Klamath Hydroelectric Project
FERC Project No. 2082

Klamath Hydroelectric Settlement Agreement
Interim Measure 7
J.C. Boyle Gravel Monitoring Report
2011

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September, 2012

KLAMATH HYDROELECTERIC PROJECT SETTLEMENT AGREEMENT INTERIM MEASURE 7 J.C. BOYLE 2011 GRAVEL MONITORING REPORT

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1 INTRODUCTION

1.1 PROJECT DESCRIPTION

PacifiCorp Energy (PacifiCorp) owns and operates the Klamath Hydroelectric Project (Project), located on the upper Klamath River in Klamath County (south-central Oregon) and Siskiyou County (north-central California). The Project has five dams on the Klamath River.- Keno, J.C. Boyle, Copco 1, Copco 2, and Iron Gate and one dam on the Fish Creek tributary. The Link River dam is owned by the U.S. Bureau of Reclamation. A map of the Project area is shown below (Figure 1.1-1).

Figure 1.1-1. Location map.

1.2 BACKGROUND

On February 18, 2010, the United States, the States of California and Oregon, PacifiCorp, Tribes, and a number of other stakeholder groups signed the Klamath Hydroelectric Settlement Agreement (KHSA). The KHSA includes provisions and detailed actions for the interim operation of PacifiCorp's dams and mitigation activities prior to removal of the dams or the termination of the KHSA. One of the measures, titled Interim Measure 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement, requires habitat restoration in the J.C. Boyle bypass and peaking reaches.

As described in Interim Measure 7 of the KHSA, PacifiCorp is to provide funding annually for the planning, permitting, and implementation of gravel placement and habitat enhancement projects, including related monitoring, in the Klamath River above Copco Reservoir and below J.C. Boyle dam. The key objective of this measure is to place suitable gravels in the J.C. Boyle bypass and peaking reaches for existing trout and potential future salmon spawning and ecological restoration purposes. The full text of Interim Measure 7 is included below.

Interim Measure 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement

> Beginning on the Effective Date and continuing through decommissioning of the J.C. Boyle Facility, PacifiCorp shall provide funding of $150,000 per year, subject to adjustment for inflation as set forth in Section 6.1.5 of the Settlement, for the planning, permitting, and implementation of gravel placement or habitat enhancement projects, including related monitoring, in the Klamath River above Copco Reservoir.
>
> Within 90 days of the Effective Date, PacifiCorp, in consultation with the IMIC, shall establish and initiate a process for identifying such projects to the Committee, and, upon approval of a project by the Committee, issuing a contract or providing funding to a third party approved by the Committee for implementation of the project.
>
> The objective of this Interim Measure is to place suitable gravels in the J.C. Boyle bypass and peaking reach using a passive approach before high flow periods, or to provide for other habitat enhancement providing equivalent fishery benefits in the Klamath River above Copco Reservoir. Projects undertaken before the Secretarial Determination shall be located outside the FERC project boundary.

Interim Measure 7 falls under the auspices of the Interim Measures Implementation Committee (IMIC). The IMIC is comprised of state, federal, tribal and private signatories to the KHSA whose purpose is to collaborate with PacifiCorp on ecological and other issues related to the implementation of several Interim Measures as set forth in Appendix D of the KHSA. The IMIC formed a technical subcommittee comprised of representatives from the Oregon Department of Fish and Wildlife (ODFW), Oregon Department of Water Resources (ODWR), the Klamath Tribes, PacifiCorp, and the Bureau of Land Management (BLM) to discuss the goals, objectives, regulatory requirements, and planning for Interim Measure 7. This subcommittee recommended the development of a long term gravel enhancement plan that would cover the expected time period (2010-2020) for implementation of Interim Measure 7.

Per the KHSA, PacifiCorp developed the J.C. Boyle Gravel Placement and Monitoring Plan (Plan) in the spring of 2011 (Mason, Bruce and Girard, et al. 2011). The Plan details monitoring objectives, methods for both gravel placement and monitoring, and annual reporting requirements. In November 2011, approximately 500 cubic yards of gravel was placed at 2 locations in the Klamath River below the J.C. Boyle powerhouse (J.C. Boyle peaking reach). This document describes the first year of monitoring (2011-2012) under Interim Measure 7.

1.3 MONITORING OBJECTIVES

The monitoring objectives outlined in the Plan include assessments of both the implementation and effectiveness of gravel enhancements under Interim Measure 7. Field observations related to implementation were intended to answer three primary questions:

1. Were placement methods cost-effective and implemented within the proposed budget constraints?

2. Were placement procedures safe and effective for getting gravel placed in the intended locations and quantities?

3. Were there any unanticipated problems in either the implementation or the effectiveness of the placements?

Effectiveness monitoring was intended to evaluate whether the placed gravel distributed and sorted as intended given the flow regime experienced during the performance period (November through early July). Effectiveness monitoring was designed to provide data to answer the following specific gravel distribution/sorting questions for each gravel placement site:

- Did the flows that occurred since the previous gravel placement result in movement (scour) of the placed gravel?

- Did the flows that occurred since the previous gravel placement result in a change in channel cross section (net scour or aggradation) across the gravel placement site or some distance downstream?

- Did the gravel placement result in a change in substrate composition across the gravel placement site or some distance downstream?

Methods used for both implementation and effectiveness monitoring are described below.

2 METHODS

2.1.1 Implementation Monitoring

Implementation of the gravel placement was addressed primarily through a questionnaire given to PacifiCorp's project manager, PacifiCorp's project engineer, and the gravel placement contractor foreman. Responses addressed gravel quantities, the methods and safety of gravel placement activities, and any recommended actions to improve placement methods or related operations.

2.1.2 Effectiveness Monitoring

Effectiveness monitoring methods were designed to determine whether placed gravel distributed and sorted as intended given the flow regime experienced during the monitoring period.

At each gravel placement site, three transects were established for cross section and substrate composition measurements: one transect within the gravel placement area; a second approximately 50-100 feet downstream; and a third in the next suitable habitat unit (e.g., pool tailout, riffle) downstream. At each transect, two to three headpins were established to allow the same transect to be re-monitored each year. A permanent benchmark was also established at each gravel augmentation site using a bolt in a small concrete pad. The headpin and benchmark locations were recorded in GPS, triangulated from obvious landmarks, and photographed to assist with future relocation.

Using a laser level and survey rod, each of the transects was surveyed along a tape strung between the end pins. The elevation relative to the benchmark was recorded at 2-foot intervals at elevations above the normal wetted channel, and one-foot intervals within the channel. At each survey station within the normal wetted water channel, the particle at the base of the survey rod was picked up and passed through a gravelometer to measure grain size and replaced on the bed. Surveying continued across the entire transect if possible. Deep/fast water precluded measurement across the entire length of some transects; measurements were made as far as safely possible along these transects.

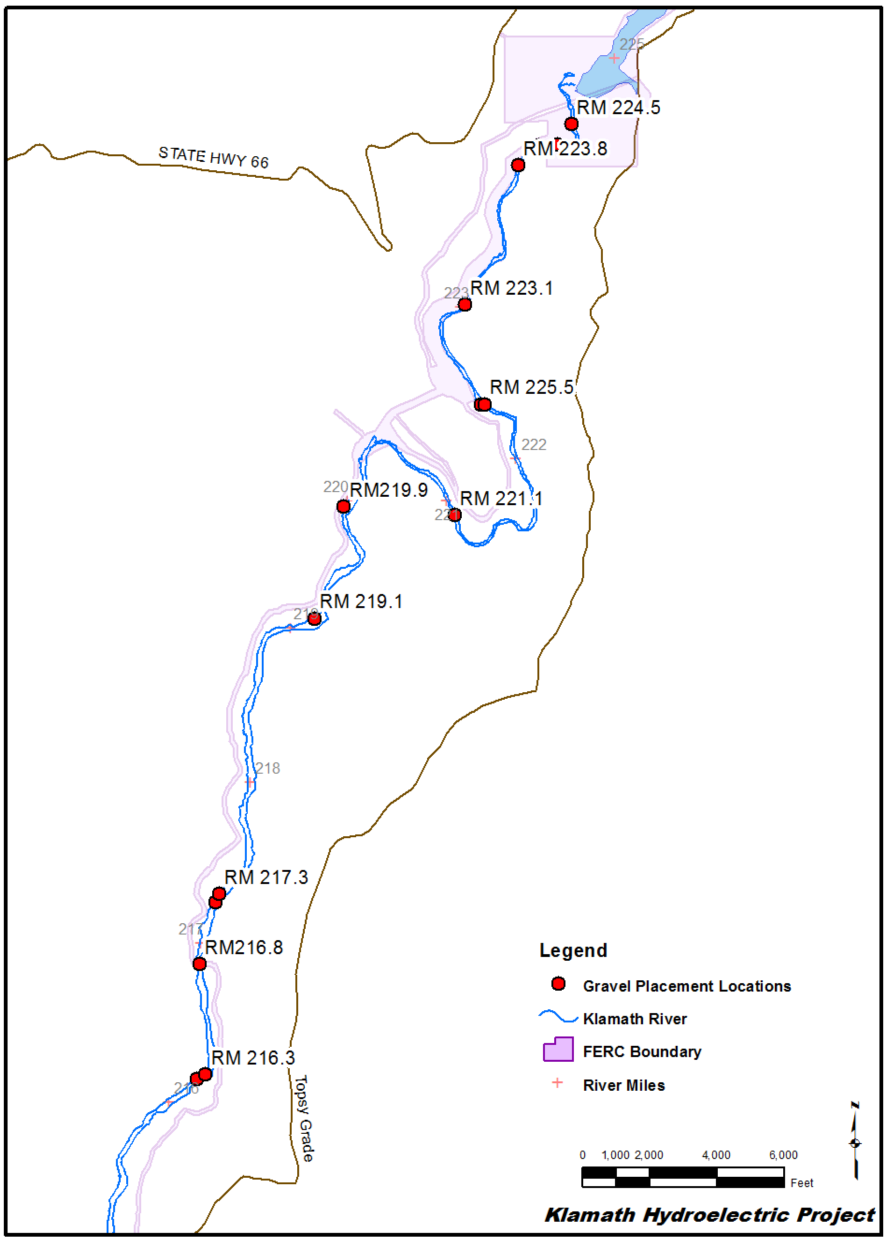
Transects across the intended gravel placement areas were surveyed just before gravel placement in November 2011. All three transects at each site were surveyed immediately following gravel placement on November 16-17, 2011 and again on July 10-11, 2012. Results were recorded and entered into a spreadsheet program for analysis.

