Klamath Hydroelectric Project
FERC Project No. 2082

Klamath Hydroelectric Settlement Agreement
Interim Measure 7
J.C. Boyle Gravel Monitoring Report
2016-2017

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KLAMATH HYDROELECTERIC PROJECT SETTLEMENT AGREEMENT INTERIM MEASURE 7 J.C. BOYLE 2016-2017 GRAVEL MONITORING REPORT

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 PROJECT DESCRIPTION

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 (Figure 1.1-1). The Link River dam is owned by the U.S. Bureau of Reclamation and operated by PacifiCorp.

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 was amended by many of these same parties and signed on April 6, 2016. The KHSA includes provisions and detailed actions for the interim operation of

PacifiCorp's dams 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 resident trout, potential future salmon spawning, and ecological restoration purposes. In full, Interim Measure 7 states:

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.

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 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. Following this Plan, approximately 500 cubic yards of gravel was placed in the river each year in the fall from 2011 through 2017. This document describes the sixth year of monitoring (gravel placed in October 2016) under Interim Measure 7. The October 2017 gravel placement monitoring results will be reported in late 2018.

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 (October through June). Effectiveness monitoring was designed 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?

2 METHODS

2.1.1 Implementation Monitoring

Implementation monitoring for gravel placement was addressed primarily through a questionnaire given to PacifiCorp's project manager and the on-site gravel placement 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 was distributed and sorted as intended given the flow regime experienced during the monitoring period. During previous monitoring periods, a combination of surveyed cross sections, scour monitors, and visual/photo observations were used to determine if placed gravel moved or not. Gravel was placed at two new sites in October 2016; scour monitors and visual observations were used to evaluate gravel movement at these sites.

In October 2017, gravel was placed at one site in the peaking reach and two sites in the bypass reach; gravel had been placed at both of these sites in past years. Based on previous years' monitoring, it was determined that visual/photo observations were sufficient to determine if placed gravel had moved at the full flow site since previous monitoring determined that the majority of gravel had moved downstream. Scour monitors and visual monitoring are being used at the site in the bypass reach. The results of the 2017 placement will be discussed in next year's monitoring report.

