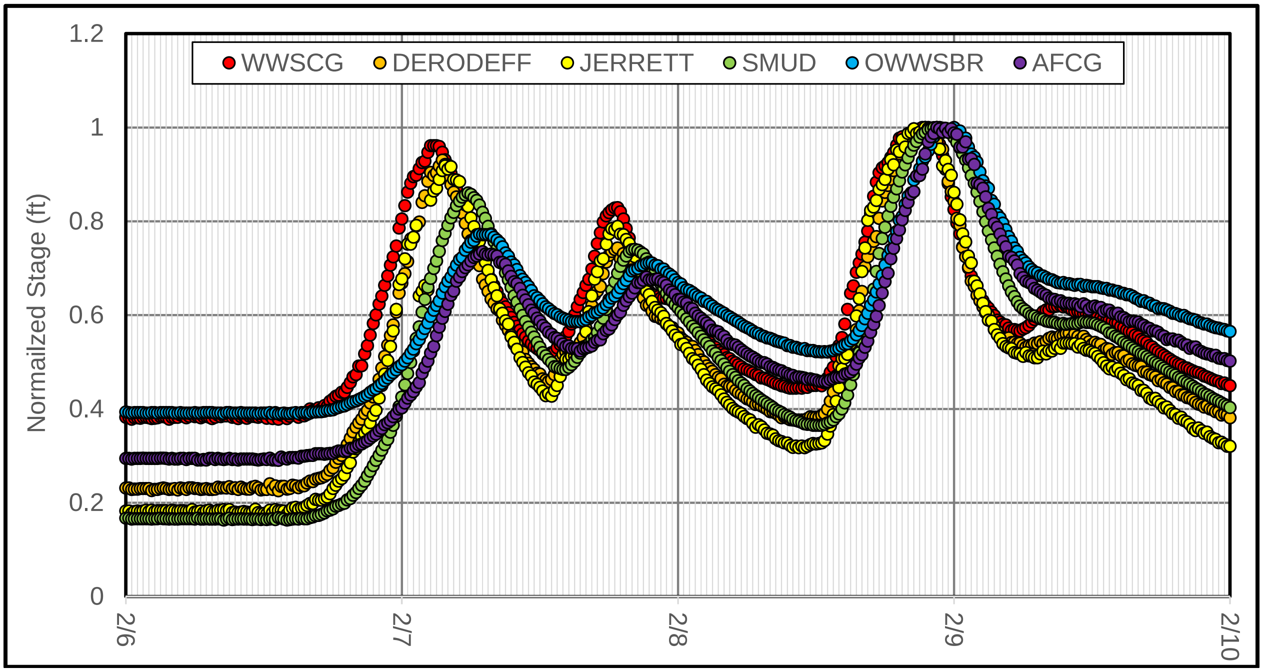


Figure 1. **Normalized Measured Stage Hydrographs, February 2015.**

d. For a simulated flow hydrograph with peak flows of 400 cfs (peak 1), 300 cfs (peak 2), and 450 cfs (peak 3), the simulated translation times are each about 3 hours. Assuming the flow hydrograph is a reasonable approximation of actual flows during the Pineapple Express event, these translation times confirm the unsteady-flow simulation is reasonably representing the translation of flood flows in Gerle Creek. Further confirmation is apparent when comparing not just the peak stages, but the full stage hydrographs.

e. The n-values do not have appreciable influence on the translation; however, the ineffective flow areas do. As an extreme case, the ineffective flow areas were set to extend landward from both bank stations at each section. Under this setup, the simulated translation times increase to about 12 hours, indicating the floodplains do actively convey flow. At the other extreme, without floodplain ineffective areas, the translation times are marginally less than 3 hours.

f. The translation timing is valuable in demonstrating how quickly steady-flow conditions can be reached along Gerle Creek. The pulse flow hydrographs in the License have a duration of 5 days, with all but the middle day at the same flow. Thus, it is reasonable to expect that steady-flow conditions will be reached in less than approximately 4 hours during the pulse flow tests.

Uncertainty Analyses

Lacking datasets for a formal calibration and validation of the model, uncertainty analyses were initiated and may be further used to quantify the sensitivity of simulated water-surface elevations to uncertain inputs. The focus of the uncertainty analyses was on three inputs (1) Manning's n-values, (2) ineffective flow areas, and (3) accretion flow estimates.

1. Manning's n-values affect calculated water-surface elevations because greater energy losses (higher n-values) require more energy to overcome, so water-surface elevations increase to provide more potential energy.
    a. The uncertainty in Manning's n-values focused on energy losses in the channel. If the n-values are biased high (model uses too great an n-value), water-surface elevations would also be biased high, but velocities could be biased low; if the n-values are biased low the opposite responses are possible.
    b. Floodplain n-values were not analyzed because even for a release of 630 cfs with the 10-year peak accretion flows, over all cross sections in the model, an average of 94 percent of the total flow is conveyed in the channel (90 percent of the sections conveyed at least 65 percent of the flow in the channel). This means that most of the flow is conveyed in the channel, so adjusting floodplain n-values is not expected to produce appreciable changes in water-surface elevations.
2. Ineffective flow areas influence water-surface elevations by decreasing the active flow area. The geometry of the ineffective flow areas has been reviewed to evaluate how much the water-surface elevations change. Locally, water-surface elevations can be very sensitive to changes in ineffective flow areas. Further sensitivity analyses focusing on the ineffective flow areas may be warranted.
3. The accretion flows influence water-surface elevations because greater flows require greater conveyance. The seasonal pulse flows (although, not the pulse flow tests) will be timed to coincide with spring snowmelt runoff, so the accretion flows from snowmelt runoff can affect flooding. Flood frequency analyses provide the input for varying the accretion flows to assess changes in water-surface elevations. These sensitivity analyses have not yet been completed.

Simulations

1. Unsteady-flow
    a. BN (below normal), AN (above normal), and WET hydrographs provided in the License, no accretion flows
    b. BN, AN, and WET hydrographs provided in the License, with 10-year accretion flows
2. Steady-flow
    a. BN days 1, 2, 4, 5 flow of 125 cfs
    b. BN day 3 flow of 180 cfs
    c. AN days 1, 2, 4, 5 flow of 200 cfs

   d. AN day 3 flow of 250 cfs
   e. WET days 1, 2, 4, 5 flow of 600 cfs
   f. WET day 3 flow of 630 cfs, which is the maximum capacity of the outlet works with a full pool at Loon Lake Reservoir
   g. BN, AN, and WET day 3 flows with lower bound n-values
   h. BN, AN, and WET day 3 flows with upper bound n-values
   i. WET day 3 flow of 630 cfs with 10-year accretion flows
3. The model can be used for numerous additional simulations to evaluate potential flood risk.

Flood Inundation Mapping

The RAS Mapper utility in HEC-RAS was used to generate water-surface extents by intersecting the simulated water-surface profiles and the LiDAR mapping. RAS Mapper facilitates exporting the resulting extents as shapefile for analysis in a GIS. The inundation mapping figures display the inundation extents without any smoothing/editing of the shapefiles.

Literature Cited

Brunner, G.W. 2010. *HEC-RAS River Analysis System Hydraulic Reference Manual, Version 4.1.* U.S. Army Corps of Engineers, Hydrologic Engineering Center. Davis, California.

Chow, V.T. 1959. Open Channel Hydraulics. McGraw-Hill Book Company. New York.

DTA and Hannaford. 2005. *Hydrology Technical Report, May 2005, Version 3.* Prepared by Devine Tarbell & Associates (DTA) and M. Hannaford. Prepared for Sacramento Municipal Utility District and Pacific Gas and Electric Company. Sacramento, California.

IACWD. 1982. *Guidelines for Determining Flood Flow Frequency, Bulletin #17B of the Hydrology Subcommittee.* Prepared by the U.S. Department of the Interior, Geological Survey, Office of Water Data Coordination, Interagency Advisory Committee on Water Data (IACWD). Reston, Virginia.

Jarrett, R.D. 1984. *Hydraulics of High Gradient Streams.* ASCE Journal of Hydraulic Engineering, Vol. 110(11). p. 1519 – 1539.

SMUD. 2015. *Gerle Creek Sensitive Site Investigation and Mitigation Monitoring Plan.* Prepared by the Sacramento Municipal Utility District (SMUD) in May 2015. Sacramento, California.

Attachment 5. *Private Landowner Correspondence Regarding Test Pulse Flow Releases*

Forest Service/Property Owner review of
SMUD's Gerle Creek Pulse Flow Study Report
09/14/2016

Attending:

Forest Service: Richard Thornburgh, Pacific District Ranger and Charis Parker, Pacific District Resource Officer

Property Owners: Nancy DeRodeff, Heidi Green, Tim Green, Steve DeRodeff (phone), Emily Ladner (phone)

Notes:

Richard explained the intent of the meeting was to review the FERC license condition regarding pulse flows on the Gerle Creek reach and to discuss the results of the Gerle Creek Pulse Flow tests with the private property owners along the affected reach.

He reviewed that, under the FERC license issued to SMUD for the Upper American River Project (UARP), pulse flows are required for Gerle Creek between Loon Lake Dam and Gerle Reservoir. The current requirement is for a 5-day pulse flow with a maximum one-day peak flow of 740 cfs, but since the outlet works of the dam can only accommodate 630 cfs, the maximum pulse flow is 630 cfs. It was recognized that there were features, such as private property, roads, bridges, and other facilities, that may be impacted by the pulse flows prescribed. A plan for test flows and monitoring was developed and the tests were implemented in June 2016. It was noted that all that is in question now is the pulse flow in wet years, since pulse flows in average or below normal years will be below what has already been tested.

The 2-day test pulse had a brief peak of about 500 cfs but was reduced quickly based on concerns voiced by property owners. A second 5-day test pulse was conducted with one day peak of about 380 cfs.

Goals of pulse flows include redefining the stream channel, sorting spawning gravel, moving bedload and fines downstream, and moving large woody debris. Pulse flows are meant to improve the health of the stream, including the health of vegetation and fish habitat.

Property owners said they could see the benefit of the higher minimum flows and generally agree with goal of flushing flows on the creek to clear sediment and algae build up. Witnessed improved water clarity with new minimum flows at first.

Property owners voiced the following concerns and questions about higher pulse flows:

- At 375 cfs, started to see damage on property, such as dead timber falling, inundation of road, and debris movement.
- Concerned about higher flows with the beaver dams now present. At the higher flow of 500 cfs, watched beaver dam area. What if higher flow caused beaver dam to break free? Would ponded water now held behind beaver dam result in more flooding of private property than predicted downstream? What about all the dead trees created by ponding water from beaver activity?

- Appears that the beaver dam is preventing or reducing the intended benefit of pulse flows downstream of the beaver dam since water ponds behind before flowing over or around.
- Seems like there is inconsistency in concern for sediment movement. For the Rubicon Trail, a lot of work was done to prevent sediment from being transported from the trail to Gerle Creek. Appears to contradict agencies being OK with pulse flow inundating Rubicon Trail (the County road next to the creek) and possible movement of sediment into creek from the trail during pulse.
- Concerned about water inundating Wentworth Springs Campground and washing oil residue downstream. Also concerned about old vault toilet location and human waste washed downstream. Forest Service did clarify that old vault toilets were cleaned/sanitized as part of decommissioning them.
- Some property owners said they think that the maximum pulse flow should be around 300-380 cfs. Agencies have not clearly explained that a higher rate would have added resource benefit to warrant potential risks to private property of higher flow rate.
- Concerned that no one has said who would be ultimately responsible for damage to private property if it occurs during pulse flows. Would like to know who is responsible, in writing.
- Ponding behind beaver dam increased during pulse flow test. As water receded, sediment was left in pools that had previously been clear.
- Generally see the benefit of increased flow in the creek but not as clear about the benefit of overtopping the banks and inundating surrounding lands.

Richard shared that the resource agencies would like to see a higher peak flow than 380 cfs to see the desired results since the test results show some change toward meeting objectives but it would be preferable to see better results. Is a one day peak flow at 500 cfs something that the property owners could live with?

- Property owners asked why the higher flow? What is the additional benefit and is there any demonstrated information that a flow at that level would achieve a different result? Feel that beaver activity would still prevent better results downstream as long as the beaver dam remains. It was noted that agencies have been taking a cautious approach in testing and it's impossible to know the extent of further benefits at higher flows without actually trying flows at that level.
- Property owners asked if there is any discussion or plan to remove the beavers and dead trees from flooded area, or whether there are plans to introduce more beavers to the area. Forest Service clarified there are no plans for either at this time.
- Some owners expressed concern that they think a 500 cfs peak flow would result in damage to private property and fear what might happen to property downstream if the beaver dam breaks loose.
- Some owners suggested that if a higher pulse is released while still snow on ground, that may alleviate some concerns. Richard noted that SMUD had expressed safety concerns about sending out staff/contractors during this period for further testing. However, final pulse flows are scheduled to occur with typical spring snow melt period.

Richard asked if there was anything they would be willing to do voluntarily, or that the Forest Service/SMUD or other agencies could assist with, on their properties to have them feel more comfortable with flows higher than what has been tested.

- Property owners said they weren’t prepared to answer that question and would like time to think about it. They will get back to Richard.

Richard thanked the property owners for their time and noted that the Forest Service very much values their opinions and observations from the testing phase of these pulse flows.

RE: SMUD Hydro License Implementation September 2016
Upper American River Project
FERC Project No. 2101

September 18, 16

Dear Mr. Perry and Mr. Thornburgh,

Mr. Thornburgh firstly let me say thank you for taking the time to meet with us to outline the desire for increased flows.

After much consideration we feel given the lack of any scientific evidence showing increased positive results from increased flows, we cannot accept any flows above the 380cfs mark that we already agreed to.

As we are all aware, the time, resources and finances have been spent to run the "Test Flows" which in essence were conducted to check for potential damage to private property along with beneficial results to the creek. As found in the SUMD report from the "Test Flows" (Dated July 2016), Damage did occur to private property along with county roads etc etc starting at 375cfs.

In regard to benefits for the creek. It was observed during the tests, on the ground that the creek had a renewed clarity. This is a positive outcome for all and in fact, One of the desired outcomes of the pulse flows. With that said, due to the constrictions down stream from site 1 (Beaver Dams) the water has since returned to its previous state and the only real outcome from the flows was and is, further dispersion of large woody debris in the area. We strongly contend that without any remediation work to this area the pulse flows will have little to no affect on creek health. Additionally, without any remediation work in this area it is impossible to know what the outcome of further increased pulse flows would be. The potential for further damage to property is highly likely.

We were informed at the most recent meeting with the USFS (Richard Thornburgh) that he can put in a recommendation to the Water Board for lower flow levels but was clear he or the agency (USFS) wanted higher than 380cfs levels. The question of liability for damage to our property has been asked several times to which we have yet to receive an answer. If our desired wish of 380cfs (Based on factual tests and damage seen) is exceeded against our request who is liable for the damages? We feel this is a fair question and needs to be answered.

This has been a long arduous project to this point and we have no desire to extended the burden to the Tax Payer any further and wish for a swift resolution to this project but with out answers to the question of liability or remediation work to the constrictions down stream we see no other choice than to stick with our original request of flows no higher than 380cfs.

To summarize: It should be noted that we feel SMUD has completed the outlined testing efficiently and thoroughly and gave unbiased scientific results. We appreciate all agencies efforts in this highly complicated and sensitive project and look forward to answers to our questions and plans to move forward to completion.

We thank you again for your efforts and concern.

Sincerely, Heidi Green T. Green

Tim and Heidi Green.
Home: [redacted]
Cell: [redacted]
[redacted]

Richard Thornburgh 19 September, 2016
District Ranger
Forest Service
Eldorado National Forest, Pacific Ranger District
7887 Highway 50
Pollock Pines, CA 95726

Richard,

As the owners of Wentworth Springs we would first like to thank you for your efforts to include us in providing feedback regarding the planning and testing for pulse flows in the Gerle Creek drainage.

Having seen firsthand the effects of the test pulse flows on our and surrounding property we have some concerns and requests regarding future planned flows. First, we do believe that at moderate pulse flow levels there is a benefit to the creek environment. However, we strongly feel that pulse flows above the 380cfs level not only damage property, they also carry more sediment into the creek bed due to the spreading out of the water beyond the creek banks thus significantly reducing the value of the flows in achieving the desired objectives.

At pulse flows above 380cfs and briefly at 500cfs our family camp was flooded and our trails near the creek were flooded. New rivulets were formed in the family camp and continued to flow until the pulse flow test was completed. Moving our current camp location, as suggested, is not a desirable solution as it is unique, historic, and situated close to water.

As well, pulse flows above 380cfs caused flooding in the road which could potentially cause the county to close the road due to high water conditions, impeding the efforts of the county and volunteers to continue to comply with the guidelines set forth by the Central Valley RWQCB during the cleanup and abatement act.

So our strong recommendation is to limit pulse flows to 380cfs or less. With no evidence of benefit from the pulse flows in the two test examination sites, we do not agree that a higher flow is warranted.

With regard to testing the 500cfs pulse flow level; we don’t believe that it would have any beneficial effect and would just spread out over the surrounding property, causing damage and also bringing more sediment back into the creek as we previously noted. Testing during the summer hasn’t and won't provide a reasonable chance of understanding what the effects would be if carried out when they would normally be applied, as we understand it, in heavy rain years with a lot of snow. Nevertheless we still believe we should limit the pulse flows to 380cfs or less.