Four sliding bead scour monitors (Shuett-Hames et al. 1999) were inserted within the gravel along/close to the transect intersecting each gravel placement area on November 16-17, 2011 (Figure 2.1-1). Depth of scour and fill were recorded for each monitor on July 10-11, 2012.

Figure 2.1-1. Scour monitor placement.

3 RESULTS

Approximately 250 cubic yards of gravel was placed at each of two sites in the J.C. Boyle peaking reach in November 2011: RM 217.3 and RM 216.3 (Figure 3.1-1). These sites were monitored in July 2012 to determine: 1) if flows during the intervening time had transported any gravel; and 2) if additional gravel should be added to the sites where gravel had been placed in 2011.



Produced by Watershed GeoDynamics for PACIFICORP ENERGY ©February 2011 PacifiCorp

Figure 3.1-1. Potential gravel placement locations identified in monitoring plan.

3.1 POST-PLACEMENT FLOWS

Both 2011 gravel placement sites are located in the peaking reach downstream of the J.C. Boyle powerhouse. Fifteen-minute flows at the USGS gage downstream of the J.C. Boyle powerhouse (USGS 1151070) were collected from the USGS website. These flows are provisional and have not been finalized by the USGS. Post gravel placement flows (mid November through early July) ranged from 367 to 4,030 cfs (Figure 3.1-2). Spill at the J. C. Boyle dam resulted in flows of 3,000 – 3,500 cfs in April and early May, which are above normal daily operation flows. The peak instantaneous flow of 4,030 occurred on May 28, 2012.

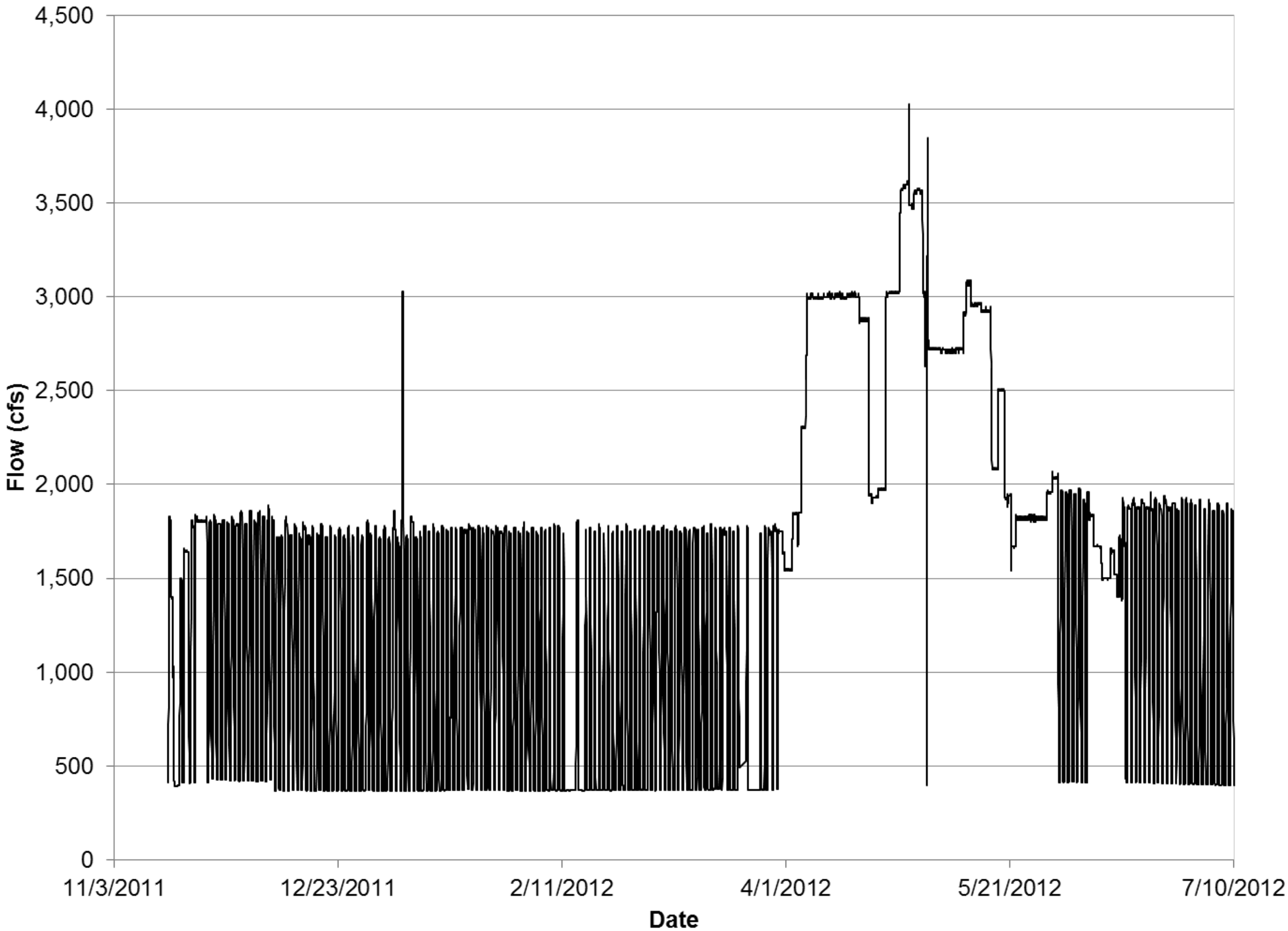


Figure 3.1-2. Post-placement flows at USGS gage 1151070, November 2011 – July 2012

3.2 IMPLEMENTATION MONITORING

Implementation monitoring questionnaires were filled out by the PacifiCorp project engineer, project manager, and the construction foreman to determine the amount of gravel placed, placement costs, and any efficiency/safety issues. Responses are compiled below (Table 3.2-1). Approximately 250 cubic yards of gravel were placed using two gravel shooter trucks at each of two selected sites at an average cost of $158/cubic yard. No safety issues or major problems were encountered during placement. At one location, a steep section of wet, unsurfaced road hindered access; scheduling placement earlier in the fall would help minimize the likelihood of wet conditions.

It was also noted that the stockpile location used (along the powerline route near JC Boyle dam) was far from the two sites where gravel was placed in 2011, resulting in a long travel time for the gravel trucks. This stockpile location could not be used for helicopter placement due to the nearby powerlines.

Table 3.2-1. Implementation monitoring questions.

Monitoring Question	2011 Results
How may cubic yards of gravel were placed at each site?	250 cubic yards at each of 2 sites
What was the average cost/yard of gravel placement?	Approximately $158/cu yard
Were the placement methods (truck/helicopter) able to place gravel where planned?	Yes; gravel shooting trucks were used.
Were any safety issues encountered?	No
Were any problems encountered during placement?	No major problems; minor problem with one steep section of wet road
Are there any recommendations to improve placement methods in the future?	• Closer/better stockpile location(s) would minimize any issues with powerlines (for helicopter placement sites) and travel time between stockpile and placement area. • Performing placement work earlier in fall would minimize likelihood of working during wet road conditions.

3.3 EFFECTIVENESS MONITORING

Bedload transport calculations performed during relicensing studies at RM 217.3 suggested that flows of 3,100 cfs could initiate transport of 0.5 inch (12.7 mm) rocks, and flows above 5,900 to 21,000 cfs could move 1 to 3 inch (25.4 to 76.2 mm) rocks, respectively, at this site (PacifiCorp 2004, 2005). This was within the range of the gravel added in 2011. Since high spring 2012 flows were in the 3,000-3,500 range with an instantaneous peak of 4,100 cfs, it was not anticipated that much of the placed gravel would be transported during the monitoring period. Results of effectiveness monitoring at each of the two sites are described below.

3.3.1 BLM Klamath Campground Site RM 217.3

The RM 217.3 site is located at the BLM Klamath Campground (Figures 3.1-1 and 3.3-1).

Location: Peaking reach, RM 217.3

Type of placement: Truck

Habitat Description: Boulder/cobble pool tailout and glide. Average wetted width 175 feet; average local gradient 0.003.

Placement volume: 250 cu yd.

Figure 3.3-1. Photo of placed gravel at RM 217.3.