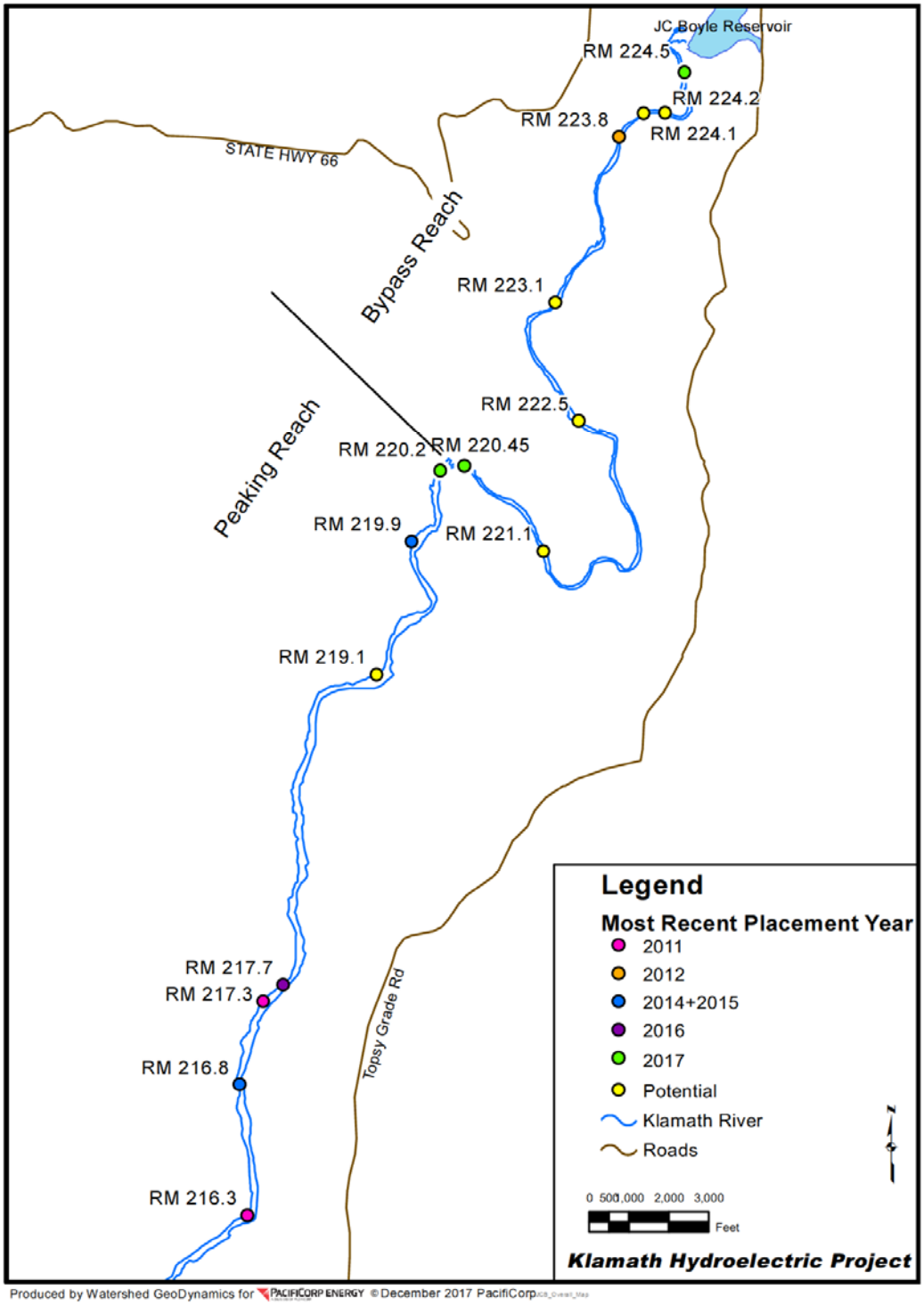
3 RESULTS

Since 2011, approximately 500 cubic yards of gravel was placed in the Klamath River below the J.C. Boyle dam each year (Table 3.1-1, Figure 3.1-1). This monitoring report considers the gravel that was placed at the sites at RM 220.45, 217.7, and 216.8 in October 2016.

Table 3.1-1. Gravel Placement Locations, Dates, and Volumes.

Site (River Mile)	Placement Date/Volume (cubic yards)						
	November 2011	October 2012	October 2013	October 2014	October 2015	October 2016*	October 2017
224.5	-	225	-	-	-	-	150
223.8	-	105	-	-	-	-	-
220.45	-	-	-	-	-	300	20
220.2	-	-	250	-	-	-	230
219.9	-	250	250	250	250	-	-
217.7	-	-	-	-	-	100	-
217.3	250	-	-	-	-	-	-
216.8	-	-	-	250	250	100	-
216.3	250	-	-	-	-	-	-

* Note: Due to safety concerns with muddy road conditions, only 100 cubic yards of gravel could be placed at RM 217.7 in October 2016; the remaining gravel intended for 217.7 was placed at RM 216.8.



Note: Gravel was placed at RM 224.5, RM 220.45, RM 220.2, RM 219.9, and RM 216.8 in multiple years; see Table 3.1-1.

Figure 3.1-1. Gravel placement locations.

3.1 POST-PLACEMENT FLOWS

3.1.1 Peaking Reach Flows (sites downstream of RM 220.3)

Two of the 2016 gravel placement sites are located in the peaking reach downstream of the J.C. Boyle powerhouse (RM 217.7 and RM 216.8). Flows from the USGS gage downstream of the J.C. Boyle powerhouse (USGS 1151070) at 15-minute intervals were collected from the USGS website. These flows are provisional and have not been finalized by the USGS but are unlikely to change substantially. Post gravel placement flows (October 2016-October 2017) ranged from approximately 345 to 8,300 cfs (Figure 3.1-2).