We also feel that there are several other issues that should definitely be addressed in any operational plan for the Gerle Creek drainage.

First is the critical problem of establishing a mitigation plan for any damage caused by the pulse flows, especially if our recommendations to limit to 380cfs are not followed. Before agreeing to any more pulse flows we would need a formal agreement that identifies who is responsible for damages if they occur now or in the future when the swamp of trees falls down and moves downstream.

Secondly, we think that there needs to be a plan to address the beaver dam situation and lack of flow through the swamp which used to be a meadow.

Finally we feel that the scores of dead trees caused by the beaver dams and consequent flooding need to be removed as they present a significant fire danger.

Thank you for your support,

Owners, Wentworth Springs (sec 31 T14N, R15E Eldorado County)

Nancy DeRodeff, Stephan DeRodeff, Emily Ladner, Susan Rose, Rebecca Rose, Nora Rose

Appendix A. Survey Control

Left and right are based on a downstream-facing perspective
All units are feet
Northing and easting coordinates reference NAD83, State Plane, California Zone II (FIPS Zone 0402)

Control for cross sections (XS) at LL-G2

XS ID	Left Pin			Right Pin		
	Northing	Easting	Elevation	Northing	Easting	Elevation
7	2,134,420.05	7,029,967.22	5,871.58	2,134,933.25	7,029,975.94	5,873.47
9	2,134,553.65	7,030,056.94	5,873.32	2,134,791.53	7,030,053.46	5,873.44
12	2,134,606.41	7,030,193.50	5,874.69	2,134,716.47	7,030,168.16	5,874.59
15	2,134,547.16	7,030,279.31	5,875.81	2,134,828.79	7,030,281.01	5,877.24
17	2,134,531.05	7,030,353.59	5,877.42	2,134,848.24	7,030,346.37	5,878.71
19	2,134,651.76	7,030,465.06	5,878.18	2,134,736.06	7,030,471.12	5,878.76
21	2,134,657.48	7,030,546.61	5,879.50	2,134,778.42	7,030,539.37	5,880.77
22	2,134,663.90	7,030,638.72	5,884.51	2,134,802.39	7,030,633.27	5,882.78

Re-surveyed pins for cross sections (XS) established in 2003

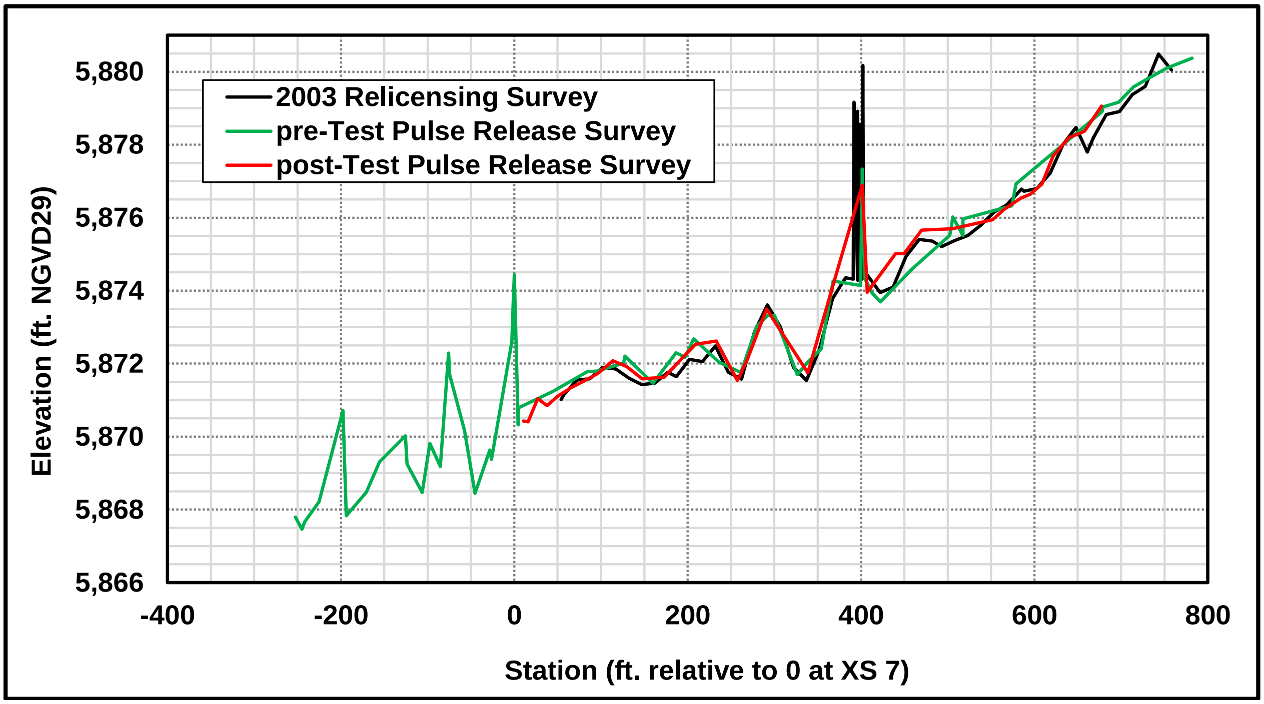
XS ID	Left Pin			Right Pin		
	Northing	Easting	Elevation	Northing	Easting	Elevation
12	Recovered pin, but it was damaged			Not recovered		
21	2,134,649.55	7,030,554.13	5,880.26	Not recovered		
22	Recovered pin, but it was damaged			Not recovered		

Re-surveyed benchmarks (BM) for longitudinal profile established in 2003

BM ID	Northing	Easting	Elevation
1	2,134,645.75	7,030,551.10	5,881.10
2	Recovered pin, but it was damaged		
3	2,134,674.88	7,030,328.57	5,876.99
4	Not recovered		

Appendix B. Longitudinal Bed and Bank Profile Data

Station and elevation values are in units of feet, elevations are referenced to the National Geodetic Vertical Datum of 1929. Station 0+00 references the LWD jam crest at cross section 7 (Table 4).



2015 pre-Test Pulse Survey		
Station	Elevation	Notes
-252.4	5867.79	
-244.9	5867.46	
-241.7	5867.67	
-225.1	5868.21	
-197.5	5870.71	
-193.8	5867.83	
-170.6	5868.47	
-155.4	5869.31	
-125.6	5870.03	
-123.7	5869.25	
-106.3	5868.47	
-97.3	5869.81	
-85.5	5869.18	
-75.9	5872.29	
-74.6	5871.70	
-57.3	5870.16	
-45.5	5868.44	

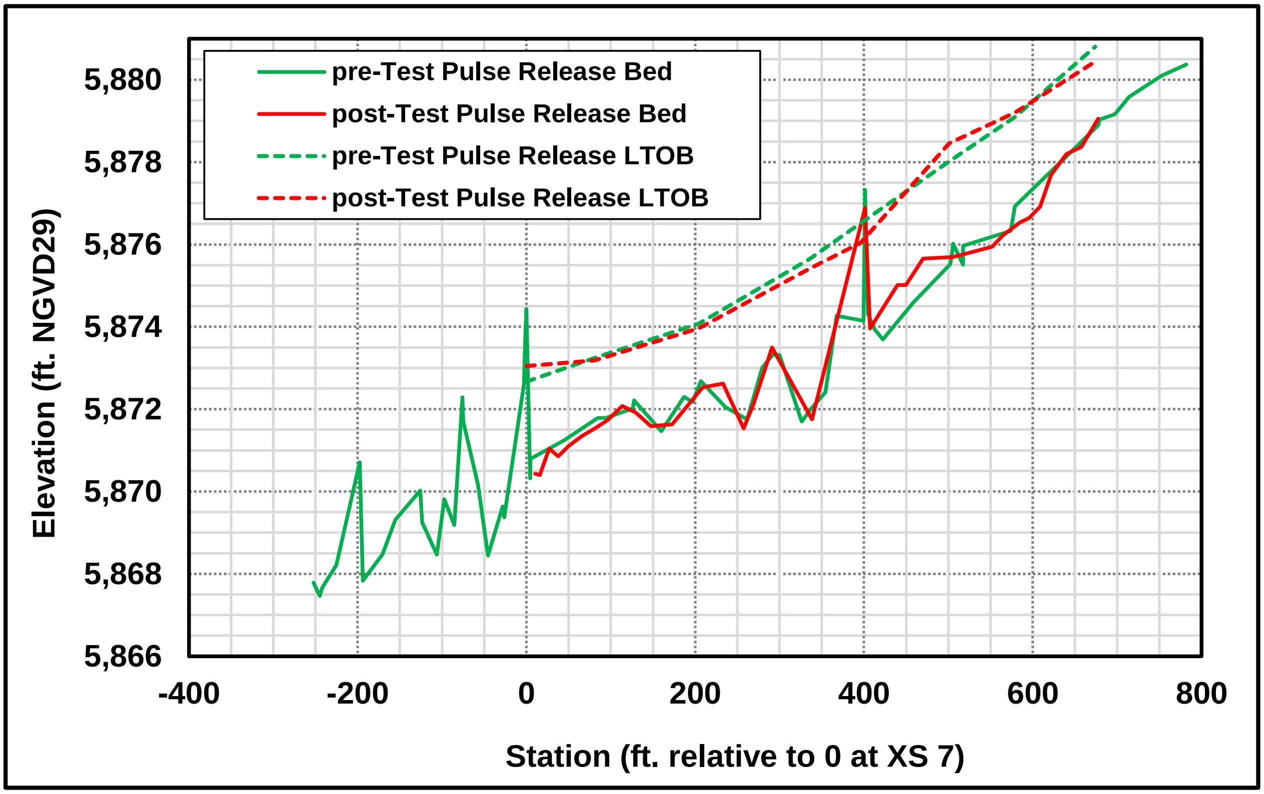
2016 post-Test Pulse Survey		
Station	Elevation	Notes
10.5	5870.43	~XS 7
16.0	5870.40	
26.9	5871.05	
37.8	5870.85	
49.9	5871.10	
65.1	5871.34	
81.6	5871.54	XS 9
96.6	5871.73	
113.5	5872.08	
129.4	5871.92	
147.5	5871.59	
172.9	5871.63	
209.0	5872.53	~XS 12
233.0	5872.62	
257.4	5871.54	
269.1	5872.13	
291.0	5873.50	

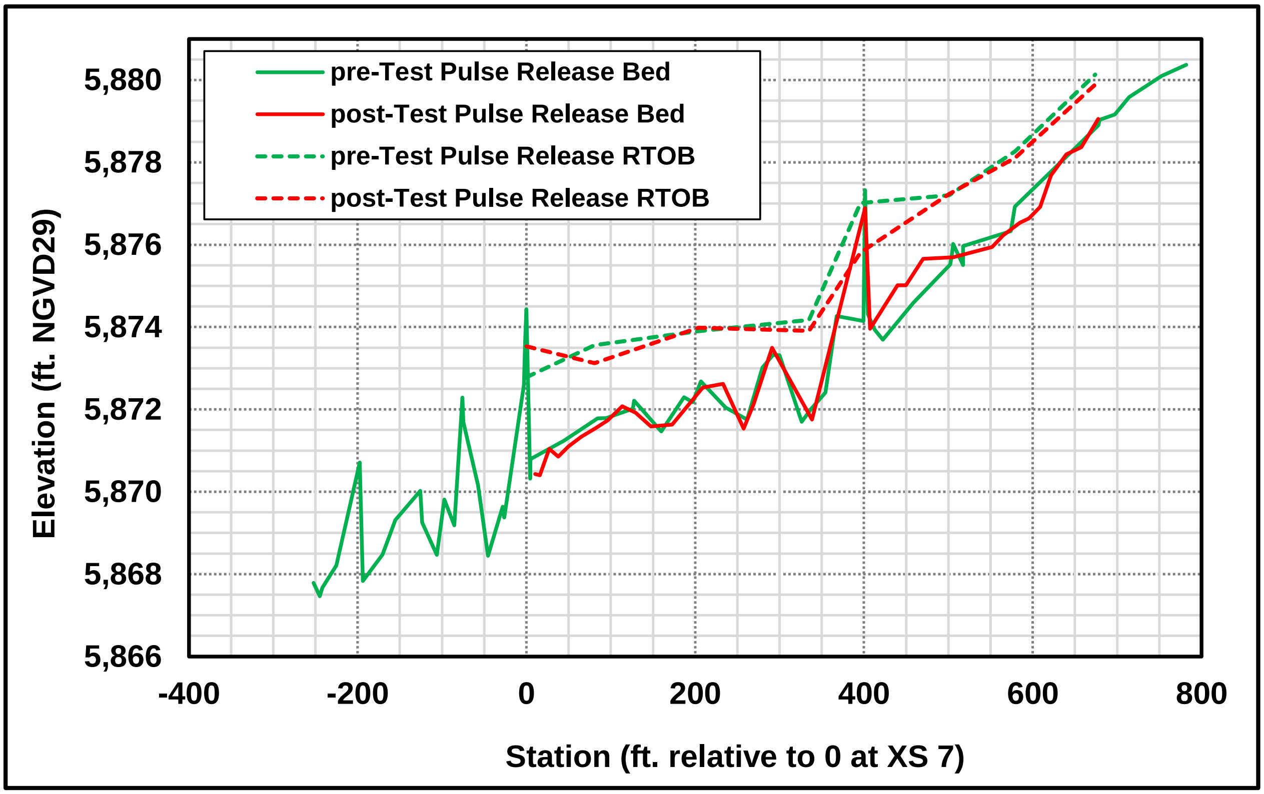
2015 pre-Test Pulse Survey		
Station	Elevation	Notes
-28.2	5869.64	
-26.3	5869.38	
-2.8	5872.60	
-1.3	5873.68	
0	5874.43	XS 7, LWD
4.5	5870.32	
4.8	5870.79	
44.4	5871.24	
84.1	5871.78	~XS 9
94.5	5871.79	
126.0	5872.01	
127.7	5872.21	
159.8	5871.46	
186.7	5872.29	
197.1	5872.17	
206.9	5872.68	~XS 12
236.1	5872.04	
261.6	5871.76	
279.7	5873.02	
292.3	5873.32	
300.1	5873.32	
326.4	5871.70	
337.4	5872.01	~XS 15
354.3	5872.41	
367.8	5874.27	
399.4	5874.15	~XS 17
401.3	5877.33	LWD
404.6	5874.31	
412.9	5873.93	
422.2	5873.69	
458.7	5874.60	
502.4	5875.52	~XS 19
504.6	5875.81	
505.8	5876.02	
517.5	5875.51	
517.5	5875.97	
574.0	5876.33	
578.9	5876.93	XS 21
646.4	5878.27	
678.0	5878.91	~XS 22
679.0	5879.04	
697.2	5879.16	
714.4	5879.58	
732.3	5879.83	

2016 post-Test Pulse Survey		
Station	Elevation	Notes
338.5	5871.75	~XS 15
371.4	5874.44	
401.3	5876.89	~XS 17, LWD
407.1	5873.95	
439.9	5875.01	
449.6	5875.01	
470.1	5875.66	
505.6	5875.69	~XS 19
551.9	5875.95	
565.1	5876.23	
584.6	5876.53	~XS 21
595.4	5876.64	
608.7	5876.92	
621.7	5877.69	
640.0	5878.19	
657.7	5878.37	
677.6	5879.06	~XS 22

2015 pre-Test Pulse Survey		
Station	Elevation	Notes
752.9	5880.10	
781.8	5880.37	

2016 post-Test Pulse Survey		
Station	Elevation	Notes





		pre-Test Pulse Elevation (ft.)		post-Test Pulse Bank Elevation (ft.)	
ID	Station	Left Bank	Right Bank	Left Bank	Right Bank
7	0	5872.67	5872.79	5873.05	5873.53
9	81	5873.25	5873.56	5873.19	5873.12
12	204	5874.07	5873.90	5873.96	5873.98
15	335	5875.64	5874.18	5875.40	5873.91
17	396	5876.51	5877.01	5876.04	5875.82
19	501	5878.02	5877.20	5878.46	5877.24
21	579	5879.10	5878.26	5879.20	5878.11
22	674	5880.80	5880.13	5880.44	5879.89

Appendix C. Cross Section Geometry Data and Plots

Station and elevation values are in units of feet, elevations are referenced to the National Geodetic Vertical Datum of 1929. Station values are referenced to the left pin.