Three transects were monitored at the RM 217.3 site; one transect across the gravel placement area (T1), one transect approximately 80 feet downstream (T2), and a third transect another 250 feet downstream (T3). Pre- and post- gravel placement cross sections (November 9 and 17, 2011, respectively) showed gravel was placed 1-1.5 feet deep across T1. The post-monitoring survey results suggest that minimal transport of placed gravel occurred during spring high flows (Figure 3.3-2). Elevations on the placed gravel were 0.5 to 4 inches lower in July 2012 than in November 2011. Scour monitors were placed at T1 stations 81, 86, 89, and 92. Only the scour monitor at station 92 was found in July; the others were likely removed by recreationalists from the campground. The scour monitor at station 92 indicated 5.75 inches of scour; the survey indicated 3 inches of scour took place. This is not unusual since some disturbance of the gravel bed takes place during insertion of the monitors, so the bed is looser and more mobile at the top of the scour monitor location.

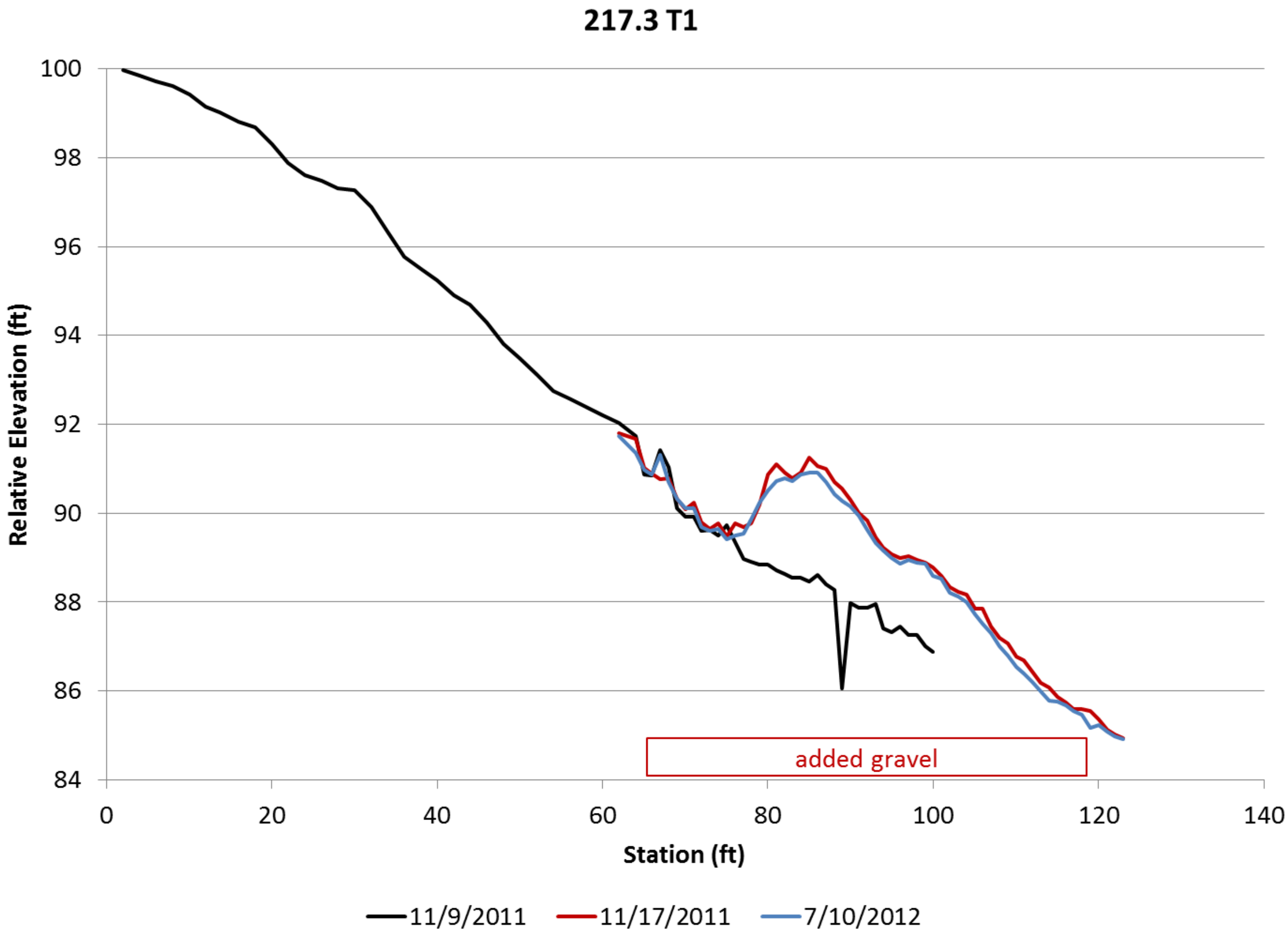


Figure 3.3-2. Cross section at T1 (across gravel placement) at RM 217.3.

Substrate size was assessed at each wetted cell (Figure 3.3-3). The added gravel (post-placement) was much finer than the pre-placement substrate size (Table 3.3-1). There was a slight coarsening of grain size during the July 2012 assessment, suggesting that some of the smaller particles in the added gravel were transported away from the site.

Table 3.3-1. Change in grain size parameters at RM 217.3 transects.

	Pre-placement		Post-placement		Following Spring high flows	
Transect	**Average (mm)**	**Median (D_{50} mm)**	**Average (mm)**	**Median (D_{50} mm)**	**Average (mm)**	**Median (D_{50} mm)**
T1 (gravel placement	87	64	29	16	38	24
T2 (80 feet downstream)	not measured	not measured	56	64	56	32
T3 (250 feet downstream)	not measured	not measured	62	32	47	32

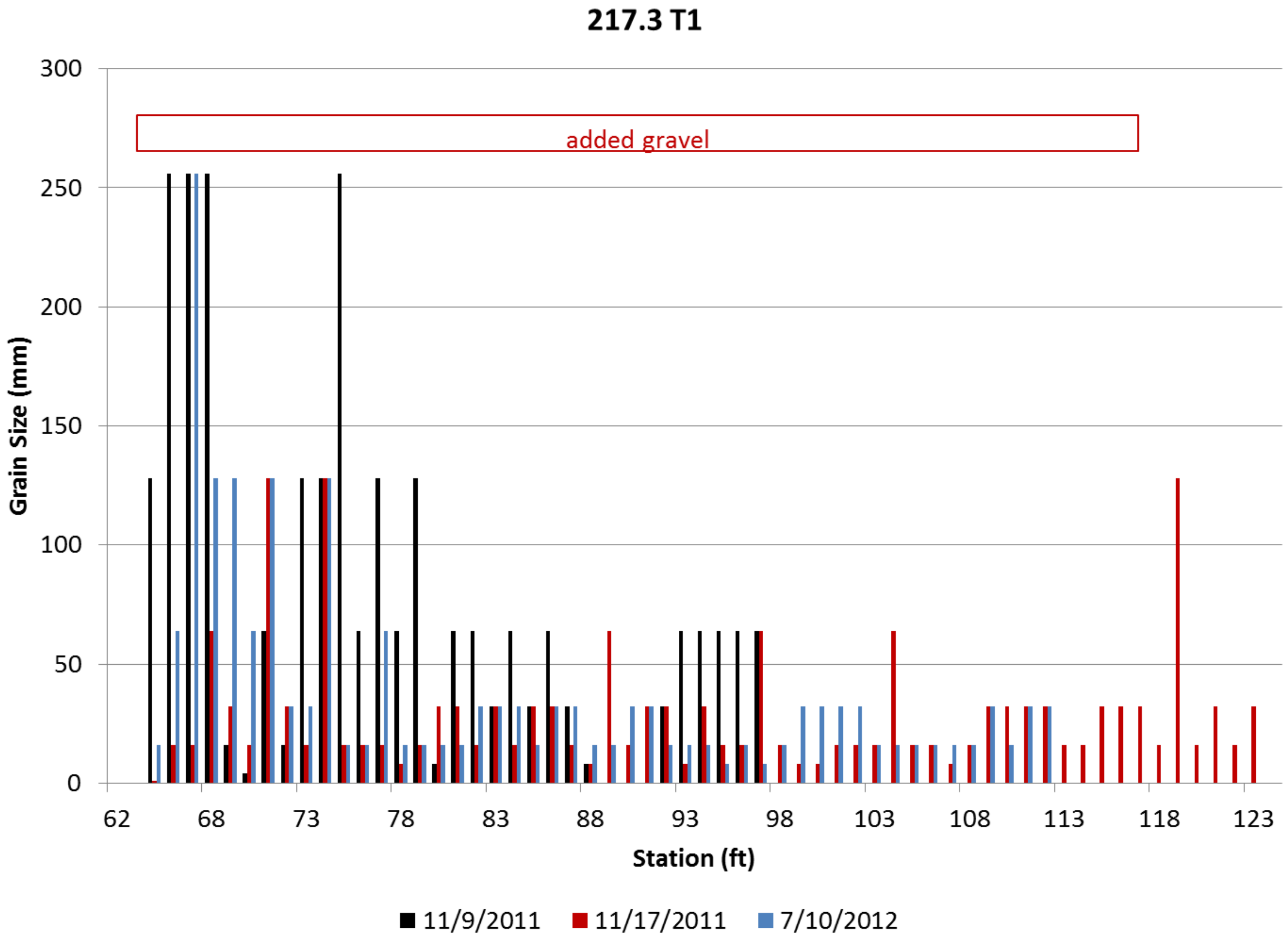


Figure 3.3-3. Grain size at T1 (across gravel placement) at RM 217.3.