3.1.2 Bypass Reach Flows (sites between RM 224.5 and RM 220.45)

Flows in the bypass reach were the normal minimum flows throughout much of the year with the exception of several spill events in February, March, April, and a smaller spill in May 2017 (Figure 3.1-3). The peak spill in late March was estimated to be 5,265 cfs at the upstream end of the bypass reach. Note that these data are provisional and subject to error; PacifiCorp does not rate data with any accuracy above 500 cfs at this gage location.

The peak flow within both the peaking and bypass reaches during the 2016-2017 monitoring period was sufficient to move at least some of the gravel placed during October 2016. Spill during March 2016 had moved much of the gravel placed during previous years (2011-2015) as reported in last year's monitoring report.

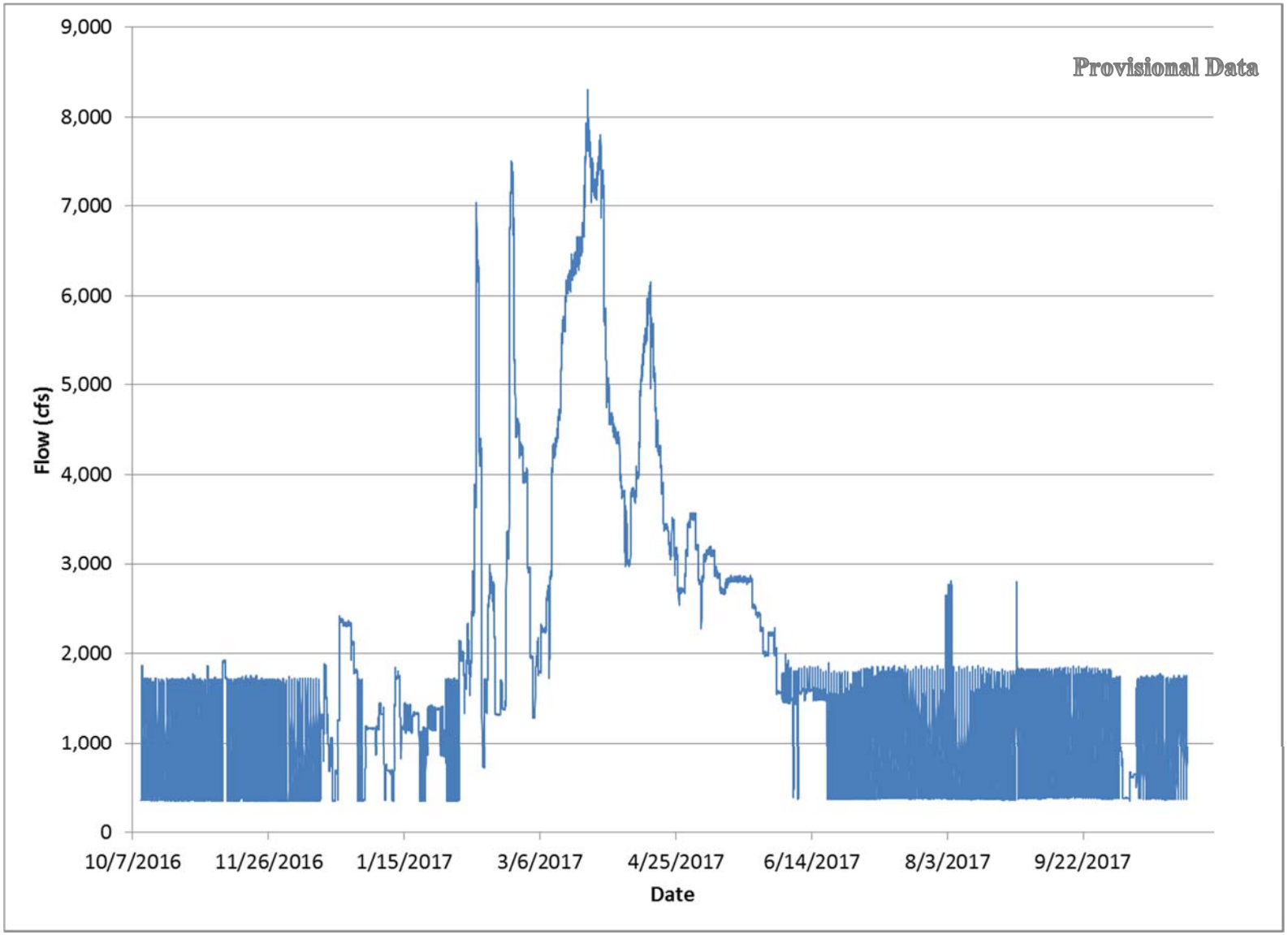


Figure 3.1-2. Post-gravel placement flows at USGS gage 1151070 downstream of J.C. Boyle powerhouse, October 2016 – October 2017