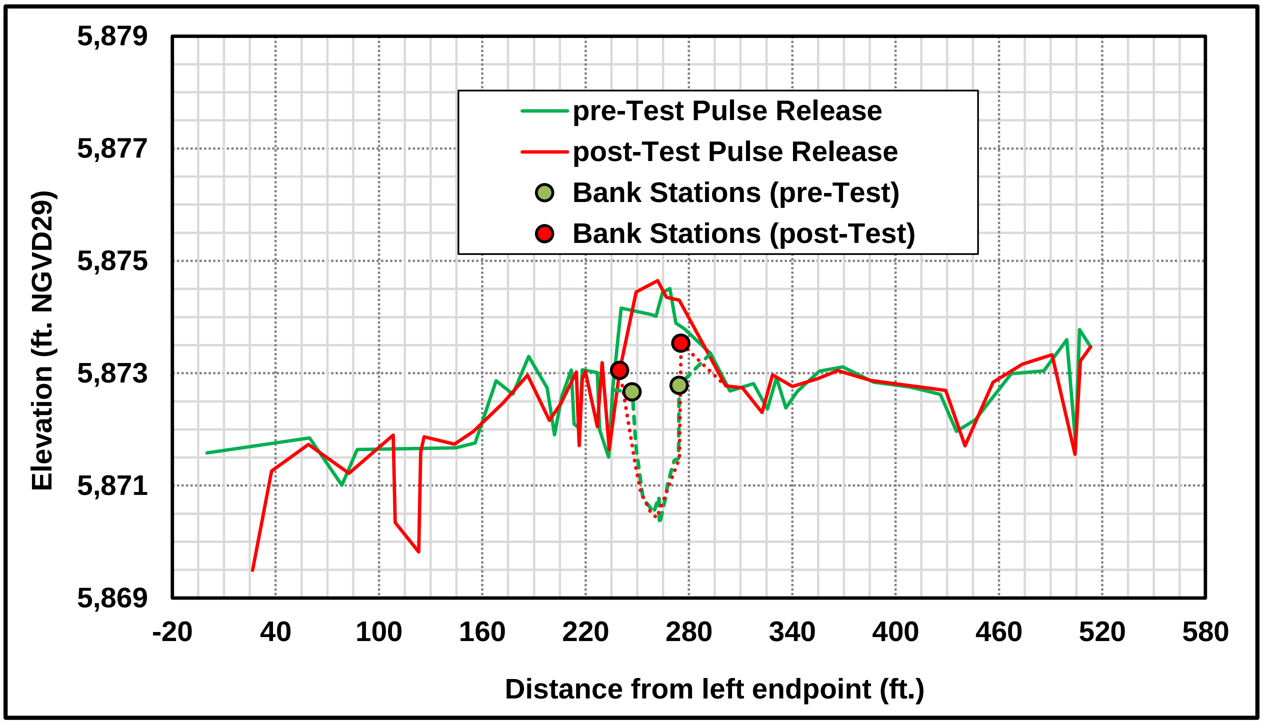


Figure 1. **Cross section 7**

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	**Elevation**	**Notes**		**Station**	**Elevation**	**Notes**
0	5871.58	BM 7L		26.6	5869.49	
59.7	5871.85			37.7	5871.26	
78.4	5871.01			59.0	5871.73	
87.3	5871.64			82.5	5871.22	
144.6	5871.67			108.2	5871.90	
155.8	5871.76			109.4	5870.34	
168.0	5872.87			123.1	5869.82	
177.8	5872.63			124.2	5871.60	EW
186.9	5873.30			126.1	5871.87	
197.6	5872.74			143.8	5871.74	
201.8	5871.91			154.9	5871.97	
206.1	5872.58			172.1	5872.47	
211.6	5873.06			186.3	5872.97	
213.3	5872.10			198.9	5872.16	
216.6	5872.01			205.6	5872.46	
218.1	5873.06			214.6	5873.02	EW
226.7	5873.01			216.3	5871.71	

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	**Elevation**	**Notes**		**Station**	**Elevation**	**Notes**
228.1	5871.99			218.1	5872.90	EW
233.4	5871.50			219.8	5873.03	
235.7	5872.70			226.8	5872.05	
240.5	5874.16	LWD		229.6	5873.19	EW
258.2	5874.04	LWD		233.7	5871.64	
260.9	5874.01	LWD		239.8	5873.05	
264.7	5874.43	LWD		249.3	5874.44	LWD
269.0	5874.51	LWD		261.9	5874.65	LWD
272.4	5873.89	LWD		267.0	5874.35	LWD
277.3	5873.79	LWD		274.4	5874.30	LWD
292.6	5873.35			301.3	5872.77	
303.8	5872.69			311.0	5872.74	
317.5	5872.82			322.5	5872.30	
325.6	5872.36			328.6	5872.97	
330.8	5872.92			340.1	5872.76	
336.2	5872.38			354.5	5872.90	
343.0	5872.68			366.4	5873.05	
355.6	5873.04			385.6	5872.87	
369.4	5873.11			429.1	5872.70	
387.2	5872.84			440.4	5871.71	
408.4	5872.75			456.6	5872.84	
426.1	5872.62			473.7	5873.16	
435.4	5871.96			490.9	5873.33	
446.5	5872.17			504.1	5871.56	
467.1	5872.99			507.3	5873.22	6/23 REW
486.0	5873.04			513.3	5873.47	BM 7R
499.5	5873.59					
504.6	5871.76					
506.9	5873.77					
513.3	5873.47	BM 7R				
Channel Survey				**Channel Survey**		
235.7	5872.70			239.8	5873.05	LTOB
247.1	5872.67	LTOB		248.8	5871.38	
249.3	5871.69			252.1	5870.88	
253.3	5870.76			257.5	5870.54	
256.6	5870.64			261.2	5870.43	
259.5	5870.52			274.4	5871.48	
262.6	5870.79			275.4	5873.53	RTOB
262.9	5870.32			301.3	5872.77	
266.5	5870.80					
267.6	5871.05					
271.4	5871.45					
274.0	5871.48					
274.3	5872.79	RTOB				

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	Elevation	Notes		Station	Elevation	Notes
292.6	5873.35					

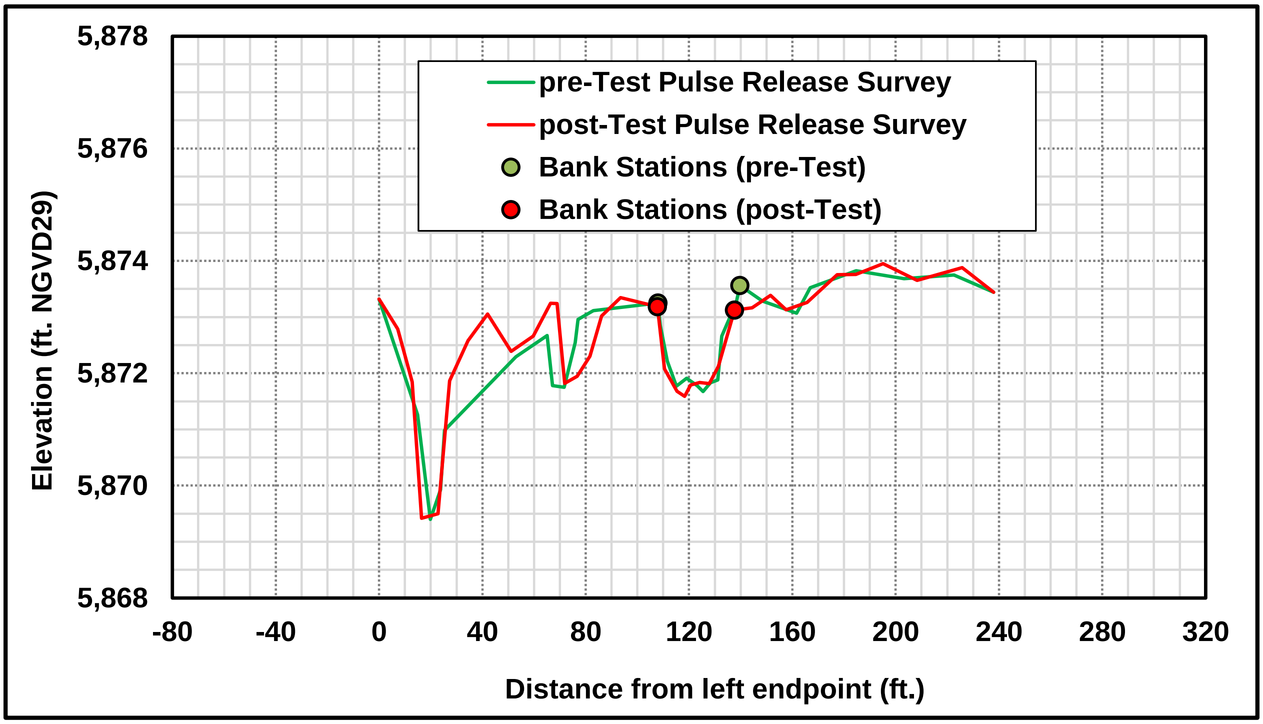


Figure 2. **Cross section 9**

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	**Elevation**	**Notes**		**Station**	**Elevation**	**Notes**
0	5873.32	BM 9L		0	5873.32	BM 9L
14.9	5871.26	EW		7.2	5872.79	
19.8	5869.40			12.8	5871.84	EW
23.8	5869.92			16.5	5869.42	
25.3	5870.99	EW		22.9	5869.50	
53.0	5872.30			27.3	5871.87	EW
65.0	5872.67	EW		34.4	5872.58	
67.2	5871.78			42.0	5873.06	
71.7	5871.75			51.2	5872.39	
75.9	5872.55			59.7	5872.66	
77.0	5872.96			66.3	5873.25	
82.9	5873.11			68.9	5873.24	EW
108.0	5873.25	LTOB		71.9	5871.82	
108.9	5872.85			76.7	5871.95	
111.6	5872.21			81.6	5872.30	
115.1	5871.77			86.2	5873.02	EW
119.1	5871.91			93.5	5873.34	
123.1	5871.78			107.7	5873.19	EW
125.5	5871.68			110.5	5872.08	LTOB
128.3	5871.83			115.3	5871.68	
131.1	5871.88			118.3	5871.59	
132.7	5872.66	EW		120.6	5871.79	

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	Elevation	Notes		Station	Elevation	Notes
138.3	5873.26			124.1	5871.84	
139.7	5873.56	RTOB		127.8	5871.82	
148.4	5873.28			131.3	5872.12	
161.6	5873.07			137.6	5873.12	EW, RTOB
166.9	5873.52			144.4	5873.16	
184.7	5873.82			151.6	5873.39	
203.3	5873.68			157.6	5873.13	
222.5	5873.75			165.8	5873.26	
237.9	5873.44	BM 9R		177.4	5873.75	
				184.6	5873.76	
				195.1	5873.95	
				208.3	5873.66	
				225.7	5873.88	
				237.9	5873.44	BM 9R

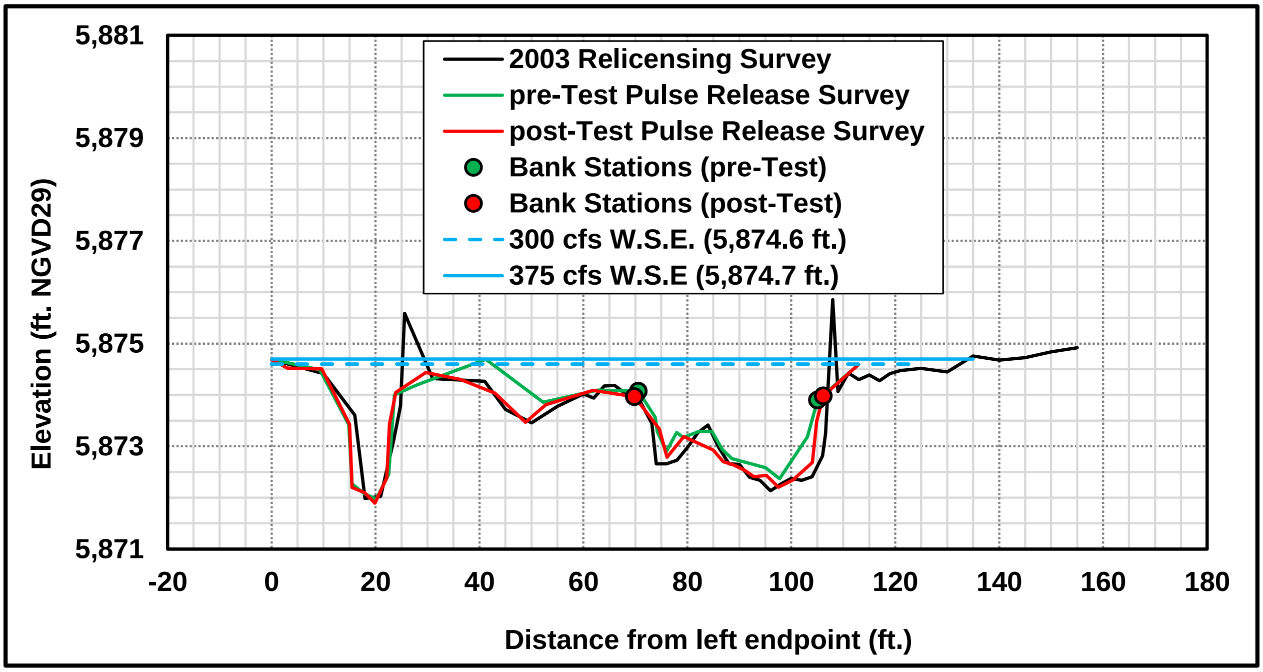


Figure 3. **Cross section 12 (lower relicensing section)**

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	**Elevation**	**Notes**		**Station**	**Elevation**	**Notes**
0.0	5874.69	BM 12L		0.0	5874.69	BM 12L
9.3	5874.49			3.0	5874.52	
14.9	5873.42			9.6	5874.51	
15.5	5872.27			15.0	5873.43	EW
17.8	5872.08			15.5	5872.20	
20.2	5871.97			17.9	5872.10	
22.5	5872.45			19.9	5871.89	
23.7	5874.00			22.2	5872.38	EW
28.0	5874.19			22.7	5873.43	
41.2	5874.69			23.9	5874.05	
52.2	5873.86			29.7	5874.43	
62.8	5874.09			36.3	5874.30	
70.6	5874.07	LTOB		43.0	5874.04	
73.8	5873.57			48.9	5873.47	
74.2	5873.28	EW		52.8	5873.81	
76.0	5872.90			61.9	5874.09	
77.9	5873.27	EW		69.9	5873.96	LTOB
79.2	5873.17			74.6	5873.34	EW
82.3	5873.29			76.1	5872.79	
84.7	5873.29	EW		79.3	5873.19	
86.7	5872.94			85.0	5872.92	
88.6	5872.76			86.9	5872.70	
91.5	5872.68			88.9	5872.64	

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	Elevation	Notes		Station	Elevation	Notes
95.1	5872.58			91.1	5872.53	
97.8	5872.37			92.8	5872.41	
103.1	5873.18	EW		95.2	5872.43	
105.1	5873.90	RTOB		97.5	5872.21	
112.9	5874.59	BM 12R		100.3	5872.34	
				104.1	5872.69	
				104.9	5873.49	EW
				106.2	5873.98	RTOB
				112.9	5874.59	BM 12R

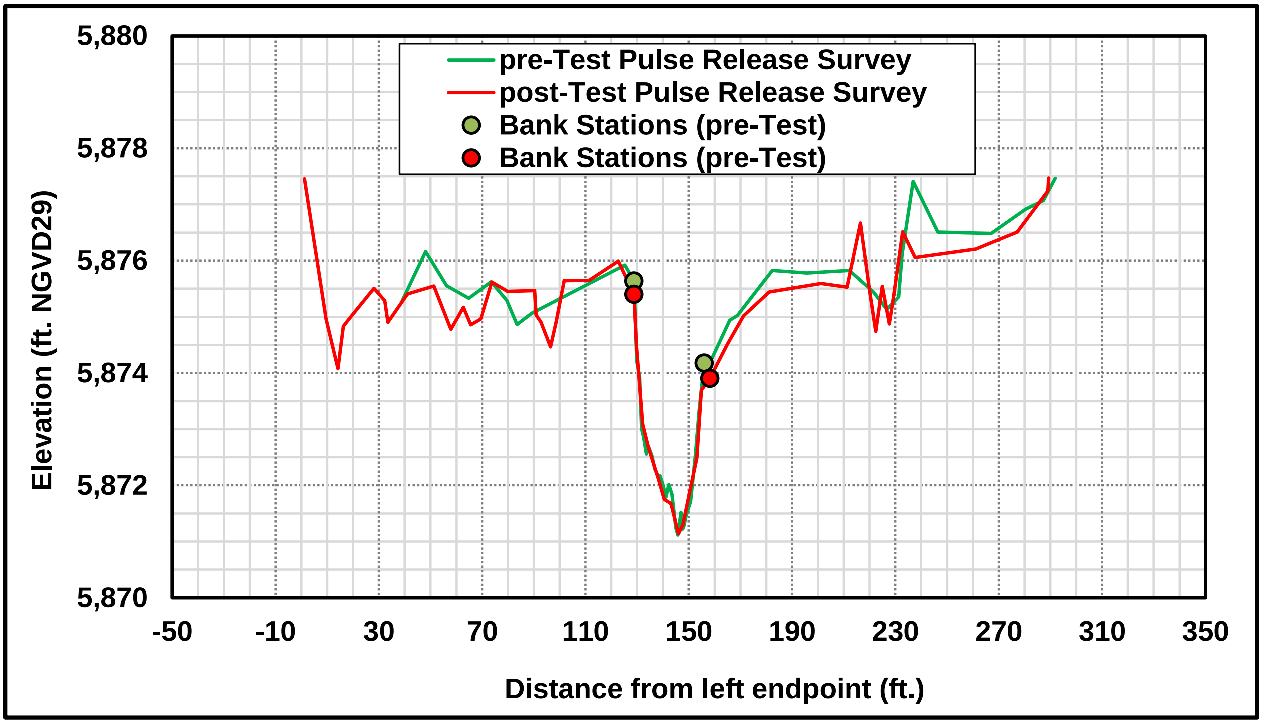


Figure 4. Cross section 15

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	Elevation	Notes		Station	Elevation	Notes
39.0	5875.28			0	5881.79	BM 15L
48.0	5876.16			1.2	5877.46	
56.2	5875.55			9.6	5874.96	
64.7	5875.33			14.2	5874.08	
73.6	5875.62			16.2	5874.83	
79.6	5875.29			18.7	5874.97	
83.6	5874.86			28.1	5875.51	
89.2	5875.06			32.3	5875.28	EW
125.2	5875.92			33.5	5874.90	
128.7	5875.64	LTOB		37.7	5875.18	EW
129.8	5874.21	EW		41.0	5875.40	
130.9	5873.93			51.3	5875.55	EW
131.7	5873.01			57.8	5874.78	
132.5	5872.86			62.7	5875.17	
133.6	5872.56			65.5	5874.86	
134.4	5872.69			69.5	5874.96	
135.8	5872.51			73.8	5875.62	
136.8	5872.29			79.9	5875.45	
138.1	5872.17			90.4	5875.47	EW
138.9	5872.17			90.9	5875.03	EW
139.9	5872.02			92.7	5874.91	EW
141.1	5871.79			96.5	5874.47	