Transect 2 at the RM 217.3 site is located 80 feet downstream of T1. This transect was at the downstream end of the range of the gravel shooter truck and a small amount of gravel was placed on 20 feet of the transect. Pre-placement measurements were not made at the T2 site since it was not anticipated that gravel would be placed here; the post-placement and July cross sections are shown in Figure 3.3-4. There was little movement of the substrate between November and July; up to 4 inches of change in elevation were measured, similar to the T1 transect. Grain size at T2 showed a minor amount of coarsening between November 2011 and July 2012 (Figure 3.3-5 and Table 3.3-1).

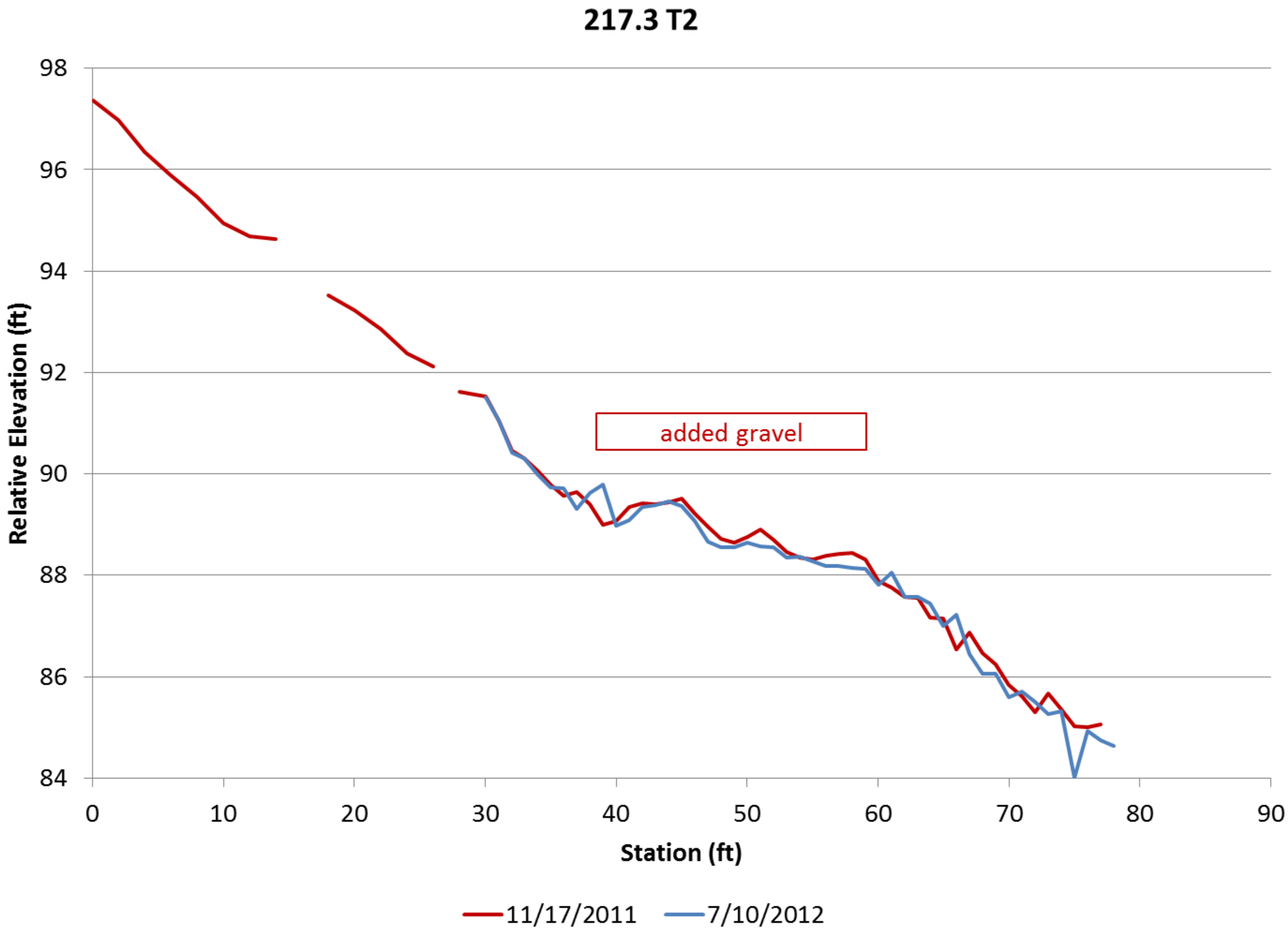


Figure 3.3-4. Cross section at T2 (80 feet downstream) at RM 217.3.

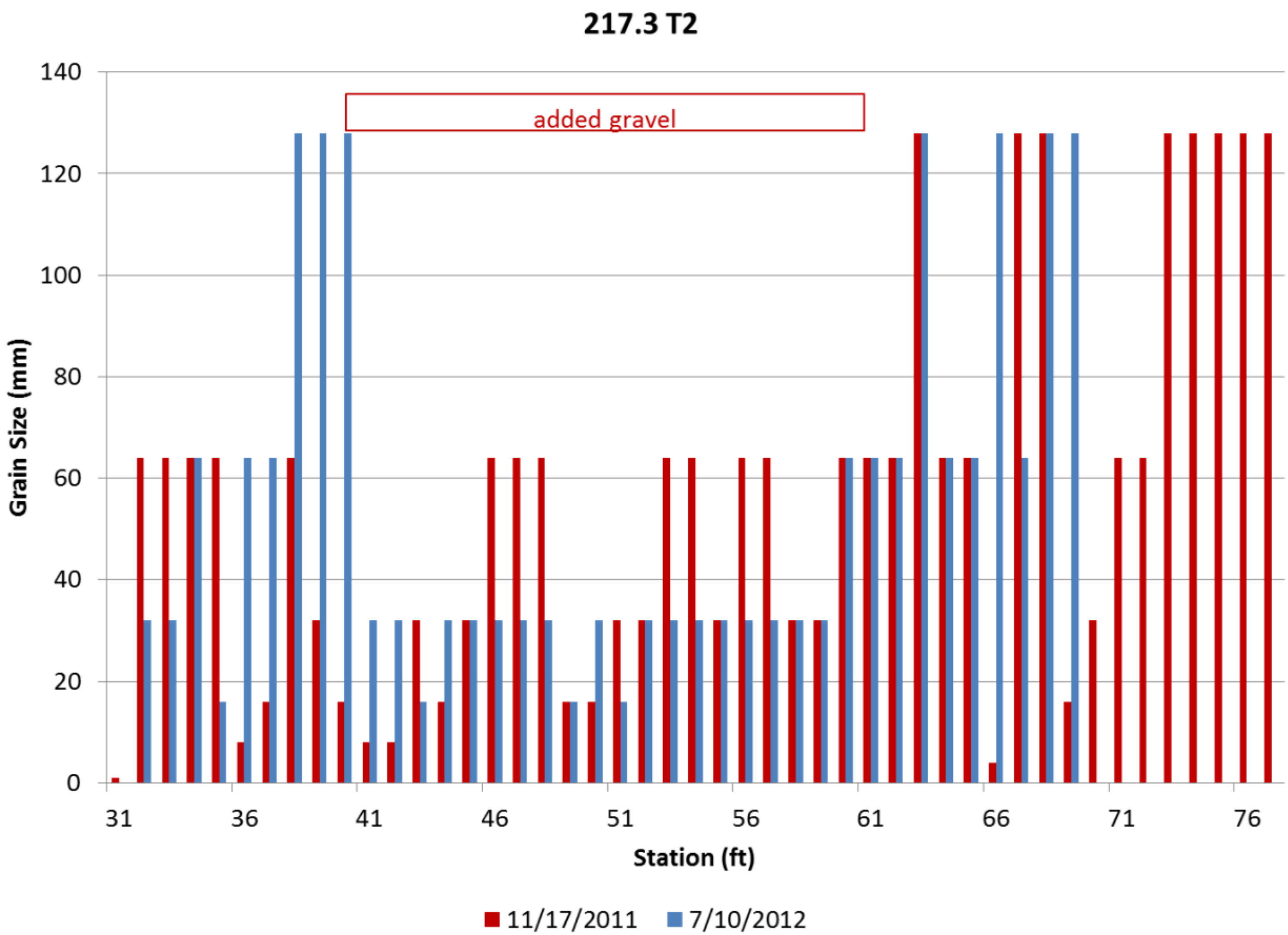


Figure 3.3-5. Grain size at T2 (80 feet downstream) at RM 217.3.

The T3 transect is located 250 feet downstream from T2. Survey and grain size measurements were taken as far into the middle of the stream as possible during each survey period given the deep, fast water at the site. Post-placement and July cross sections at T3 are shown in Figure 3.3-6. A thick layer of algae on the rocks in July suggests that the substrate at T3 was not mobile during spring high flows. The majority of variations in elevation are likely due to placement of the survey rod on or off the large cobble and boulder substrate during the surveys. Grain size at T3 showed a minor amount of fining (average grain size across transect is decreasing) between November and July (Figure 3.3-7 and Table 3.3-1). It is possible that some of the measured fining of grain size could be the result of transport of small gravel from the upstream gravel placement site.