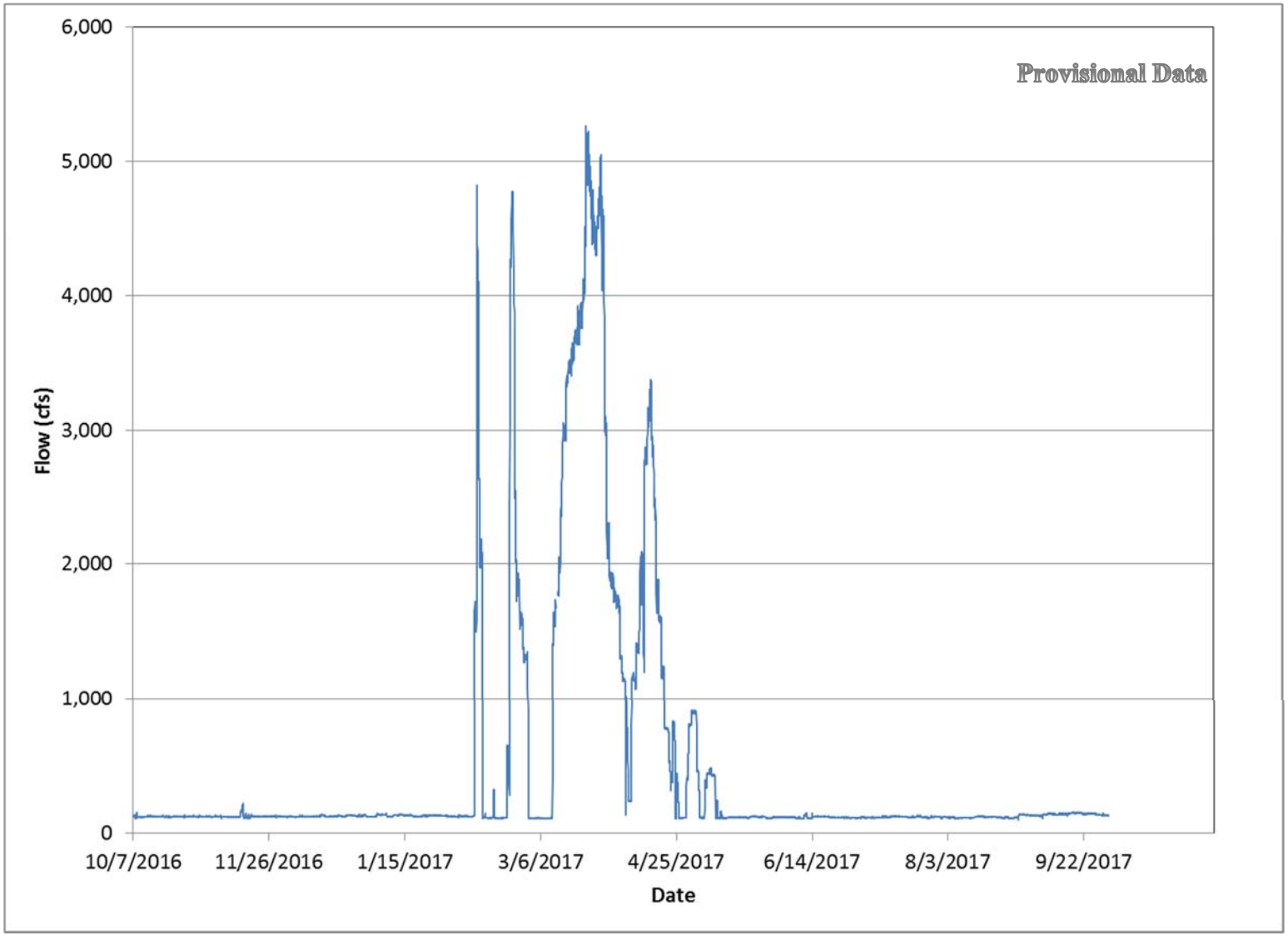


Figure 3.1-3. Post-gravel placement flows at PacifiCorp gage downstream of J.C. Boyle dam (bypass reach) October 2016–October 2017 (at flows greater than 500 cfs these gage values may not be too precise)

3.2 IMPLEMENTATION MONITORING

Implementation monitoring questionnaires were filled out by the PacifiCorp project manager and the construction foreman to determine the amount of gravel placed, placement costs, and any efficiency/safety issues (Table 3.2-1). In October 2016, approximately 300 cubic yards of gravel were placed using conveyored aggregate delivery (CAD) trucks at the RM 220.45 site, 100 cubic yards at the RM 217.4 site and 100 cubic yards at the RM 216.8 site. The campground access road to the RM 217.4 site was rendered impassable to the conveyor trucks by overnight rainfall, so the remaining gravel that was intended for the RM 217.4 site was placed at RM 216.8. Grading and graveling of the campground access road would help avoid this problem if the RM 217.4 site is used in the future.

Table 3.2-1. Implementation monitoring questions, October 2016 placement.

Monitoring Question	2016 Results
How may cubic yards of gravel were placed at each site?	RM 220.45 – 300 cubic yards RM 217.4 – 100 cubic yards RM 216.8 – 100 cubic yards
Were the placement methods (truck/helicopter) able to place gravel where planned?	All sites were placed using high speed CAD trucks. No issues were encountered with the conveyor placement.
Were any safety issues encountered?	No major safety issues were encountered. Use of a rope, backpack for tools, and trekking pole would make monitoring access to the far side of the RM 220.45 site easier since the current is swift and there are deep spots.
Were any problems encountered during placement?	The campground access road to the RM 217.4 site was rendered impassable to the conveyor trucks by overnight rainfall, so the remaining gravel was placed at RM 216.8.
Are there any recommendations to improve placement methods in the future?	Grading and graveling of the campground access road would help avoid this problem in the future.

3.3 EFFECTIVENESS MONITORING

Gravel added to the placement sites was in the 0.5 to 3-inch (12.7 to 76.2 mm) median diameter size range. Past estimates of the flow required to initiate gravel transport were made at several transect locations in the bypass and peaking reaches (PacifiCorp 2004, 2005; Mason Bruce and Girard et al. 2011). While no calculations were made near the RM 220.45 site in the bypass reach, estimates at upstream sites suggest that flows of 1,500 to 2,500 cfs could move 1 to 3-inch (25.4 to 76.2 mm) diameter rocks, respectively, suggesting that the high Spring 2017 flows (extended high flows, peak of 5,265 cfs) could have moved the gravel placed at this site.