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	**Elevation**	**Notes**		**Station**	**Elevation**	**Notes**
142.3	5872.01			98.7	5874.91	
143.5	5871.85			101.7	5875.65	
145.0	5871.24			111.4	5875.65	
145.8	5871.12			122.8	5875.99	
146.9	5871.52			128.7	5875.40	LTOB
147.6	5871.22			129.7	5874.49	EW
148.3	5871.30			132.2	5873.09	
148.7	5871.43			134.4	5872.68	
150.7	5871.72			138.3	5872.11	
152.6	5872.54			140.5	5871.75	
154.1	5873.32			143.2	5871.68	
156.0	5874.18	RTOB		146.0	5871.13	
157.5	5874.12			147.8	5871.30	
165.9	5874.94			150.6	5871.94	
168.8	5875.02			153.2	5872.48	
182.3	5875.82			154.9	5873.69	
195.7	5875.78			158.2	5873.91	RTOB
212.2	5875.82			165.0	5874.52	
221.5	5875.44			171.3	5875.02	
226.7	5875.13			181.2	5875.44	
231.3	5875.36			201.2	5875.59	
232.6	5876.11			211.3	5875.53	
236.9	5877.41			216.5	5876.67	
246.4	5876.51			220.0	5875.48	EW
267.0	5876.49			222.3	5874.74	
280.5	5876.91			224.9	5875.54	
287.3	5877.07			227.7	5874.87	
291.9	5877.47	BM 15R		229.3	5875.35	EW
				232.8	5876.51	
				237.7	5876.06	
				261.1	5876.21	
				277.1	5876.51	
				289.0	5877.24	
				289.3	5877.47	BM 15R

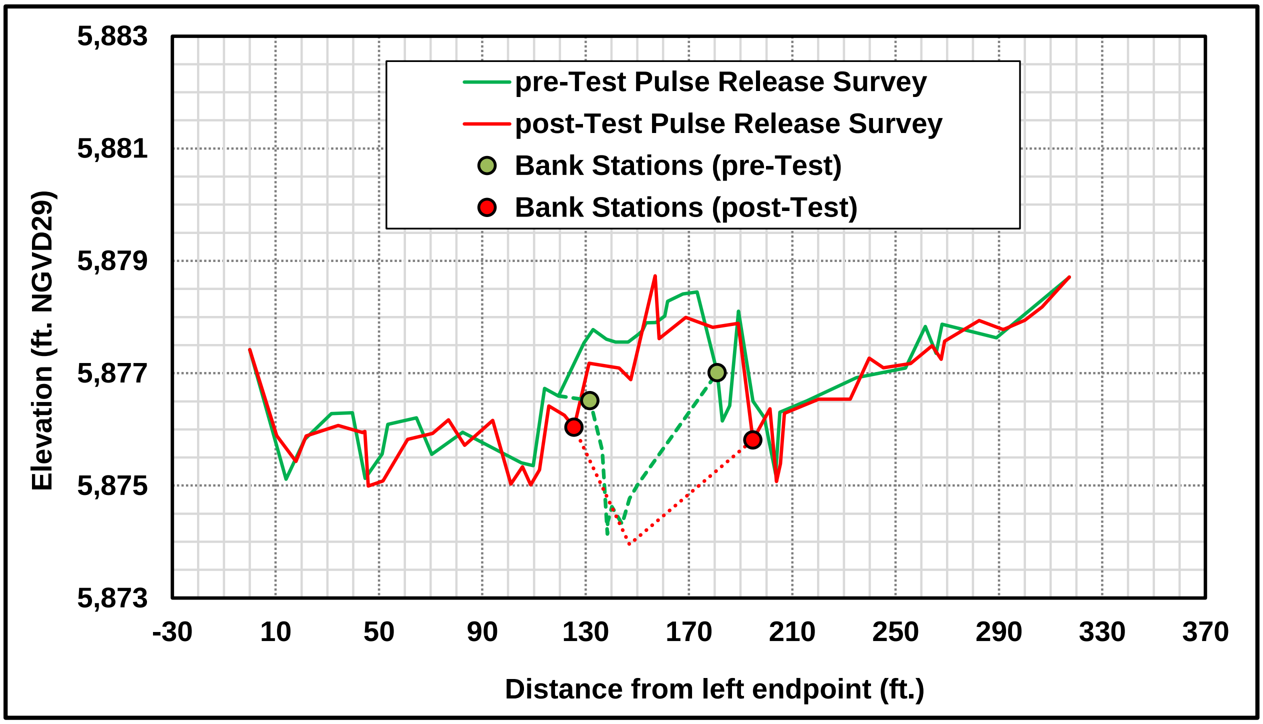


Figure 5. **Cross section 17**

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	**Elevation**	**Notes**		**Station**	**Elevation**	**Notes**
0	5877.42	BM 17L		0	5877.42	BM 17L
14.0	5875.11			10.4	5875.89	
21.2	5875.83			17.9	5875.43	
31.6	5876.28			21.8	5875.88	
39.7	5876.30			34.2	5876.07	
44.7	5875.13			43.6	5875.95	
51.2	5875.56			44.6	5875.96	EW
53.5	5876.09			45.8	5874.99	
64.5	5876.20			51.6	5875.09	
70.5	5875.55			61.1	5875.82	
82.4	5875.95			70.8	5875.93	
97.1	5875.60			76.9	5876.17	
105.1	5875.40			83.1	5875.72	
109.7	5875.35			94.0	5876.16	
114.1	5876.73			101.0	5875.03	
119.5	5876.59			105.6	5875.34	
129.3	5877.54	LWD		108.7	5875.01	
132.8	5877.78	LWD	~LTOB	112.1	5875.28	
138.1	5877.61	LWD		115.7	5876.42	
141.5	5877.56	LWD		121.8	5876.25	
146.5	5877.55	LWD		125.5	5876.04	LTOB
150.5	5877.70	LWD		131.3	5877.18	LWD

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	**Elevation**	**Notes**		**Station**	**Elevation**	**Notes**
151.9	5877.75	LWD		143.0	5877.09	LWD
153.4	5877.90	LWD		147.5	5876.89	LWD
157.3	5877.90	LWD		156.9	5878.73	LWD
160.7	5878.02			158.4	5877.62	LWD
161.7	5878.28			168.7	5878.00	LWD
167.7	5878.41			179.1	5877.82	LWD
173.2	5878.45			189.0	5877.89	LWD
181.0	5877.01	RTOB		194.8	5875.82	RTOB
182.9	5876.15			201.4	5876.37	
185.8	5876.42			203.9	5875.07	
189.1	5878.11			205.5	5875.39	
194.8	5876.50			206.9	5876.29	
199.2	5876.21			220.3	5876.54	
203.6	5875.21			232.4	5876.54	
205.2	5876.31			239.7	5877.27	
215.6	5876.51			245.2	5877.10	
234.9	5876.92			255.8	5877.17	
253.8	5877.09			264.2	5877.49	
261.5	5877.83			267.7	5877.25	
265.7	5877.36			269.0	5877.57	6/25 REW
267.9	5877.87			282.4	5877.94	
289.1	5877.63			291.7	5877.78	
317.3	5878.71	BM 17R		300.0	5877.94	
				306.8	5878.18	
				317.3	5878.71	BM 17R
Channel Survey				**Channel Survey**		
119.5	5876.59			125.5	5876.04	LTOB
131.7	5876.51	LTOB		147.0	5873.95	
136.4	5875.63			194.8	5875.82	RTOB
138.4	5874.14					
138.5	5874.35					
140.1	5874.62					
144.2	5874.31					
147.0	5874.77					
150.3	5875.02					
181.0	5877.01	RTOB				

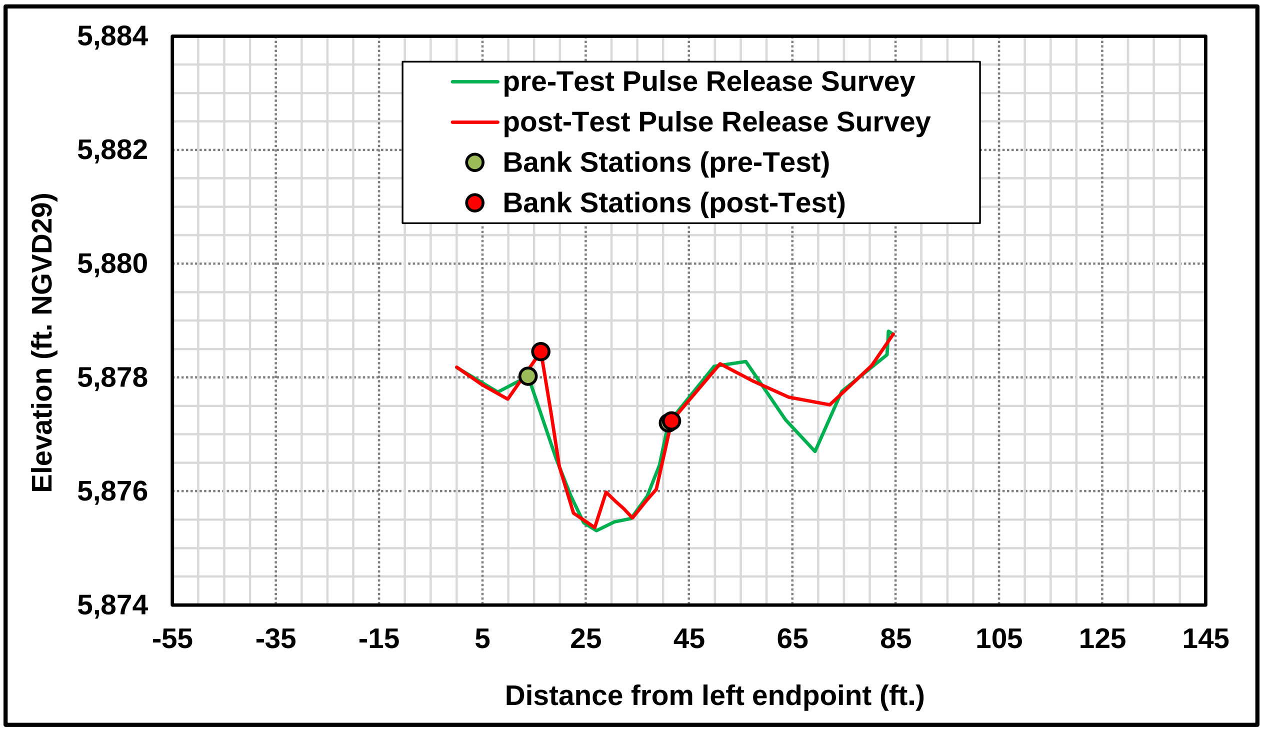


Figure 6. Cross section 19

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	**Elevation**	**Notes**		**Station**	**Elevation**	**Notes**
0.0	5878.18	BM 19L		0.0	5878.18	BM 19L
8.0	5877.75			5.0	5877.87	
13.9	5878.02	LTOB		9.9	5877.62	
19.3	5876.57	EW		16.3	5878.46	LTOB
22.2	5875.92			18.3	5877.34	EW
24.6	5875.44			19.9	5876.43	
27.1	5875.31			22.6	5875.61	
30.5	5875.46			26.7	5875.36	
33.8	5875.52			29.0	5875.98	
36.9	5875.91			30.8	5875.82	
39.3	5876.45	EW		32.3	5875.69	
41.0	5877.20	RTOB		34.1	5875.53	
49.9	5878.19			36.8	5875.83	
56.0	5878.28			38.7	5876.03	
63.7	5877.26			41.6	5877.24	EW, RTOB
69.4	5876.70			45.2	5877.62	
74.5	5877.75			51.0	5878.24	
83.3	5878.40			57.4	5877.94	
83.6	5878.81			64.3	5877.65	
84.5	5878.76	BM 19R		72.3	5877.52	
				80.3	5878.21	
				84.5	5878.76	BM 19R

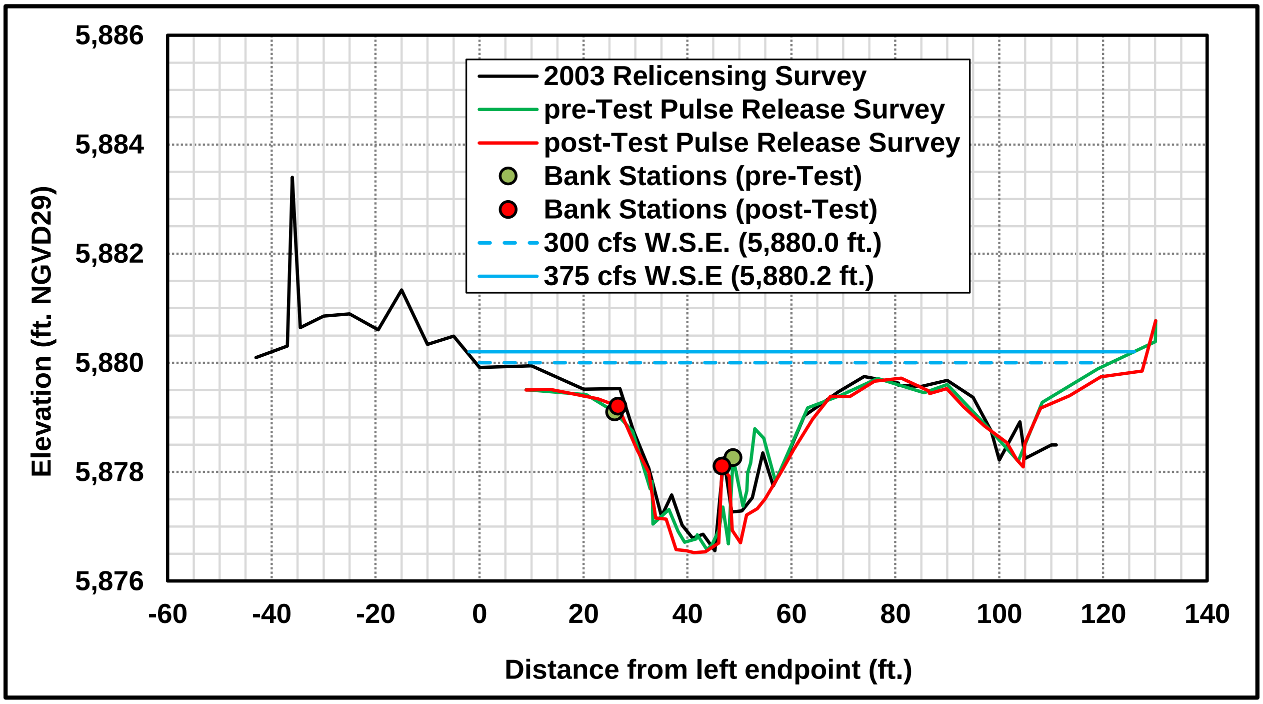


Figure 7. **Cross section 21 (middle relicensing section)**

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	Elevation	Notes		Station	Elevation	Notes
9.0	5879.50	BM 21L		9.0	5879.50	BM 21L
20.6	5879.41			13.7	5879.51	
26.0	5879.10	LTOB		22.8	5879.34	
29.5	5878.74			26.6	5879.20	LTOB
32.8	5877.69			30.3	5878.41	
33.2	5877.83	EW		32.6	5877.99	EW
33.4	5877.04			33.9	5877.16	
36.5	5877.31			35.9	5877.13	
37.2	5877.13			37.8	5876.58	
38.2	5876.91			39.8	5876.56	
39.5	5876.71			41.2	5876.52	
41.7	5876.77			43.4	5876.53	
41.9	5876.85			46.1	5876.70	
43.7	5876.58			46.7	5878.11	RTOB
44.8	5876.67			48.0	5877.91	
46.0	5876.93			48.6	5876.93	
46.8	5877.36			50.2	5876.70	
47.9	5876.68			51.4	5877.21	
48.8	5878.26	RTOB		53.5	5877.32	
50.7	5877.37			54.9	5877.50	
51.4	5877.66			58.1	5878.00	EW
51.6	5877.98	EW		60.4	5878.40	

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	**Elevation**	**Notes**		**Station**	**Elevation**	**Notes**
52.2	5878.17			64.1	5878.97	
53.0	5878.79			67.5	5879.39	
54.7	5878.62			71.3	5879.38	
54.8	5878.57			76.0	5879.66	
56.9	5877.83			81.2	5879.72	
63.2	5879.17			86.4	5879.49	
69.5	5879.40			86.6	5879.44	
76.6	5879.71			89.9	5879.53	
85.6	5879.45			93.1	5879.20	
90.0	5879.60			97.2	5878.84	
97.4	5878.86			101.5	5878.54	EW
103.7	5878.20			103.3	5878.23	
108.3	5879.28			104.6	5878.09	
119.0	5879.89			104.9	5878.53	EW
130.0	5880.39			108.0	5879.17	
130.1	5880.77	BM 21R		113.5	5879.40	6/23 REW
				119.6	5879.74	
				127.5	5879.85	6/25 REW
				130.1	5880.77	BM 21R