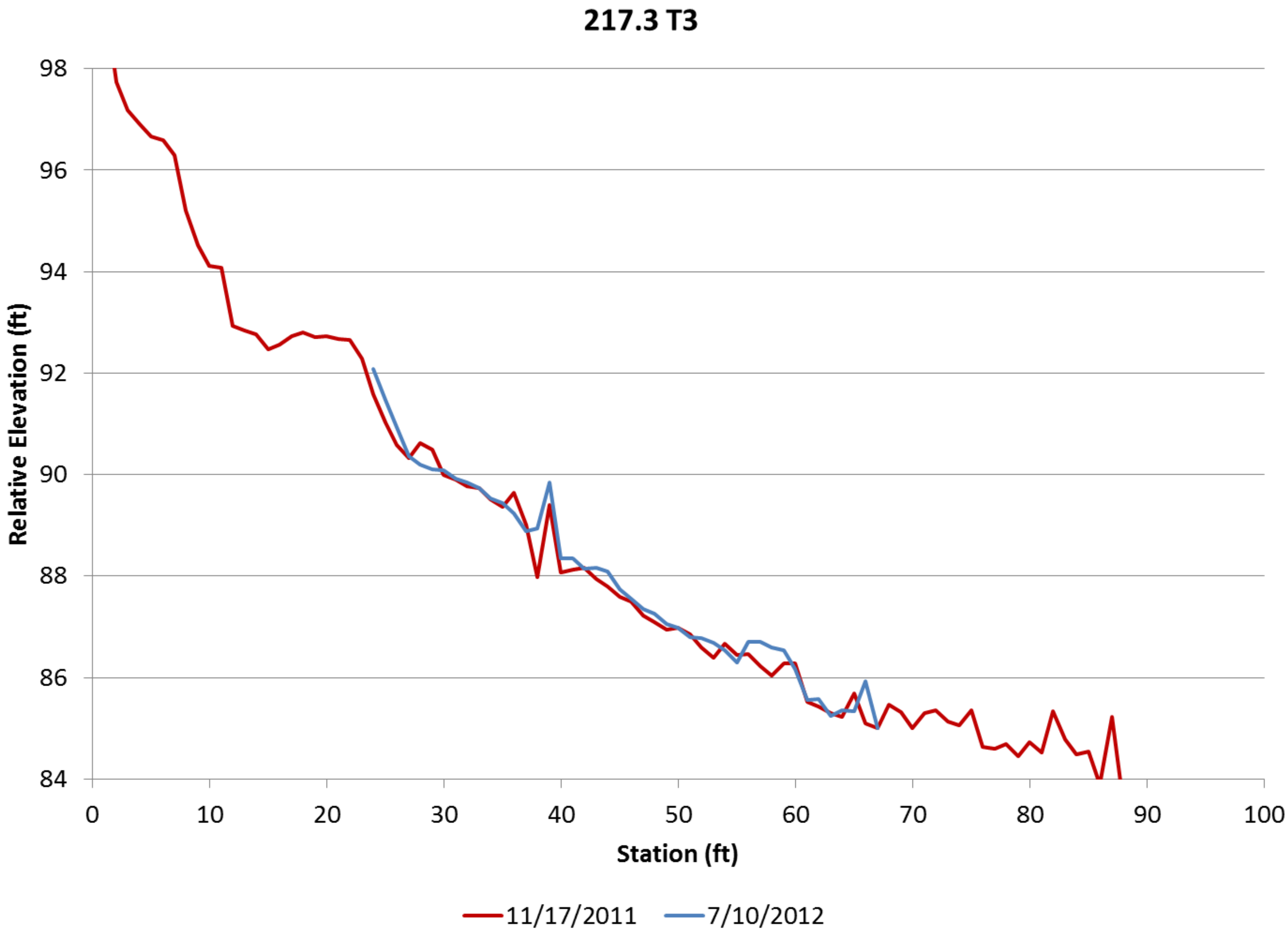


Figure 3.3-6. Cross section at T3 (250 feet downstream) at RM 217.3.

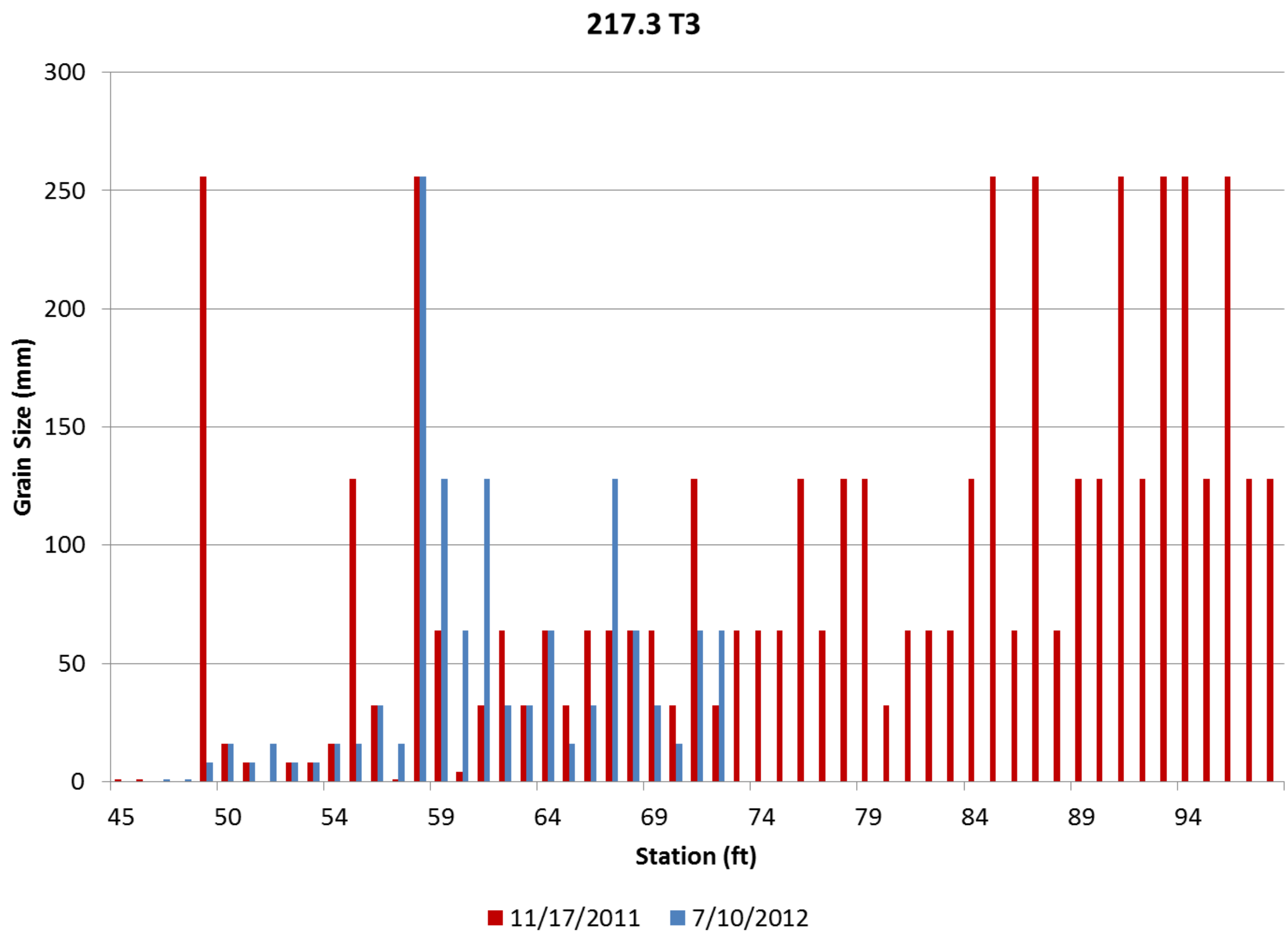


Figure 3.3-7. Grain size at T3 (250 feet downstream) at RM 217.3.

3.3.2 Dispersed Campground Site RM 216.3

The RM 216.3 site is located in a dispersed use campground upstream from Frain Ranch (Figures 3.1-1 and 3.3-8).

Location: Peaking reach, RM 216.3

Type of placement: Truck

Habitat Description: Cobble pool tailout and riffle/run. Average wetted width 160 feet; average local gradient 0.005.

Placement volume: 250 cu yd.

Figure 3.3-8. Gravel being placed at RM 216.3, November 2011.

Three transects were monitored at RM 216.3; one across the gravel placement area (T1), one approximately 95 feet downstream (T2), and a third transect another 950 feet downstream (T3).

At the transect across the gravel placement area (T1), cross sections and grain size were surveyed prior to gravel placement (November 9, 2011), immediately following gravel placement (November 16, 2011), and in July (July 7, 2012). The surveyed cross section showed gravel was placed 0.5 to 1 foot deep at T1; minimal transport of gravel took place during spring high flows (Figure 3.3-9). Following spring high flows, elevations on the placed gravel were up to 3 inches lower than in November. Scour monitors were placed near stations 96, 106 (2 monitors, one on transect and one upstream) and 108. The scour monitor at station 96 showed 1.5 inches of scour; the survey indicated 0.5 inches of scour. The scour monitor at station 106 was not found. The scour monitor 11 feet upstream from station 106 showed 3.75 inches of scour. The scour monitor near station 108 indicated 9 inches of scour; the survey data indicate less than an inch of scour took place at this station. The discrepancy in scour depths at station 108 could be caused by local scour and subsequent fill as the gravel re-distributed at the site, or as a result of loosened substrate at the scour monitor locations that occurred during monitor installation.

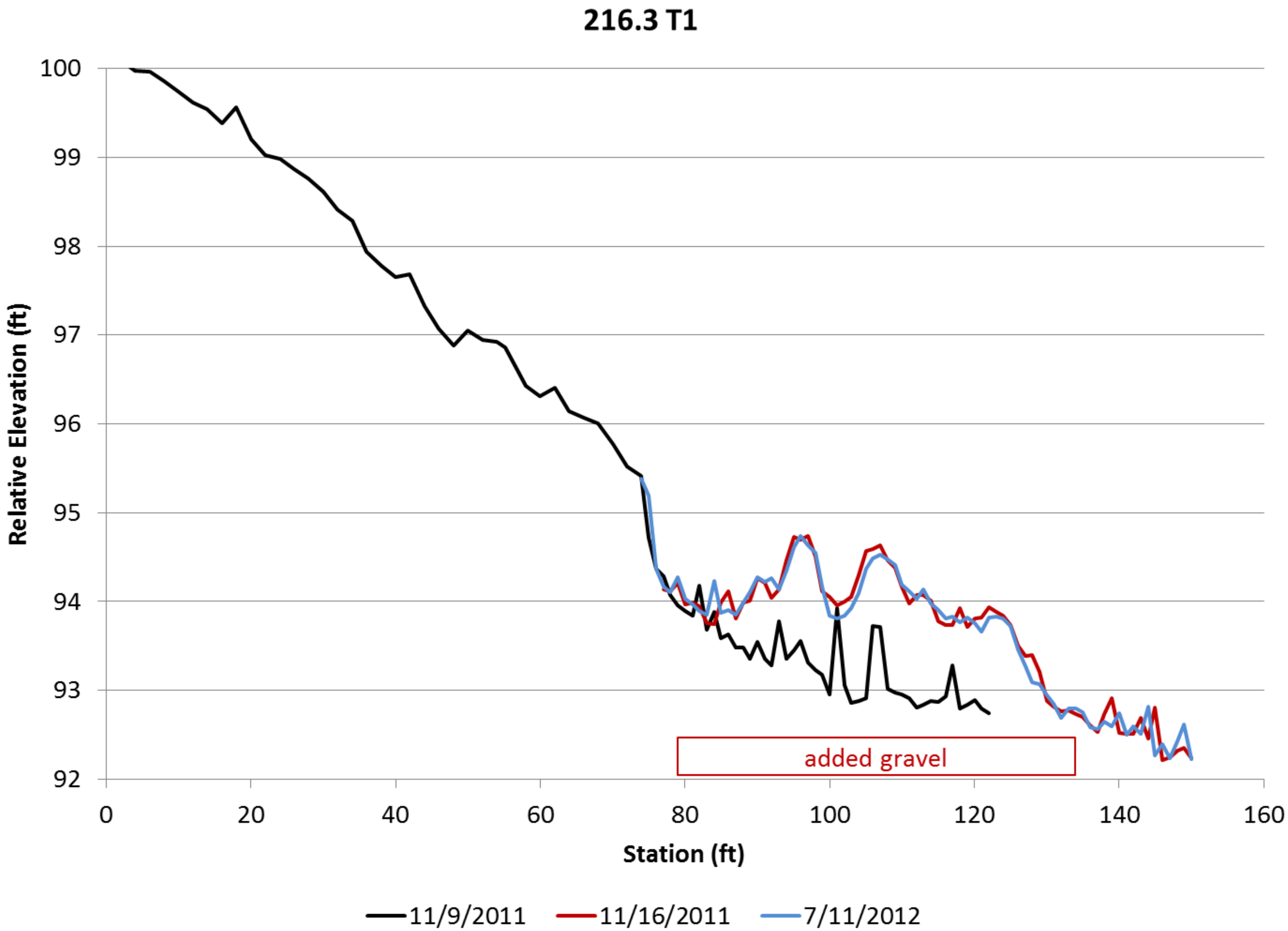


Figure 3.3-9. Cross section at T1 (across gravel placement) at RM 216.3.

Substrate size was assessed at each wetted cell on Transect 1 (Figure 3.3-10). The added gravel was much finer than the pre-placement substrate size (Table 3.3-2). There was a slight coarsening of grain size following high flows, suggesting that some of the smaller particles in the added gravel were transported away from the site.

Table 3.3-2. Change in grain size parameters at RM 216.3 transects.

Transect	Pre-placement Average (mm)	Pre-placement Median (D_{50} mm)	Post-placement Average (mm)	Post-placement Median (D_{50} mm)	Following Spring high flows Average (mm)	Following Spring high flows Median (D_{50} mm)
T1 (gravel placement	106	64	37	32	45	32
T2 (95 feet downstream)	not measured	not measured	32	32	48	32
T3 (950 feet downstream)	not measured	not measured	84	64	91	64

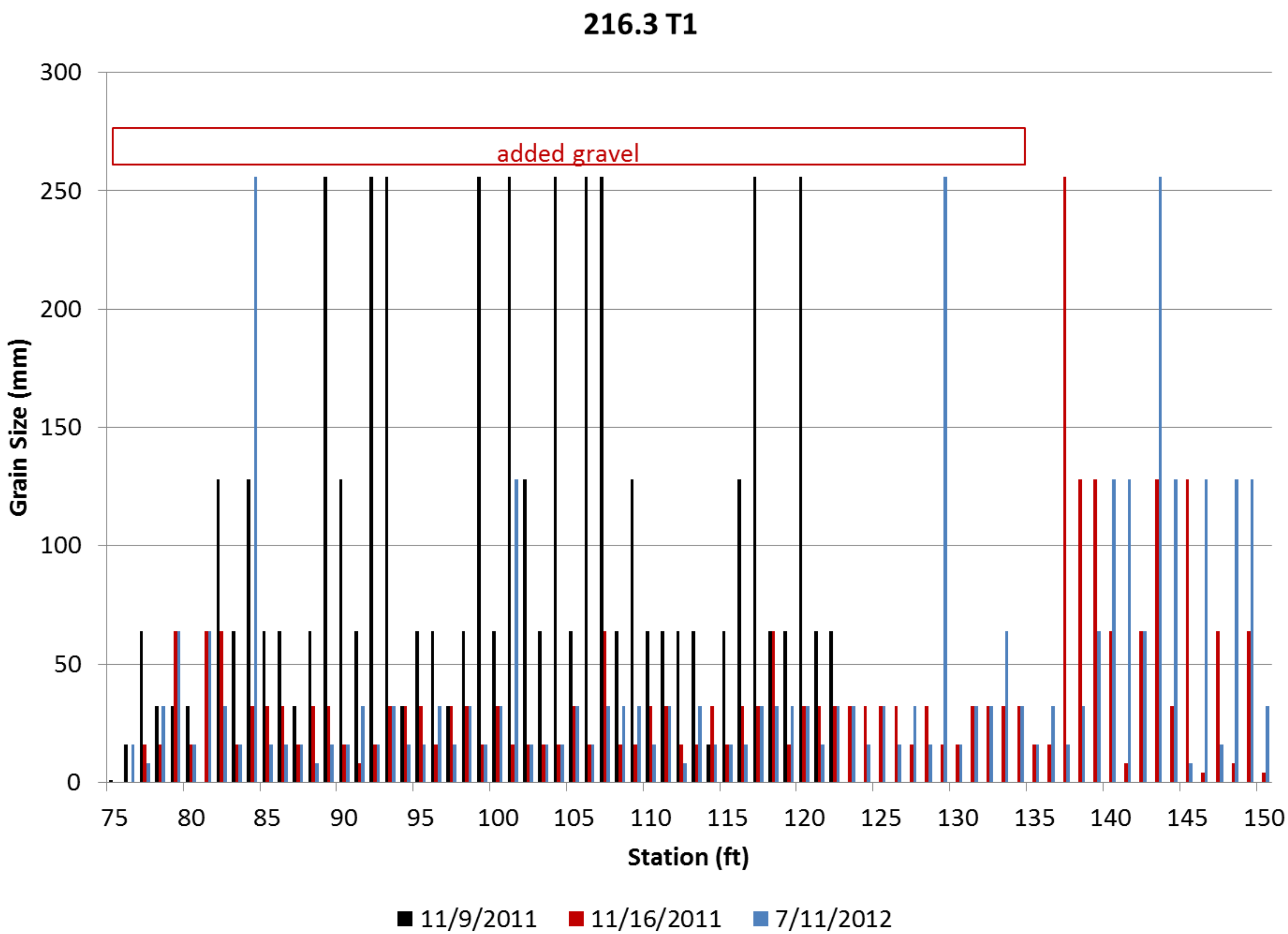


Figure 3.3-10. Grain size at T1 (across gravel placement) at RM 216.3.

Transect 2 at the RM 216.3 site is located 95 feet downstream of T1. The T2 transect was at the downstream end of the range of the gravel shooter truck and gravel was placed over 35 feet of Transect 2. Pre-placement measurements were not made at T2 since it was not anticipated that gravel would be placed here; the post-placement and July cross sections at T2 are shown in Figure 3.3-11. There was little movement of the substrate between November 2011 and July 2012. Grain size at T2 showed a minor amount of coarsening between November and July suggesting some of the finer gravel was transported from the transect T1 (Figure 3.3-12 and Table 3.3-2).