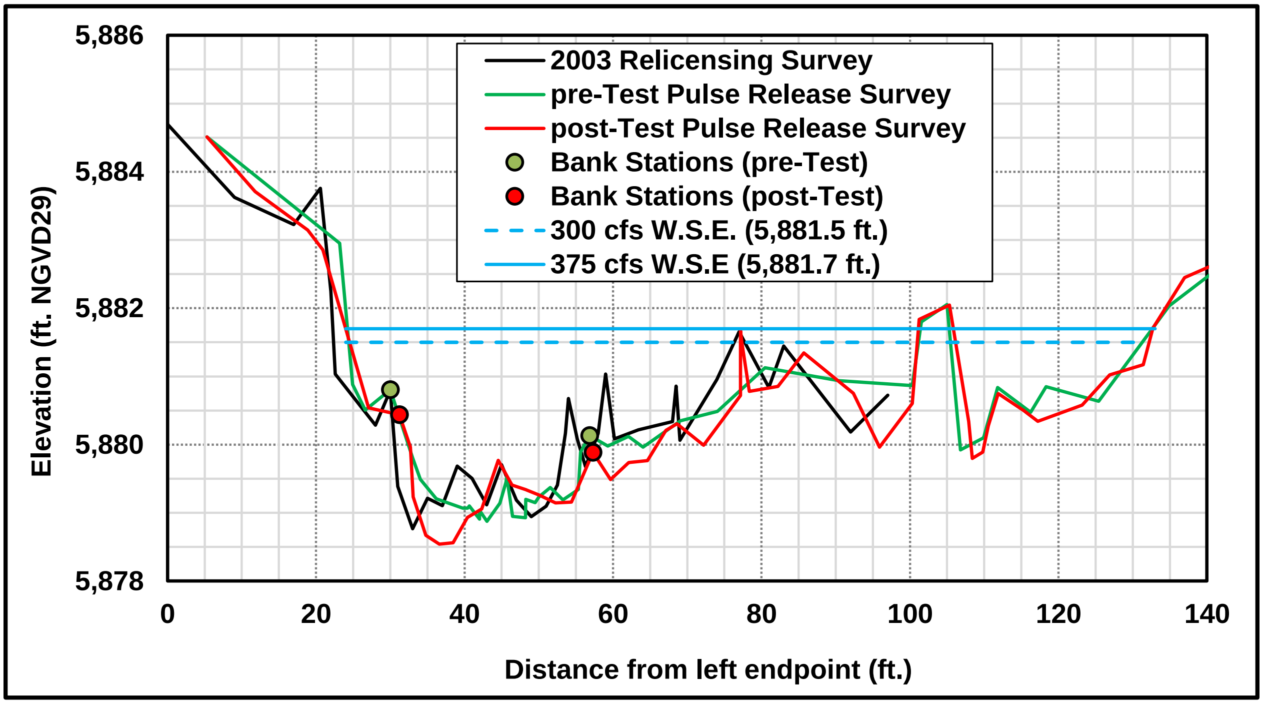


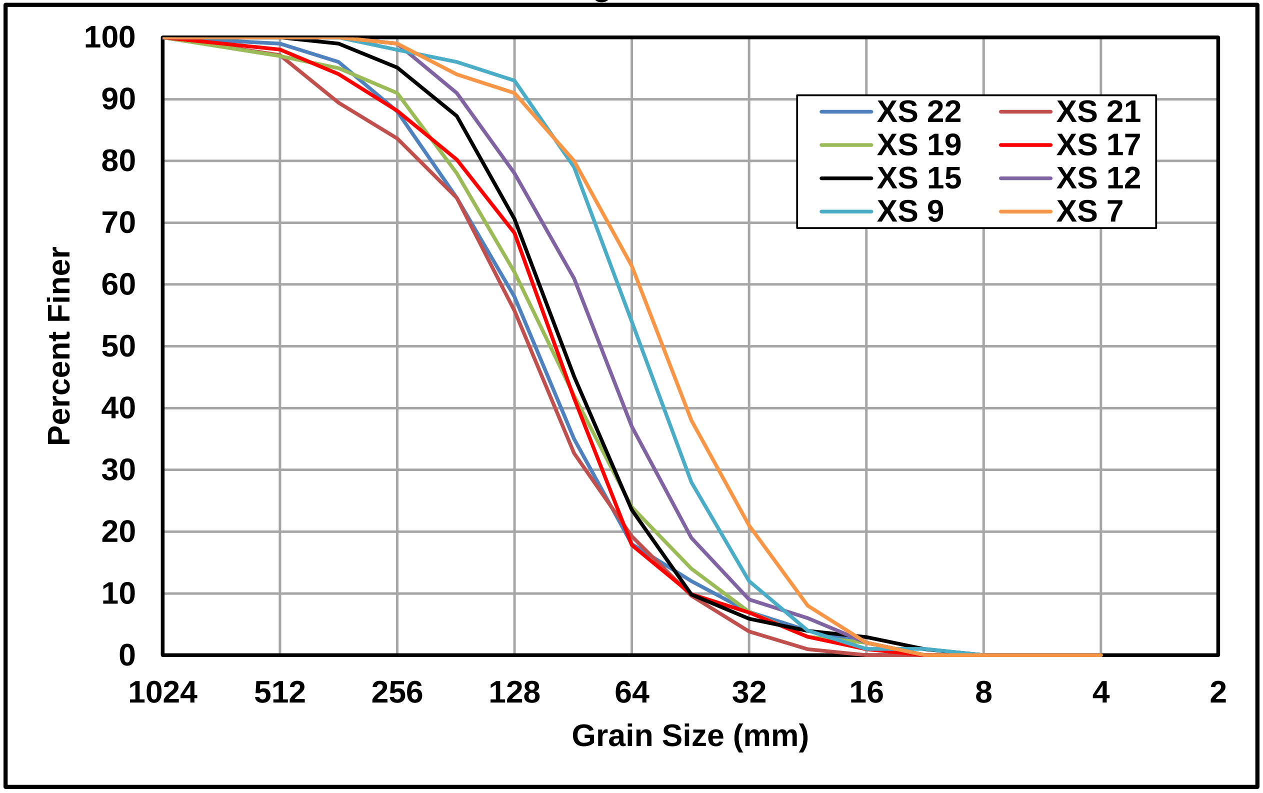
Figure 8. **Cross section 22 (upper relicensing section)**

pre-Test Pulse Release Survey				post-Test Pulse Release Survey		
Station	**Elevation**	**Notes**		**Station**	**Elevation**	**Notes**
5.3	5884.51	BM 22L		5.3	5884.51	BM 22L
23.2	5882.95			11.8	5883.71	
24.9	5880.88			18.9	5883.15	
26.6	5880.51			20.9	5882.86	
30.0	5880.80	LTOB		27.1	5880.54	
33.0	5879.81	EW		31.2	5880.44	LTOB
34.1	5879.49			32.7	5879.97	EW
36.2	5879.21			33.1	5879.24	
39.7	5879.07			34.8	5878.67	
40.4	5879.07			36.6	5878.54	
40.6	5879.10			38.4	5878.56	
42.0	5878.91			40.4	5878.93	
42.0	5879.04			42.3	5879.06	
43.0	5878.88			44.5	5879.77	
44.8	5879.14			46.4	5879.41	
45.6	5879.45			48.3	5879.34	
45.7	5879.53			48.3	5879.33	
46.5	5878.95			50.1	5879.26	
48.2	5878.93			52.3	5879.15	
48.2	5879.20			54.4	5879.16	
49.5	5879.15			57.3	5879.89	RTOB
50.0	5879.24			59.7	5879.49	

51.5	5879.37			62.1	5879.74	
53.3	5879.19			64.6	5879.77	
55.3	5879.34			67.1	5880.21	EW
55.6	5879.89	EW		68.6	5880.31	
56.9	5880.13	RTOB		72.2	5879.99	
59.3	5879.98			77.2	5880.72	
62.1	5880.12			77.2	5881.68	
64.1	5879.96			77.3	5881.50	
69.1	5880.35			78.3	5880.78	
74.1	5880.49			82.2	5880.86	
80.5	5881.13			85.7	5881.35	
90.4	5880.94			92.4	5880.75	
100.3	5880.87			95.9	5879.96	
101.5	5881.80			100.3	5880.60	
105.0	5882.05			101.3	5881.84	
106.8	5879.92			105.3	5882.05	
109.9	5880.10			107.9	5880.34	
111.8	5880.84			108.4	5879.80	
116.3	5880.47			109.8	5879.89	
118.3	5880.85			110.6	5880.28	
125.4	5880.64			111.9	5880.75	
134.9	5882.03			115.3	5880.50	
143.9	5882.78	BM 22R		117.2	5880.34	
				123.2	5880.58	
				126.9	5881.02	
				131.4	5881.17	6/22 REW
				132.7	5881.71	6/25 REW
				137.0	5882.45	
				143.9	5882.78	BM 22R

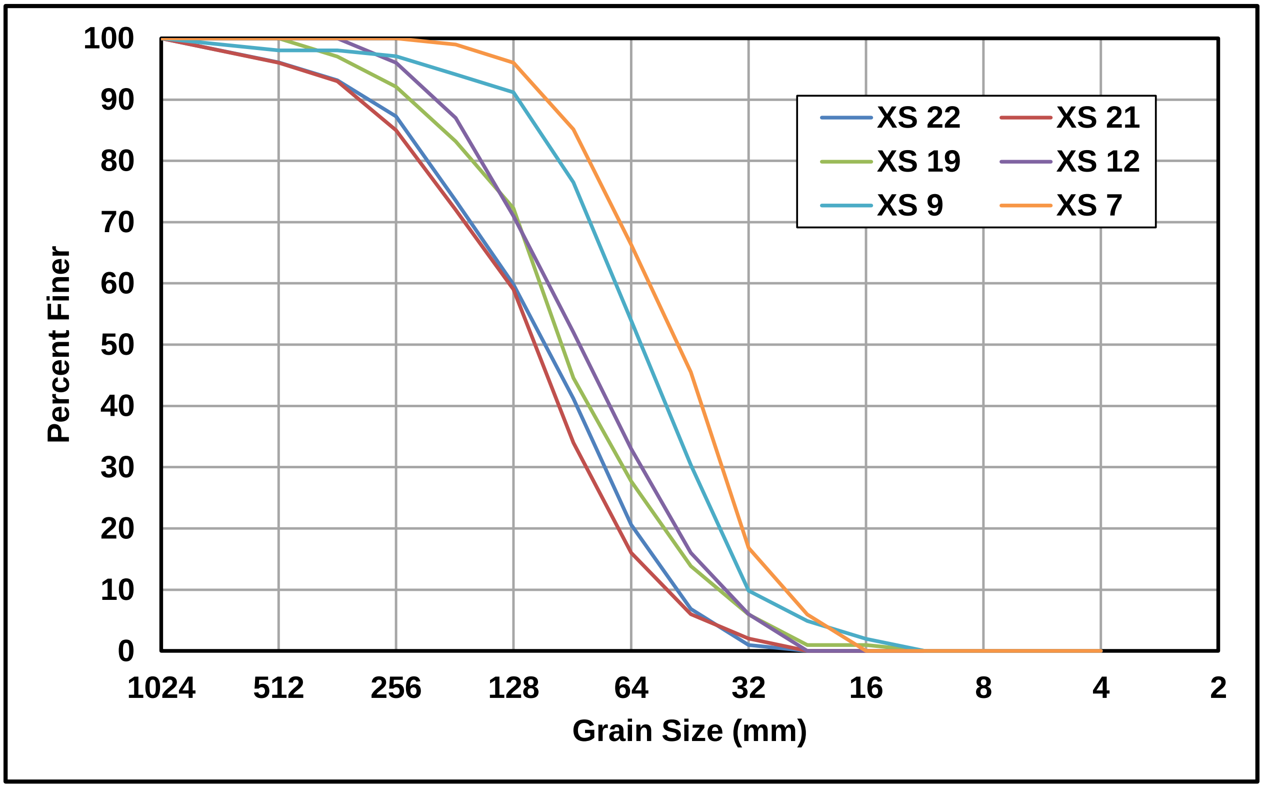
Appendix D. LL-G2 Bed Surface Gradation Data and Plots

Pre-Test Pulse Flow Release Monitoring

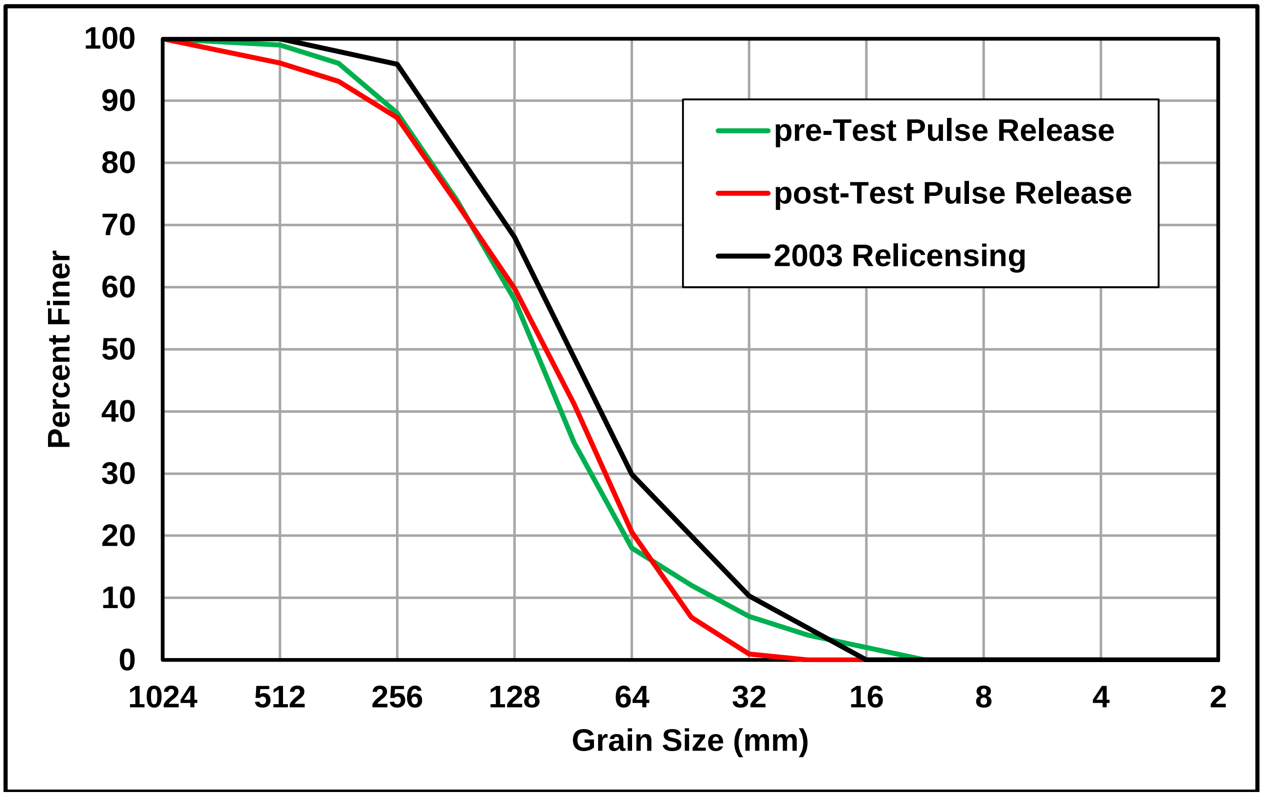


Grain Size (mm)	Cross-Section ID, incremental count retained							
	22	21	19	17	15	12	9	7
1024	0	0	0	0	0	0	0	0
512	1	3	3	2	0	0	0	0
362	3	8	2	4	1	0	0	0
256	8	6	4	6	4	1	2	1
180	14	10	13	8	8	8	2	5
128	16	19	16	12	17	13	3	3
90	23	24	20	27	26	17	14	11
64	17	14	18	24	22	24	25	17
45	6	10	10	8	14	18	26	25
32	5	6	7	3	4	10	16	17
22.6	3	3	4	4	2	3	8	13
16	2	1	1	2	1	4	3	6
11.3	2	0	2	1	2	2	0	2
8	0	0	0	0	1	0	1	0
4	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
Fines	3	3	0	0	4	0	0	0

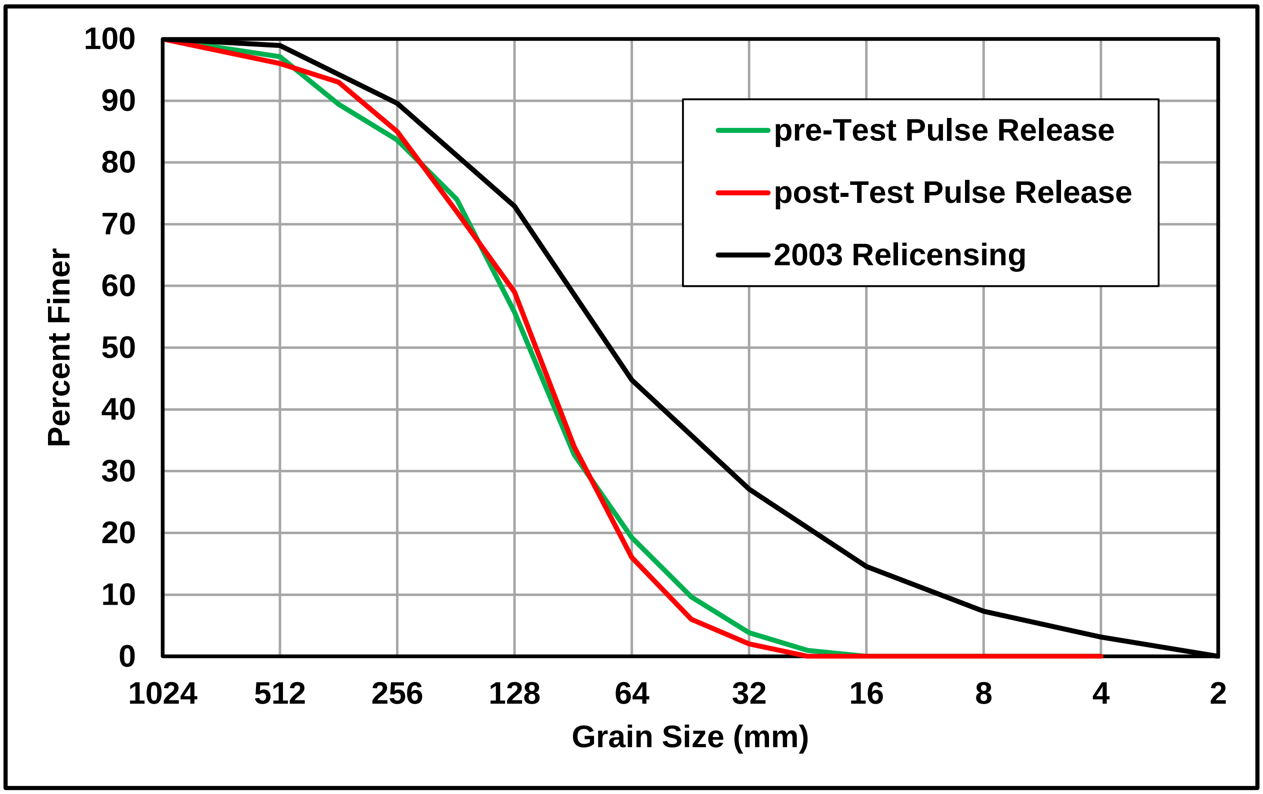
Post-Test Pulse Flow Release Monitoring



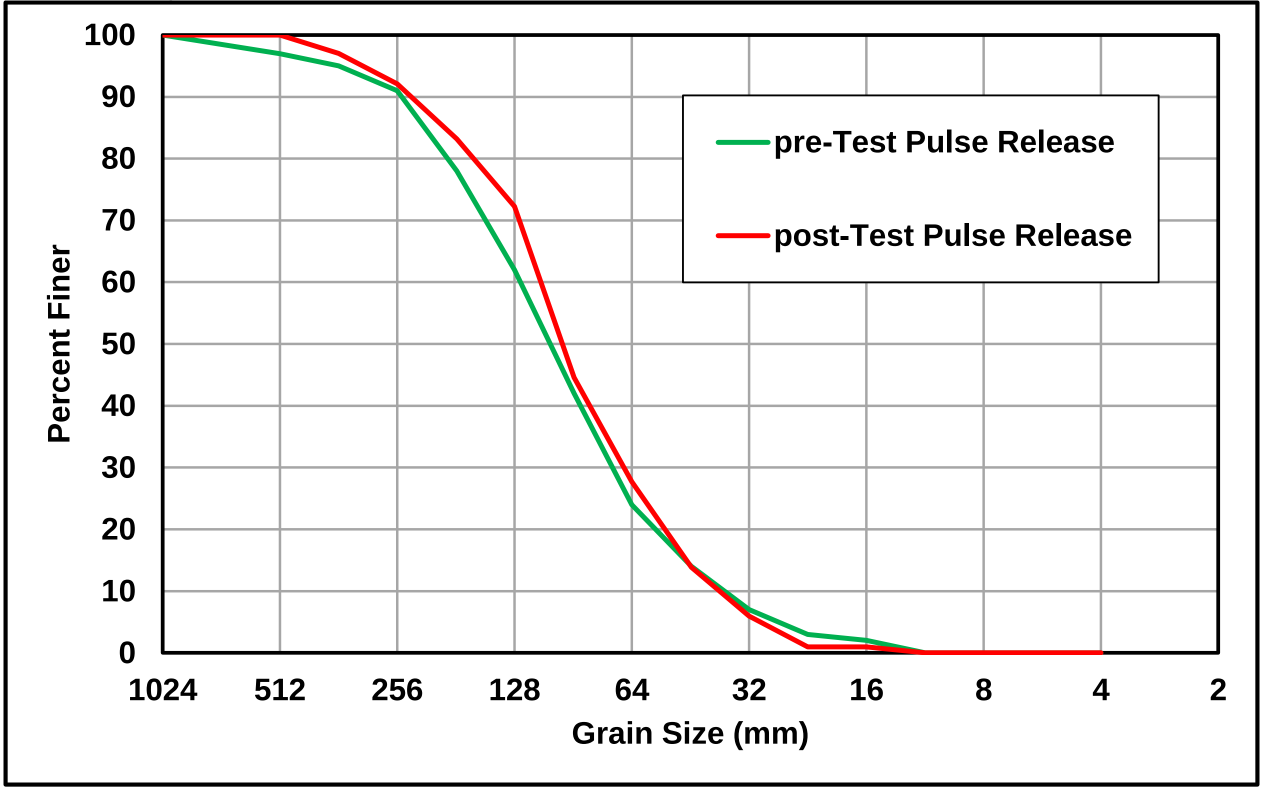
Grain Size (mm)	Cross Section ID, incremental count retained							
	22	21	19	17	15	12	9	7
1024	0	0	0	Water too deep to safely sample	Water too deep to safely sample	0	0	0
512	4	4	0			0	0	0
362	3	3	3			0	0	0
256	6	8	5			4	1	0
180	14	13	9			9	3	1
128	14	13	11			16	3	3
90	19	25	28			19	15	11
64	21	18	17			19	23	19
45	14	10	14			17	24	21
32	6	4	8			10	21	29
22.6	1	2	5			6	5	11
16	0	0	0			0	3	6
11.3	0	0	1			0	2	0
8	0	0	0			0	0	0
4	0	0	0			0	0	0
2	0	0	0			0	0	0
Fines	0	0	1			1	2	2



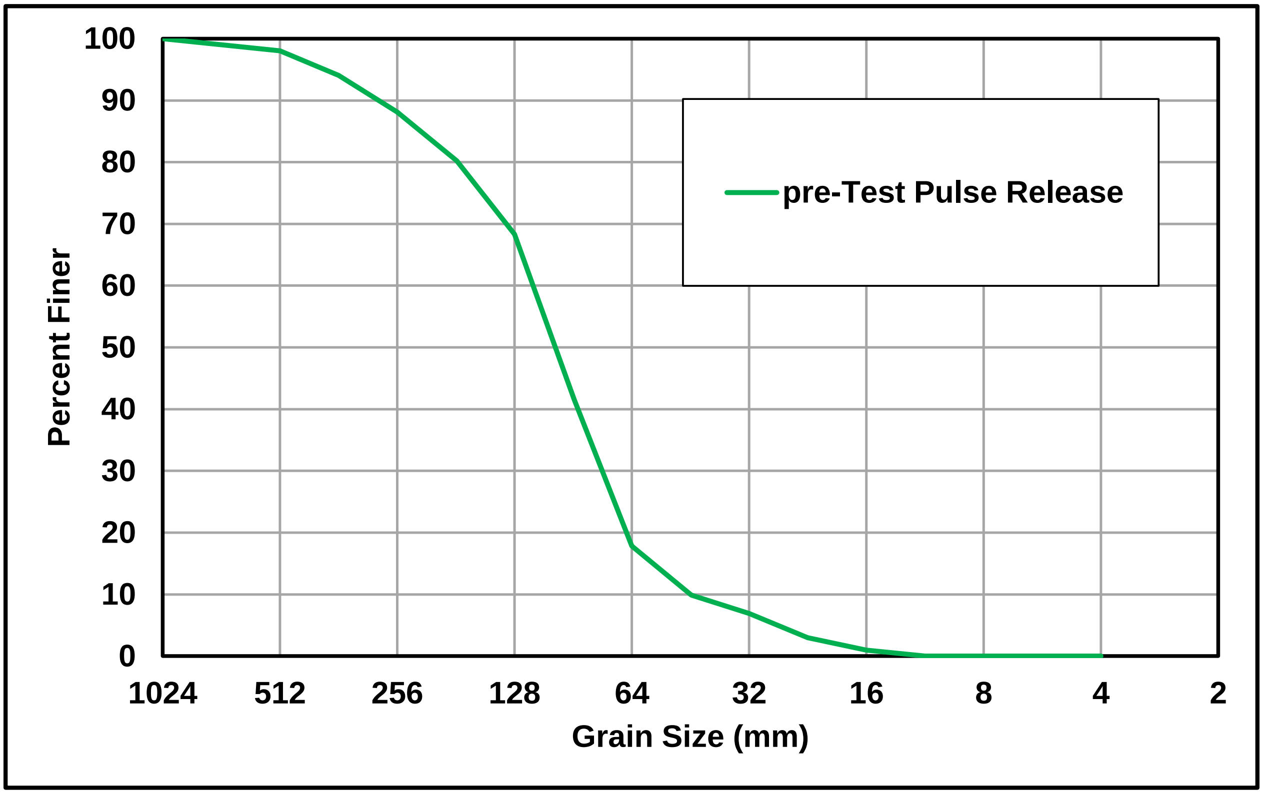
Bed surface gradations at cross section 22



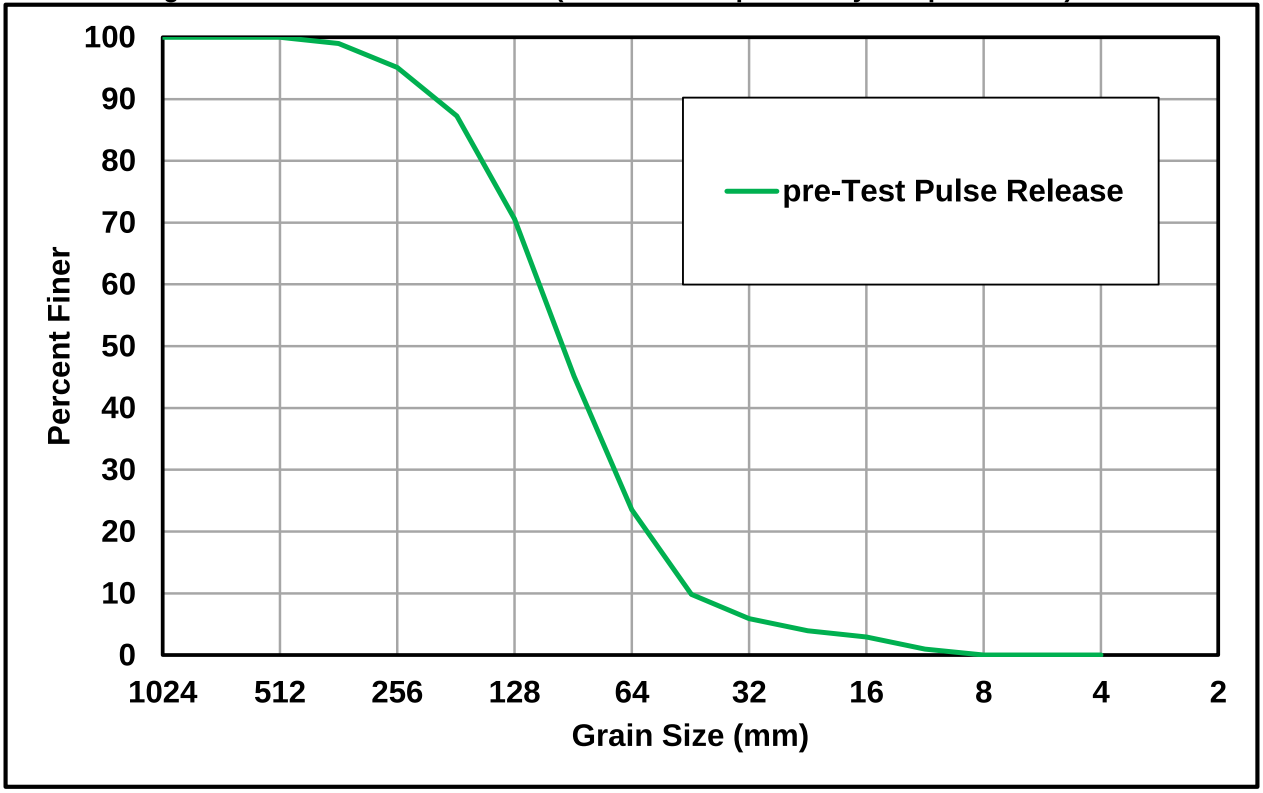
Bed surface gradations at cross section 21



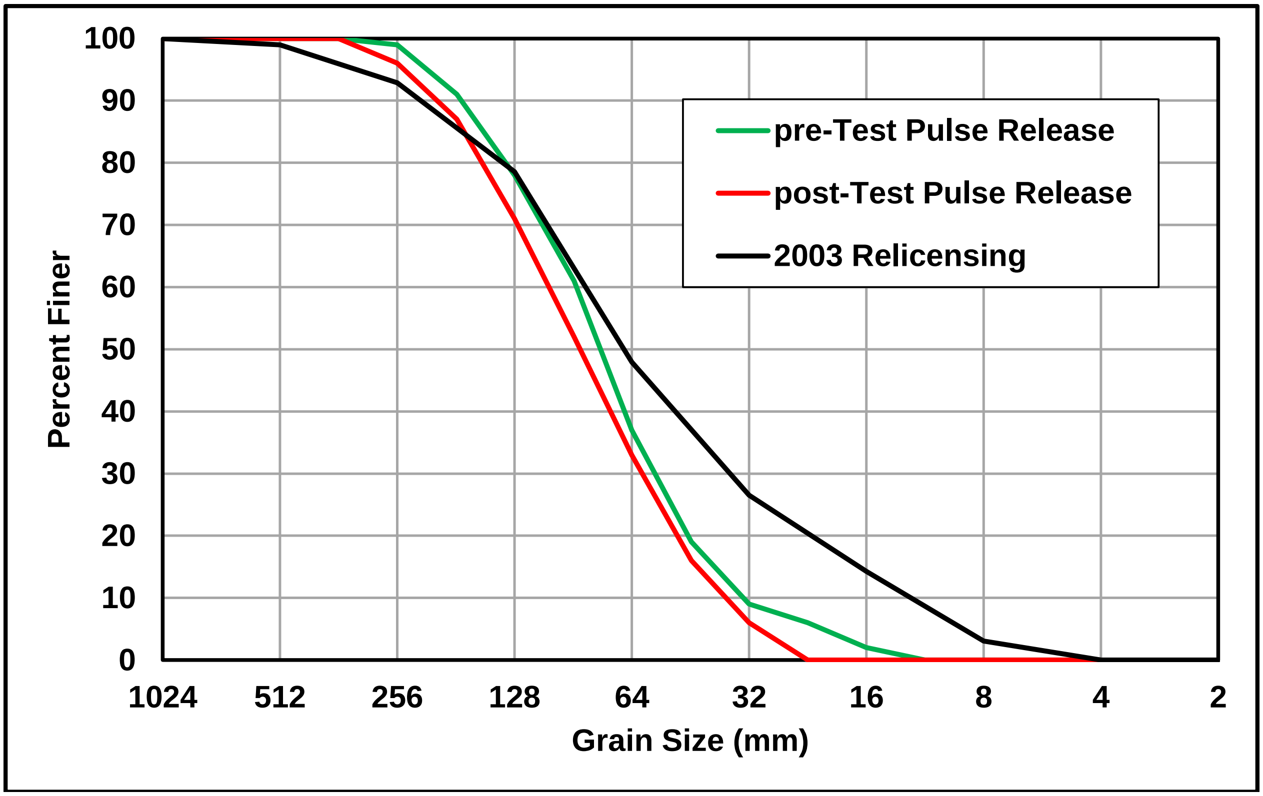
Bed surface gradations at cross section 19