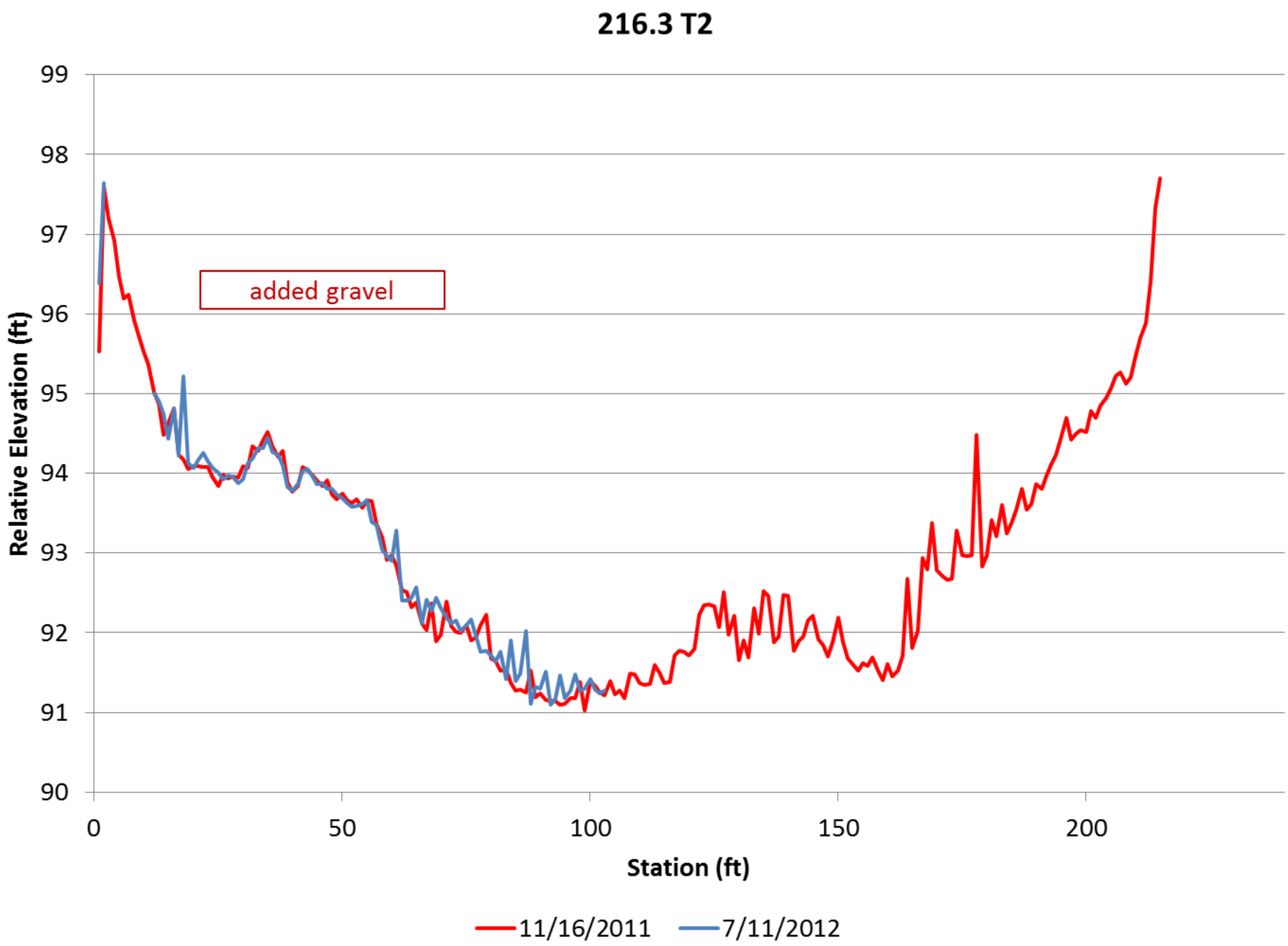


Figure 3.3-11. Cross section at T2 (95 feet downstream) at RM 216.3.

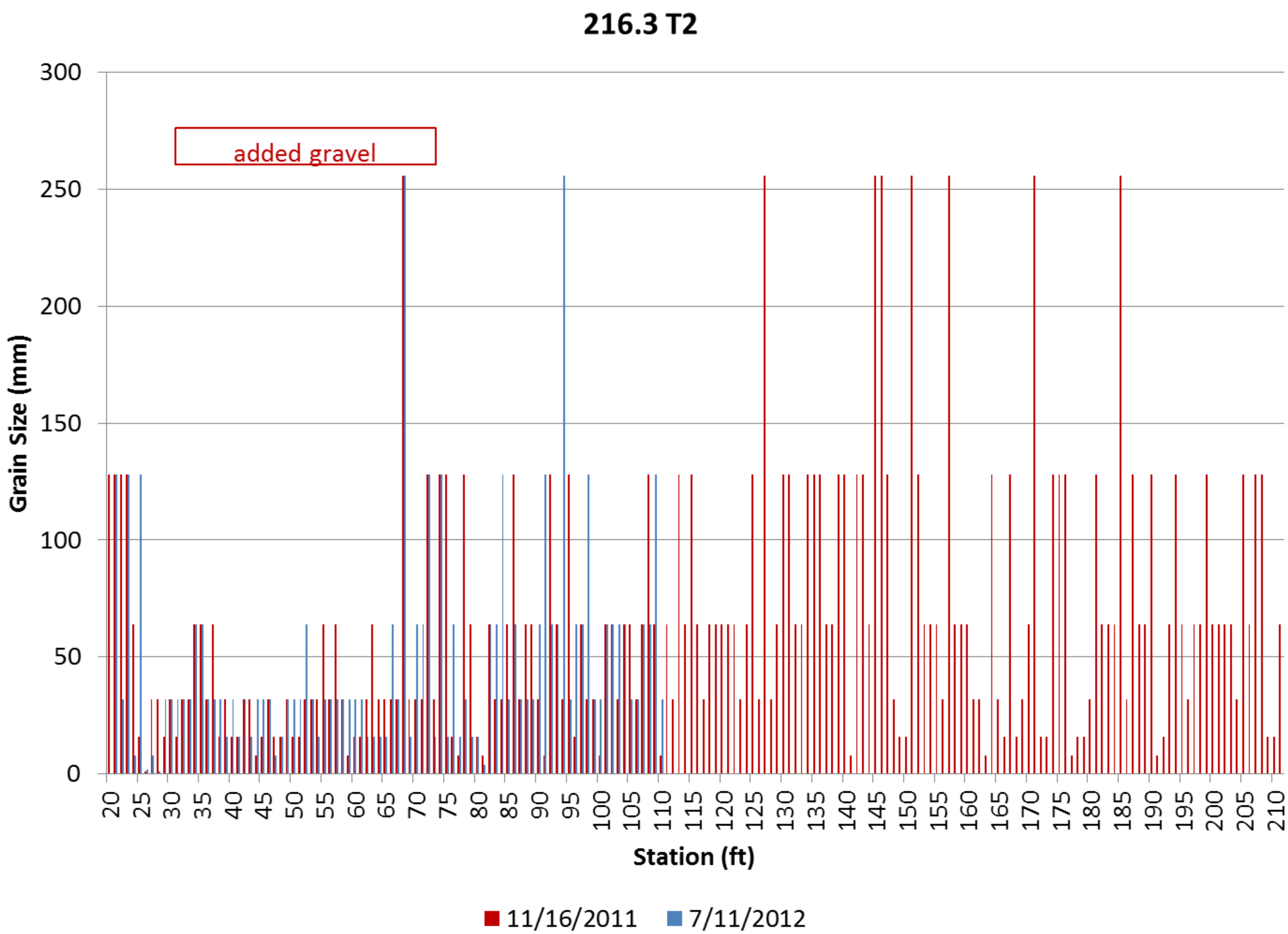


Figure 3.3-12. Grain size at T2 (95 feet downstream) at RM 216.3.

Transect T3 is located 950 feet downstream from T2. Surveying and grain size measurements were taken as far into the middle of the stream as possible during each survey period given the deep, fast water at the site. Post-placement and July 2012 cross sections are shown in Figure 3.3-13. The majority of variations in elevation are likely due to placement of the survey rod on or off the large cobble and boulder substrate during the surveys; the apparent 5-6 increase in elevation from station 150 to 238 is likely due to a slight upstream shift in the tape position (it was not possible to have a permanent endpoint in the middle of the stream). Grain size at T3 showed no apparent difference between November 2011 and July 2012 (Figure 3.3-14 and Table 3.3-2).