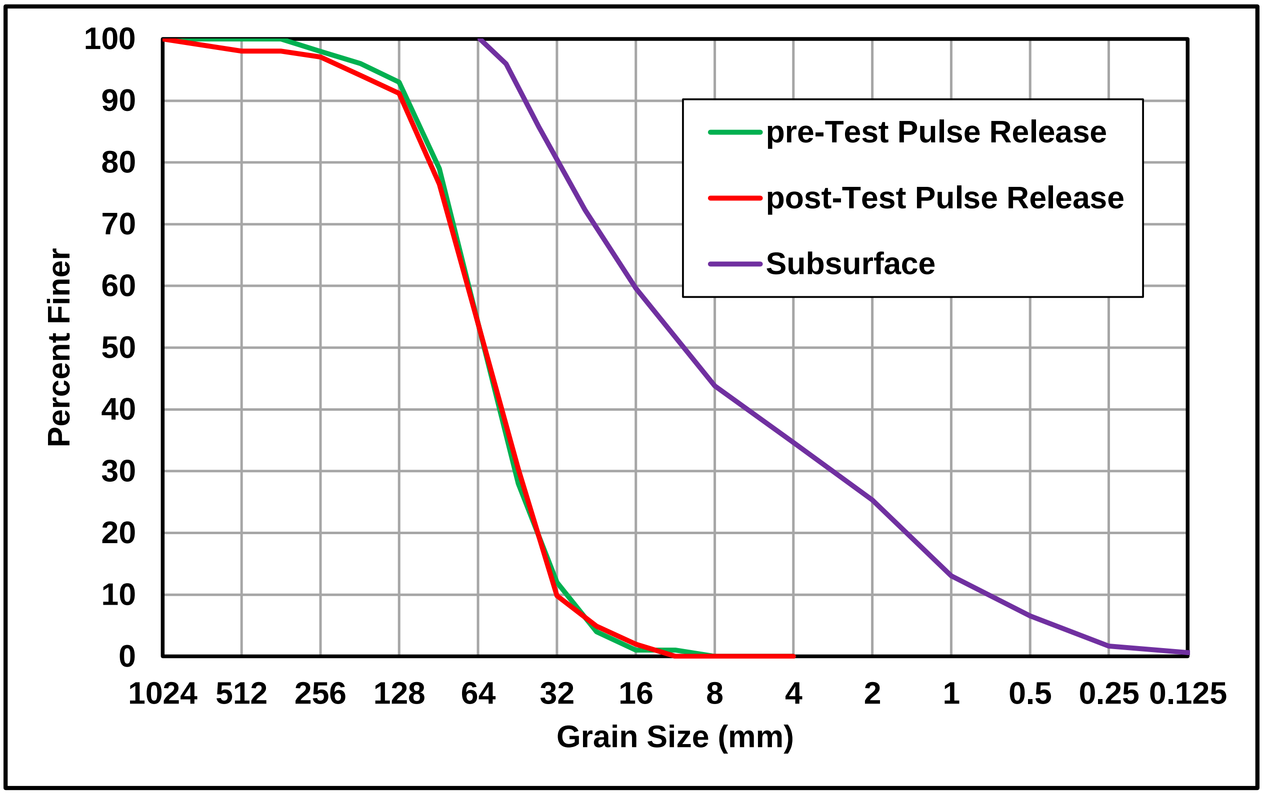
Bed surface gradations at cross section 17 (water too deep to safely sample in 2016)



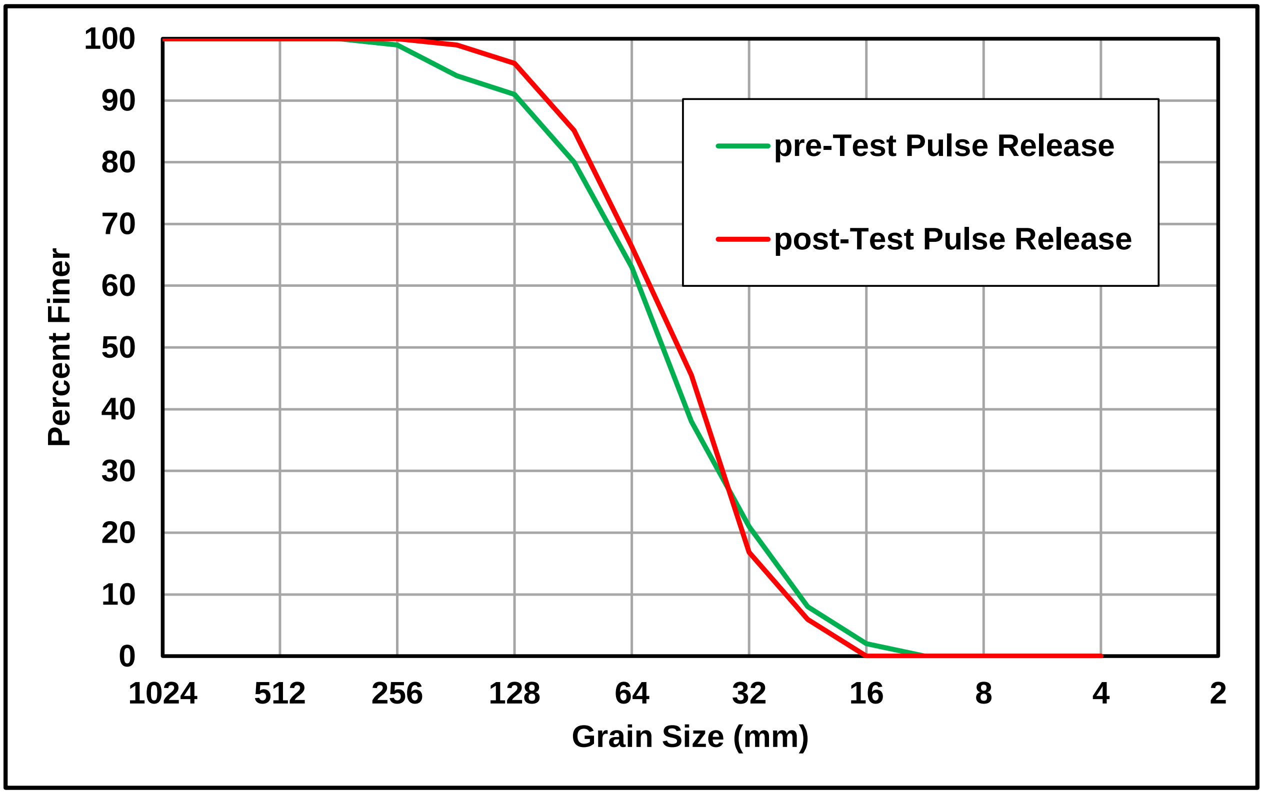
Bed surface gradations at cross section 15 (water too deep to safely sample in 2016)



Bed surface gradations at cross section 12



Bed surface gradations at cross section 9



Bed surface gradations at cross section 7

Pre-Test Pulse Flow Release Subsurface Sample
Approximately 100 lbs. collected near cross section 9
Total dry mass: 43,498.7 g

Sieve	Opening (mm)	Cumulative Mass Retained (g)	Cumulative Percent Finer
2.5”	63	0	100
2.0”	50	1,760.3	96.0
1.5”	37.5	6,191.6	85.8
1.0”	25	12,038.3	72.3
5/8”	16	17,559.0	59.6
5/16”	8	24,434.4	43.8
No. 5	4	28,434.4	34.6
No. 10	2	32,478.0	25.3
No. 18	1	37,813.1	13.1
No. 35	0.5	40,647.5	6.6
No. 60	0.25	42,762.4	1.7
No. 120	0.125	43,230.3	0.6
No. 230	0.0625	43,351.1	0.3

Appendix E. Photograph Points for Geomorphic Monitoring

Appendix E. Photograph Points for Geomorphic Monitoring

Figure No.	Cross Section	Description	Photograph Time	Flow (cfs)[1]
1	7 (Pre-Pulse)	riverward from pin	11/05/2015 02:07 PM	7
2	7 (Post-Pulse)	riverward from pin	7/1/2016 10:30 AM	28
3	7 (Pre-Pulse)	from left bank of side channel	11/5/2015 2:09 PM	7
4	7 (Post-Pulse)	from left bank of side channel	7/1/2016 10:32 AM	28
5	7 (Pre-Pulse)	downstream in side channel	11/5/2015 2:10 PM	7
6	7 (Post-Pulse)	downstream in side channel	7/1/2016 10:32 AM	28
7	7 (Pre-Pulse)	riverward from interior side channel	11/5/2015 2:11 PM	7
8	7 (Post-Pulse)	riverward from interior side channel	7/1/2016 10:34 AM	28
9	7 (Pre-Pulse)	riverward from left bank	11/5/2015 2:13 PM	7
10	7 (Post-Pulse)	riverward from left bank	7/1/2016 10:35 AM	28
11	7 (Pre-Pulse)	landward from left bank	11/5/2015 2:13 PM	7
12	7 (Post-Pulse)	landward from left bank	7/1/2016 10:35 AM	28
13	7 (Pre-Pulse)	upstream from below log jam	11/5/2015 2:15 PM	7
14	7 (Post-Pulse)	upstream from top of log jam	7/1/2016 10:36 AM	28
15	7 (Pre-Pulse)	downstream from above log jam	11/5/2015 2:14 PM	7
16	7 (Post-Pulse)	downstream from above log jam	7/1/2016 10:36 AM	28
17	7 (Pre-Pulse)	riverward from right bank	11/5/2015 2:16 PM	7
18	7 (Post-Pulse)	riverward from right bank	7/1/2016 10:37 AM	28
19	7 (Pre-Pulse)	landward from right bank	11/5/2015 2:16 PM	7
20	7 (Post-Pulse)	landward from right bank	7/1/2016 10:37 AM	28

Figure No.	Cross Section	Description	Photograph Time	Flow (cfs)[1]
21	7 (Pre-Pulse)	riverward from right pin	11/5/2015 2:19 PM	7
22	7 (Post-Pulse)	riverward from right pin	7/1/2016 10:39 AM	28
23	9 (Pre-Pulse)	riverward from left pin	11/05/2015 01:47 PM	7
24	9 (Post-Pulse)	riverward from left pin	7/1/2016 10:44 AM	28
25	9 (Pre-Pulse)	upstream in primary side channel	11/05/2015 01:46 PM	7
26	9 (Post-Pulse)	upstream in primary side channel	7/1/2016 10:47 AM	28
27	9 (Pre-Pulse)	riverward from left bank	11/05/2015 01:54 PM	7
28	9 (Post-Pulse)	riverward from left bank	7/1/2016 10:49 AM	28
29	9 (Pre-Pulse)	looking upstream	11/05/2015 01:55 PM	7
30	9 (Post-Pulse)	looking upstream	7/1/2016 10:50 AM	28
31	9 (Pre-Pulse)	looking downstream	11/05/2015 01:55 PM	7
32	9 (Post-Pulse)	looking downstream	7/1/2016 10:50 AM	28
33	9 (Pre-Pulse)	riverward from right bank	11/05/2015 01:57 PM	7
34	9 (Post-Pulse)	riverward from right bank	7/1/2016 10:50 AM	28
35	9 (Pre-Pulse)	landward from right bank	11/05/2015 01:57 PM	7
36	9 (Post-Pulse)	landward from right bank	7/1/2016 10:50 AM	28
37	9 (Pre-Pulse)	riverward from right pin	11/05/2015 01:59 PM	7
38	9 (Post-Pulse)	riverward from right pin	7/1/2016 10:52 AM	28
39	12 (Pre-Pulse)	riverward from left pin	11/05/2015 01:21 PM	7
40a	12 (Post-Pulse)	riverward from left pin	7/1/2016 10:55 AM	28
40b	12 (Post-Pulse)	riverward towards side channel (compare to Figure 39)	7/1/2016 10:56 AM	28

Figure No.	Cross Section	Description	Photograph Time	Flow (cfs)[1]
41	12 (Pre-Pulse)	landward from left bank	11/05/2015 01:22 PM	7
42	12 (Post-Pulse)	landward from left bank	7/1/2016 10:57 AM	28
43	12 (Pre-Pulse)	riverward from left bank	11/05/2015 01:22 PM	7
44	12 (Post-Pulse)	riverward from left bank	7/1/2016 10:57 AM	28
45	12 (Pre-Pulse)	looking upstream	11/05/2015 01:23 PM	7
46	12 (Post-Pulse)	looking upstream	7/1/2016 10:58 AM	28
47	12 (Pre-Pulse)	riverward from right pin	11/05/2015 01:25 PM	7
48	12 (Post-Pulse)	riverward from right pin	7/1/2016 10:59 AM	28
49	15 (Pre-Pulse)	riverward from left bank	10/9/2015 11:30 AM	7
50	15 (Post-Pulse)	riverward from left bank	7/1/2016 11:08 AM	28
51	15 (Pre-Pulse)	looking upstream	10/9/2015 11:31 AM	7
52	15 (Post-Pulse)	looking upstream	7/1/2016 11:06 AM	28
53	15 (Pre-Pulse)	riverward from right bank	10/9/2015 11:29 AM	7
54	15 (Post-Pulse)	riverward from right bank	7/1/2016 11:05 AM	28
55	17 (Pre-Pulse)	riverward from left end of log jam	10/9/2015 11:25 AM	7
56	17 (Post-Pulse)	riverward from left end of log jam	7/1/2016 11:18 AM	28
57	17 (Pre-Pulse)	looking upstream from log jam	10/9/2015 11:24 AM	7
58	17 (Post-Pulse)	looking upstream from log jam	7/1/2016 11:19 AM	28
59	17 (Pre-Pulse)	looking downstream from log jam	10/9/2015 11:24 AM	7
60	17 (Post-Pulse)	looking downstream from log jam	7/1/2016 11:19 AM	28
61	17 (Pre-Pulse)	riverward from right end of log jam	10/9/2015 11:23 AM	7

Figure No.	Cross Section	Description	Photograph Time	Flow (cfs)[1]
62	17 (Post-Pulse)	riverward from right end of log jam	7/1/2016 11:20 AM	28
63	19 (Pre-Pulse)	riverward from left pin	10/9/2015 11:11 AM	7
64	19 (Post-Pulse)	riverward from left pin	7/1/2016 11:25 AM	28
65	19 (Pre-Pulse)	riverward from left bank	10/9/2015 11:13 AM	7
66	19 (Post-Pulse)	riverward from left bank	7/1/2016 11:27 AM	28
67	19 (Pre-Pulse)	looking upstream (flagging at section)	10/9/2015 11:14 AM	7
68	19 (Post-Pulse)	looking upstream	7/1/2016 11:27 AM	28
69	19 (Pre-Pulse)	looking downstream (flagging at section)	10/9/2015 11:15 AM	7
70	19 (Post-Pulse)	looking downstream	7/1/2016 11:27 AM	28
71	19 (Pre-Pulse)	riverward from right bank	10/9/2015 11:15 AM	7
72	19 (Post-Pulse)	riverward from right bank	7/1/2016 11:26 AM	28
73	21 (Pre-Pulse)	riverward from left pin	10/7/2015 5:15 PM	7
74	21 (Post-Pulse)	riverward from left pin	7/1/2016 11:30 AM	28
75	21 (Pre-Pulse)	riverward from left bank	10/7/2015 5:16 PM	7
76	21 (Post-Pulse)	riverward from left bank	7/1/2016 11:30 AM	28
77	21 (Pre-Pulse)	looking upstream	10/7/2015 5:18 PM	7
78	21 (Post-Pulse)	looking upstream	7/1/2016 11:31 AM	28
79	21 (Pre-Pulse)	looking downstream	10/7/2015 5:19 PM	7
80	21 (Post-Pulse)	looking downstream	7/1/2016 11:31 AM	28
81	21 (Pre-Pulse)	riverward from right bank	10/7/2015 5:19 PM	7
82	21 (Post-Pulse)	riverward from right bank	7/1/2016 11:32 AM	28

Figure No.	Cross Section	Description	Photograph Time	Flow (cfs)[1]
83	21 (Pre-Pulse)	riverward from right pin	10/7/2015 5:22 PM	7
84	21 (Post-Pulse)	riverward from right pin	7/1/2016 11:34 AM	28
85	22 (Pre-Pulse)	riverward from left pin	10/7/2015 2:52 PM	7
86	22 (Post-Pulse)	riverward from left pin	7/1/2016 11:38 AM	28
87	22 (Pre-Pulse)	riverward from left bank	10/7/2015 2:54 PM	7
88	22 (Post-Pulse)	riverward from left bank	7/1/2016 11:38 AM	28
89	22 (Pre-Pulse)	looking upstream	10/7/2015 2:56 PM	7
90	22 (Post-Pulse)	looking upstream	7/1/2016 11:37 AM	28
91	22 (Pre-Pulse)	looking downstream (flagging at section)	10/7/2015 2:57 PM	7
92	22 (Post-Pulse)	looking downstream	7/1/2016 11:37 AM	28
93	22 (Pre-Pulse)	riverward from right bank	10/7/2015 2:58 PM	7
94	22 (Post-Pulse)	riverward from right bank	7/1/2016 11:36 AM	28
95	22 (Pre-Pulse)	riverward from right pin	10/7/2015 3:02 PM	7
96	22 (Post-Pulse)	riverward from right pin	7/1/2016 11:35 AM	28

Note:

[1] Provisional flow as measured at the USGS gaging station (11429500) at the time the photograph was taken.