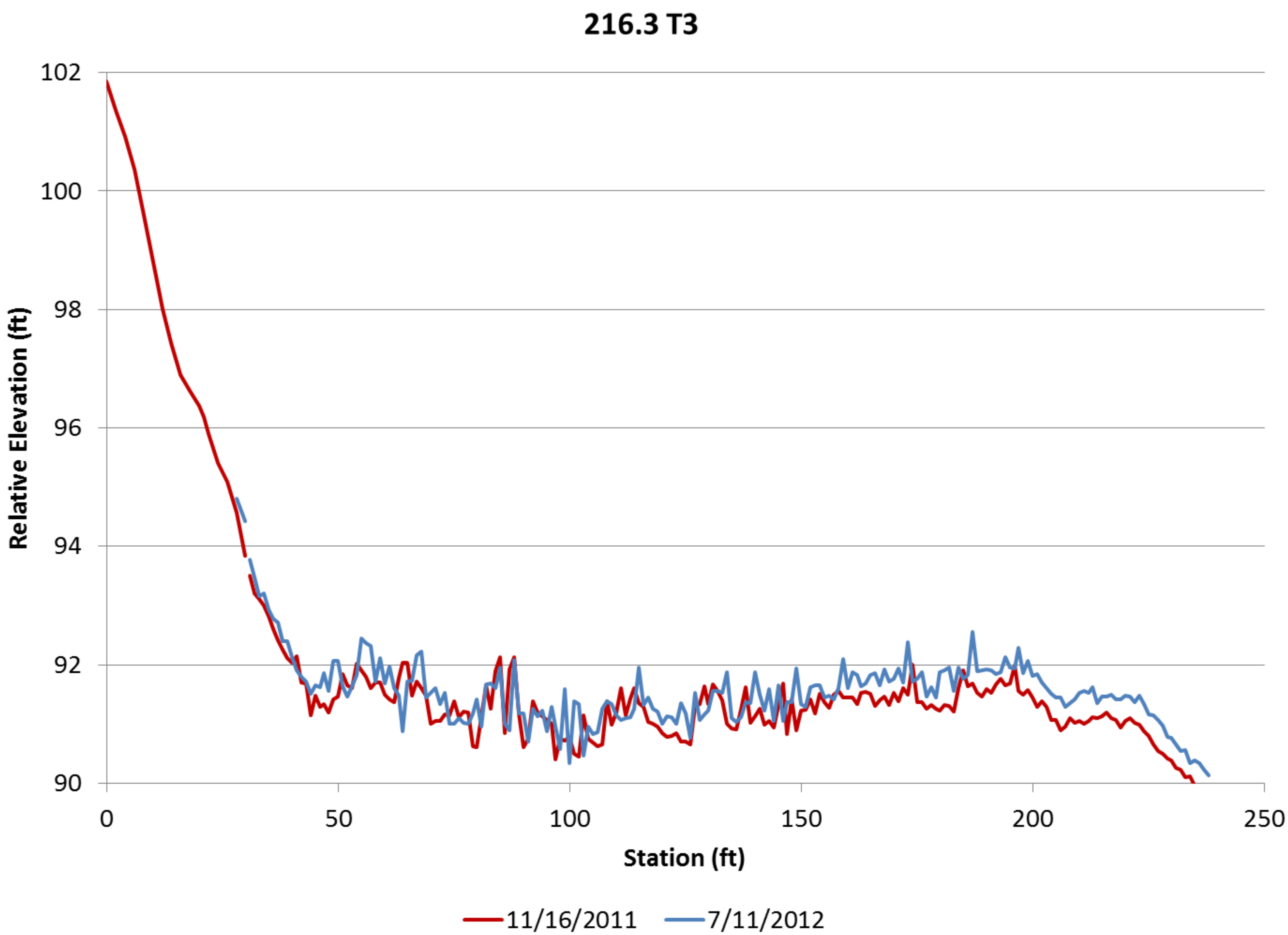


Figure 3.3-13. Cross section at T3 (950 feet downstream) at RM 216.3.

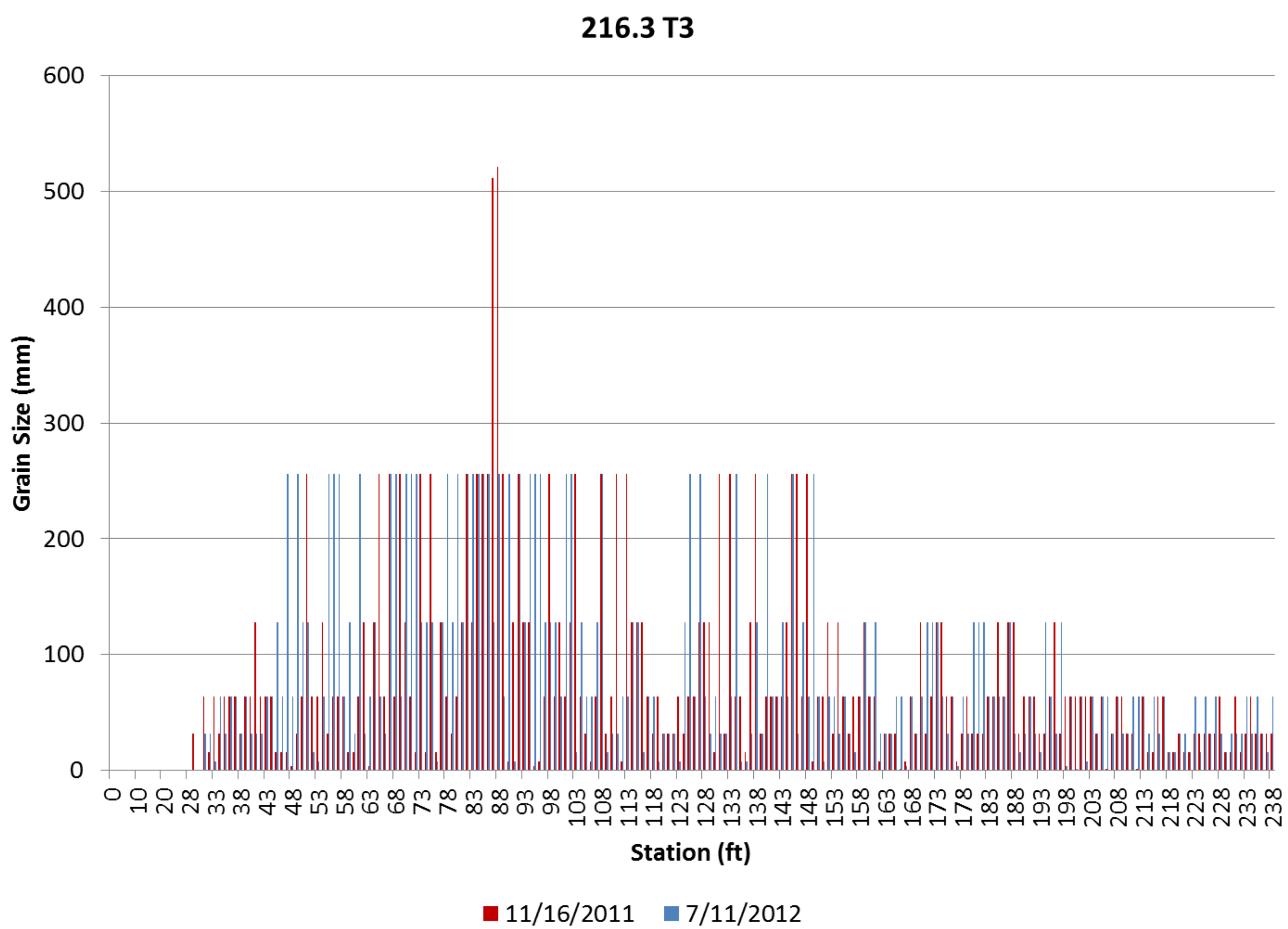


Figure 3.3-14. Grain size at T3 (950 feet downstream) at RM 216.3.

3.4 SUMMARY OF 2011 GRAVEL PLACEMENT

The truck-based gravel placement at the RM 217.3 and 216.3 sites occurred in November 2011 with no major issues or safety incidents. One minor issue was a small steep section of wet, unimproved access road that resulted in increased transport time from the staging area to the gravel placement sites. The gravel placement contractor recommended conducting subsequent truck-based applications earlier in the fall to increase the likelihood of drier weather and better road conditions.

Approximately 250 cubic yards of gravel was placed at each site, 0.5-1.5 feet deep. Monitoring of the placed gravel showed that the high flows of 3,000-3,500 cfs (instantaneous peak of 4,100 cfs) between November 2011 and July 2012 moved small amounts of gravel, but the majority of placed gravel remained at the site. Some of the transported gravel may have contributed to a reduction in particle size at one of the downstream monitoring transects at RM 217.3, but results were not conclusive. Based on the placement and monitoring of gravel at the two sites, it is recommended that no additional gravel placement be placed at the RM 217.3 or 216.3 sites until larger peak flows occur that have the opportunity to move the placed gravel.

Truck-based gravel placement is an appropriate method to add gravel to the Klamath River if the trucks can get close access to the river. No major changes to the gravel placement methods are suggested, except moving the schedule for placement earlier in the fall if the unimproved road access is needed for subsequent placement sites.

4 REFERENCES

Mason, Bruce, & Girard, Inc., Watershed GeoDynamics, and Northwest Hydraulic Consultants. 2011. Klamath hydroelectric project settlement agreement interim measure 7, J.C. Boyle gravel placement and monitoring plan. Report prepared for PacifiCorp. September 2011.

PacifiCorp. 2004. Water resources, final technical report for relicensing the Klamath Hydroelectric Project (FERC Project No. 2082). February.

PacifiCorp. 2005. Sediment budget and supporting hydraulic calculations spreadsheet files (Microsoft .xls format) submitted in response to FERC AIR WQ-5.

Schuett-Hames, D., R. Conrad, A. Pleus, and K. Lautz, 1999. TFW monitoring program method manual for the salmonid spawning gravel scour survey. Prepared for the Washington State Department of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-008; DNR #110. December.