Figure 1. **Pre-pulse, cross section 7, facing riverward from left pin**

Figure 2. **Post-pulse, cross section 7, facing riverward from left pin**

Figure 3 **Pre-pulse, cross section 7, facing riverward from left bank of side channel**

Figure 4. **Post-pulse, cross section 7, facing riverward from left bank of side channel**

Figure 5. **Pre-pulse, cross section 7, facing downstream in side channel**

Figure 6. **Post-pulse, cross section 7, facing downstream in side channel**

Figure 7. **Pre-pulse, cross section 7, facing riverward from interior side channel**

Figure 8. **Post-pulse, cross section 7, facing riverward from interior side channel**

Figure 9. Pre-pulse, cross section 7, facing riverward from left bank

Figure 10. Post-pulse, cross section 7, facing riverward from left bank

Figure 11. Pre-pulse, cross section 7, facing landward from left bank

Figure 12. Post-pulse, cross section 7, facing landward from left bank

Figure 13. Pre-pulse, cross section 7, facing upstream from downstream of log jam

Figure 14. Post-pulse, cross section 7, facing upstream from top of log jam

Figure 15. **Pre-pulse, cross section 7, facing downstream from upstream of log jam**

Figure 16. **Post-pulse, cross section 7, facing downstream from top of log jam**

Figure 17. Pre-pulse, cross section 7, facing riverward from right bank

Figure 18. Post-pulse, cross section 7, facing riverward from right bank

Figure 19. **Pre-pulse, cross section 7, facing landward from right bank**

Figure 20. **Post-pulse, cross section 7, facing landward from right bank**

Figure 21. Pre-pulse, cross section 7, facing riverward from right pin

Figure 22. Post-pulse, cross section 7, facing riverward from right pin

Figure 23. **Pre-pulse, cross section 9, facing riverward from left pin**

Figure 24. **Post-pulse, cross section 9, facing riverward from left pin**

Figure 25. Pre-pulse, cross section 9, facing upstream in primary side channel

Figure 26. Post-pulse, cross section 9, facing upstream in primary side channel

Figure 27. **Pre-pulse, cross section 9, facing riverward from left bank**

Figure 28. **Post-pulse, cross section 9, facing riverward from left bank**

Figure 29. **Pre-pulse, cross section 9, facing upstream**

Figure 30. **Post-pulse, cross section 9, facing upstream**

Figure 31. **Pre-pulse, cross section 9, facing downstream**

Figure 32. **Post-pulse, cross section 9, facing downstream**

Figure 33. **Pre-pulse, cross section 9, facing riverward from right bank**

Figure 34. **Post-pulse, cross section 9, facing riverward from right bank**

Figure 35. Pre-pulse, cross section 9, facing landward from right bank

Figure 36. Post-pulse, cross section 9, facing landward from right bank

Figure 37. Pre-pulse, cross section 9, facing riverward from right pin

Figure 38. Post-pulse, cross section 9, facing riverward from right pin

Figure 39. **Pre-pulse, cross section 12, facing riverward from left pin**

Figure 40a. **Post-pulse, cross section 12, facing riverward from left pin**

Figure 40b. Post-pulse, cross section 12, facing riverward towards side channel (compare to Figure 39)

Figure 41. **Pre-pulse, cross section 12, facing landward from left bank**

Figure 42. **Post-pulse, cross section 12, facing landward from left bank**

Figure 43. Pre-pulse, cross section 12, facing riverward from left bank

Figure 44. Post-pulse, cross section 12, facing riverward from left bank

Figure 45. **Pre-pulse, cross section 12, facing upstream**

Figure 46. **Post-pulse, cross section 12, facing upstream**

Figure 47. **Pre-pulse, cross section 12, facing riverward from right pin**

Figure 48. **Post-pulse, cross section 12, facing riverward from right pin**

Figure 49. **Pre-pulse, cross section 15, facing riverward from left bank**

Figure 50. **Post-pulse, cross section 15, facing riverward from left bank**

Figure 51. **Pre-pulse, cross section 15, facing upstream**

Figure 52. **Post-pulse, cross section 15, facing upstream**

Figure 53. Pre-pulse, cross section 15, facing riverward from right bank

Figure 54. Post-pulse, cross section 15, facing riverward from right bank

Figure 55. **Pre-pulse, cross section 17, facing riverward from left end of log jam**

Figure 56. **Post-pulse, cross section 17, facing riverward from left end of log jam**

Figure 58. **Pre-pulse, cross section 17, facing upstream from log jam**

Figure 58. **Post-pulse, cross section 17, facing upstream from log jam**

Figure 59. Pre-pulse, cross section 17, facing downstream from log jam

Figure 60. Post-pulse, cross section 17, facing downstream from log jam

Figure 61. Pre-pulse, cross section 17, facing riverward from right end of log jam

Figure 62. Post-pulse, cross section 17, facing riverward from right end of log jam

Figure 63. Pre-pulse, cross section 19, facing riverward from left pin

Figure 64. Post-pulse, cross section 19, facing riverward from left pin

Figure 65. **Pre-pulse, cross section 19, facing riverward from left bank**

Figure 66. **Post-pulse, cross section 19, facing riverward from left bank**

Figure 67. **Pre-pulse, cross section 19, facing upstream (flagging at section)**

Figure 68. **Post-pulse, cross section 19, facing upstream**

Figure 69. **Pre-pulse, cross section 19, facing downstream (flagging at section)**

Figure 70. **Post-pulse, cross section 19, facing downstream**

Figure 71. Pre-pulse, cross section 19, facing riverward from right bank

Figure 72. Post-pulse, cross section 19, facing riverward from right bank

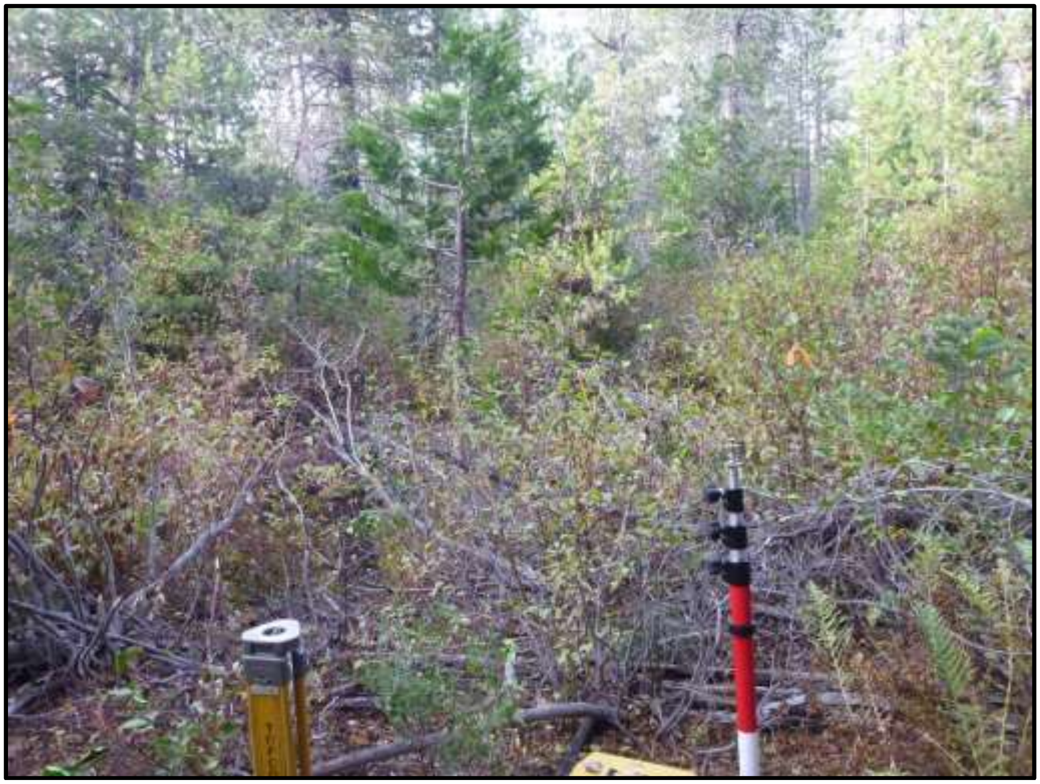


Figure 73. **Pre-pulse, cross section 21, facing riverward from left pin**

Figure 74. **Post-pulse, cross section 21, facing riverward from left pin**

Figure 75. Pre-pulse, cross section 21, facing riverward from left bank

Figure 76. Post-pulse, cross section 21, facing riverward from left bank

Figure 77. **Pre-pulse, cross section 21, facing upstream**

Figure 78. **Post-pulse, cross section 21, facing upstream**

Figure 79. **Pre-pulse, cross section 21, facing downstream**

Figure 80. **Post-pulse, cross section 21, facing downstream**

Figure 81. Pre-pulse, cross section 21, facing riverward from right bank

Figure 82. Post-pulse, cross section 21, facing riverward from right bank

Figure 83. **Pre-pulse, cross section 21, facing riverward from right pin**

Figure 84. **Post-pulse, cross section 21, facing riverward from right pin**

Figure 85. **Pre-pulse, cross section 22, facing riverward from left pin**

Figure 86. **Post-pulse, cross section 22, facing riverward from left pin**

Figure 87. Pre-pulse, cross section 22, facing riverward from left bank

Figure 88. Post-pulse, cross section 22, facing riverward from left bank

Figure 89. Pre-pulse, cross section 22, facing upstream

Figure 90. Post-pulse, cross section 22, facing upstream

Figure 91. **Pre-pulse, cross section 22, facing downstream (flagging at section)**

Figure 92. **Post-pulse, cross section 22, facing downstream**

Figure 93. Pre-pulse, cross section 22, facing riverward from right bank

Figure 94. Post-pulse, cross section 22, facing riverward from right bank

Figure 95. Pre-pulse, cross section 22, facing riverward from right pin

Figure 96. Post-pulse, cross section 22, facing riverward from right pin

Appendix F. Detailed Riparian Vegetation Community Mapping Results

Provided a separate Excel file
<<AppendixF. Detailed Riparian Vegetation Community Mapping Results.xlsx>>

Appendix G. Photograph Points for Riparian Vegetation Monitoring

7L From left bank facing right bank—October 7, 2015

7L From left bank facing right bank—June 30, 2016

7L From left bank facing transect—October 7, 2015

7L From left bank facing transect—June 30, 2016

7L From end of transect facing creek—October 7, 2015

7L.3 From end of transect facing creek—June 30, 2016

7L From end of transect facing away from creek—October 7, 2015

7L From end transect facing away from creek—June 30, 2016

Riparian Study Area Photo Points

7R From right bank facing left bank—October 7, 2015

7R From right bank facing left bank—June 30, 2016

7R From right bank facing transect—October 7, 2015

7R From right bank facing transect—June 30, 2016

Riparian Study Area Photo Points

7R From end of transect facing away from creek—October 7, 2015

7R From end of transect facing away from creek—June 30, 2016

7R From end of transect facing creek—October 7, 2015

7R From end of transect facing creek—June 30, 2016

Riparian Study Area Photo Points

9L From left bank facing right bank—October 8, 2015

9L From left bank facing right bank—June 30, 2016

9L From left bank facing transect—October 8, 2015

9L From left bank facing transect—June 30, 2016

Riparian Study Area Photo Points

9L From end of transect facing away from creek—October 8, 2015

9L From end of transect facing away from creek—June 30, 2016

9L From end of transect facing creek—October 8, 2015

9L From end of transect facing creek—June 30, 2016

Riparian Study Area Photo Points

9R From right bank facing left bank—October 8, 2015

9R From right bank facing left bank—June 29, 2016

9R From right bank facing transect—October , 2015

9R From right bank facing transect—June 29, 2016

Riparian Study Area Photo Points

9R From end of transect facing away from creek—October 8, 2015

9R From end of transect facing away from creek—June 29, 2016

9R From end of transect facing creek—October 8, 2015

9R From end of transect facing creek—June 29, 2016

Riparian Study Area Photo Points

12L From left bank facing right bank—October 7, 2015

12L From left bank facing right bank—June 30, 2016

12L From left bank facing transect—October 7, 2015

12L From left bank facing transect—June 30, 2016

12L From end of transect facing away from creek—October 8, 2015

12L From end of transect facing away from creek—June 30, 2016

12L From end of transect facing creek—October 8, 2015

12L From end of transect facing creek—June 30, 2016

12R From right bank facing left bank—October 7, 2015

12R From right bank facing left bank—June 29, 2016

12R From right bank facing transect—October 7, 2015

12R From right bank facing transect—June 29, 2016

12R From end of transect facing creek—October 7, 2015

12R From end of transect facing creek—June 29, 2016

12R From end of transect facing away from creek—October 7, 2015

12R From end of transect facing away from creek—June 29, 2016

Riparian Study Area Photo Points

15L From left bank facing right bank—October 8, 2015

15L From left bank facing right bank—June 30, 2016

15L From left bank facing transect—October 8, 2015

15L From left bank facing transect—June 30, 2016

Riparian Study Area Photo Points

15L From end of transect facing creek—October 8, 2015

15L From end of transect facing creek—June 30, 2016

15L From end of transect facing away from creek—October 8, 2015

15L From end of transect facing away from creek—June 30, 2016

Riparian Study Area Photo Points

15R From right bank facing left bank—October 8, 2015

15R From right bank facing left bank—June 29, 2016

15R From right bank facing transect—October 8, 2015

15R From right bank facing transect—June 29, 2016

Riparian Study Area Photo Points


15R From end of transect facing away from creek—October 8, 2015


15R From end of transect facing away from creek—June 29, 2016


15R From end of transect facing creek—October 8, 2015


15R From end of transect facing creek—June 29, 2016

Riparian Study Area Photo Points

17L From left bank facing right bank—October 8, 2015

17L From left bank facing right bank—June 30, 2016

17L From left bank facing transect—October 8, 2015

17L From left bank facing transect—June 30, 2016

17L From end of transect facing creek—October 8, 2015

17L From end of transect facing creek—June 30, 2016

17L From end of transect facing away from creek—October 8, 2015

17L From end of transect facing away from creek—June 30, 2016

Riparian Study Area Photo Points

17R From end of transect facing away from creek—October 8, 2015

17R From end of transect facing away from creek—June 28, 2016

17R From end of transect facing creek—October 8, 2015

17R From end of transect facing creek—June 30, 2016

Riparian Study Area Photo Points


17R From right bank facing left bank—October 8, 2015


17R From right bank facing left bank—June 28, 2016


17R From right bank facing transect—October 8, 2015


17R From right bank facing transect—June 30, 2016

19L From left bank facing right bank—October 8, 2015

19L From left bank facing right bank—June 30, 2016

19L From left bank facing transect—October 8, 2015

19L From left bank facing transect—June 30, 2016

19L From end of transect facing creek—October 8, 2015

19L From end of transect facing creek—June 30, 2016

19L From end of transect facing away from creek—October 8, 2015

19L From end of transect facing away from creek—June 30, 2016


19R From right bank facing left bank—October 8, 2015


19R From right bank facing left bank—June 28, 2016


19R From right bank facing transect—October 8, 2015


19R From right bank facing transect—June 28, 2016

Riparian Study Area Photo Points


19R From end of transect facing creek—October 8, 2015


19R From end of transect facing creek—June 28, 2016


19R From end of transect facing away from creek—October 8, 2015


19R From end of transect facing away from creek—June 28, 2016

21L From left bank facing right bank—October 8, 2015

21L From left bank facing right bank—July 1, 2016

21L From left bank facing transect—October 8, 2015

21L From left bank facing transect—July 1, 2016

Riparian Study Area Photo Points


21L From end of transect facing creek—October 8, 2015


21L From end of transect facing creek—July 1, 2016


21L From end of transect facing away from creek—October 8, 2015


21L From end of transect facing away from creek—July 1, 2016

Riparian Study Area Photo Points


21R From right bank facing left bank—October 8, 2015


21R From right bank facing left bank—June 28, 2016


21R From right bank facing transect—October 8, 2015


21R From right bank facing transect—June 28, 2016

21R From end of transect facing creek—October 8, 2015

21R From end of transect facing creek—June 28, 2016

21R From end of transect facing away from creek—October 8, 2015

21R From end of transect facing away from creek—June 28, 2016

22L From left bank facing right bank—October 8, 2015

22L From left bank facing right bank—July 1, 2016

22L From left bank facing transect—October 8, 2015

22L From left bank facing transect—July 1, 2016

Riparian Study Area Photo Points

22L From end of transect facing creek—October 8, 2015

22L From end of transect facing creek—July 1, 2016

22L From end of transect facing away from creek—October 8, 2015

22L From end of transect facing away from creek—July 1, 2016

Riparian Study Area Photo Points


22R From right bank facing left bank—October 8, 2015


22R From right bank facing left bank—June 28, 2016


22R From right bank facing transect—October 8, 2015


22R From right bank facing transect—June 28, 2016

22R From end of transect facing creek—October 8, 2015

22R From end of transect facing creek—June 28, 2016

22R From end of transect facing away from creek—October 8, 2015

22R From end of transect facing away from creek—June 28, 2016

Riparian Study Area Photo Points

Greenline right bank at upstream monument facing upstream—Oct. 14, 2015

Greenline right bank at upstream monument facing upstream—June 29, 2016

Greenline right bank at upstream monument facing downstream—Oct. 14, 2015

Greenline right bank at upstream monument facing downstream—June 29, 2016

Greenline Study Area Photo Points

Greenline right bank at downstream monument facing upstream—
October 14, 2015

Greenline right bank at downstream monument facing upstream—
June 29, 2016

Greenline right bank at downstream monument facing downstream—
October 14, 2015

Greenline right bank at downstream monument facing downstream—
June 29, 2016

Greenline Study Area Photo Points

Greenline left bank at downstream monument facing upstream—October 14, 2015

Greenline left bank at downstream monument facing upstream—June 29, 2016

Greenline left bank at downstream monument facing downstream—October 14, 2015

Greenline left bank at downstream monument facing downstream—June 29, 2016

Greenline Study Area Photo Points

Greenline left bank at upstream monument facing upstream—October 14, 2015

Greenline left bank at upstream monument facing upstream— June 29, 2016

Greenline left bank at upstream monument facing downstream—October 14, 2015

Greenline left bank at upstream monument facing downstream—June 29, 2016

Greenline Study Area Photo Points