Estimates of flow required to initiate gravel transport near the two sites in the peaking reach (RM 217.7 and 216.8) suggest flows of 1,000 to 1,500 cfs would move gravel in the 0.5-inch (12.7 mm) diameter size range; flows of 15,000 to 18,000 would move gravel in the 3-inch (76.2 mm) diameter size range. Flows in the peaking reach ranged from about 345 to 8,300 cfs during the monitoring period, so it was expected that some of the gravel would be transported away from the two sites.

Results of effectiveness monitoring at each of the three sites are described below.

3.3.1 Upstream of Powerhouse Site, RM 220.45

The RM 220.45 site is located at the upstream end of the switchyard/powerhouse parking lot, just upstream from the powerhouse at the end of the bypass reach (Figure 3.1-1). Gravel was shot from a truck in the parking lot into the river.

Location: Bypass reach, RM 220.45, just upstream from the powerhouse

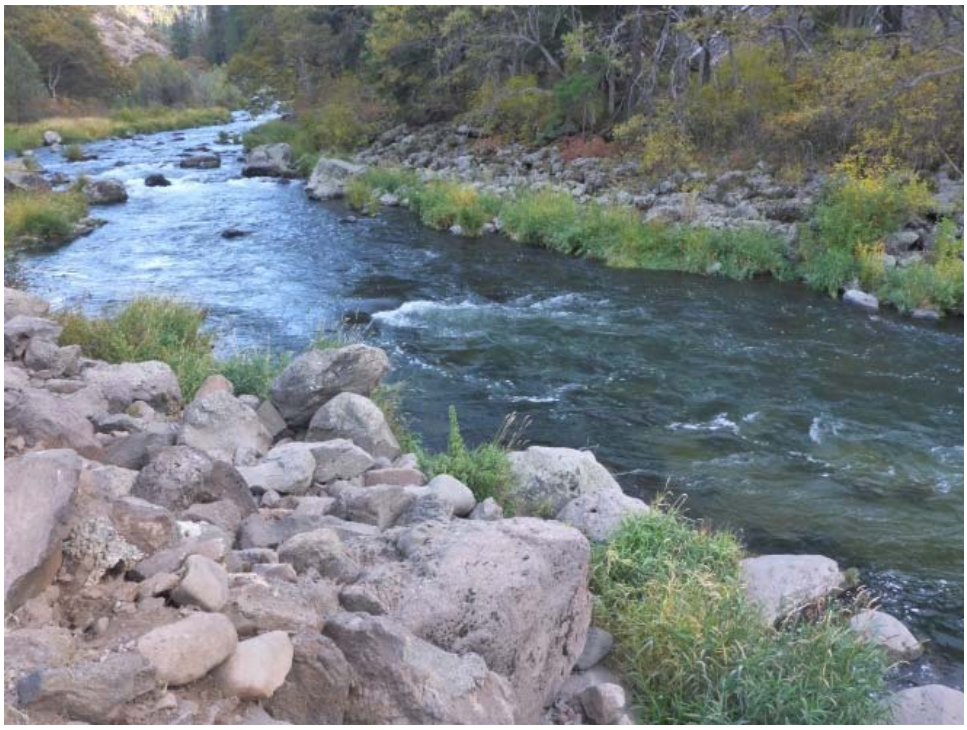
Type of placement: CAD Truck

Habitat Description: Cobble/boulder riffle. Average wetted width 40 feet; average local gradient 0.013.

2016 Placement volume: 300 cubic yards.

Four scour monitors were placed at this site since it had not been used previously for gravel placement. In 2017, following a year with relatively high Spring flows, none of the scour monitors were found, and visual observations showed that most of the gravel placed in 2016 had been transported away from the site during the monitoring period (Figure 3.3-1 and 3.3-2). Underwater observations in October 2017 showed a thin layer of gravel remained on the bottom of the stream, but the piles of gravel that were placed in 2016 were gone.

Figure 3.3-1. Photos of placed gravel at RM 220.45, October 2016 (just after placement). Note gravel was placed on far shoreline in 2016.



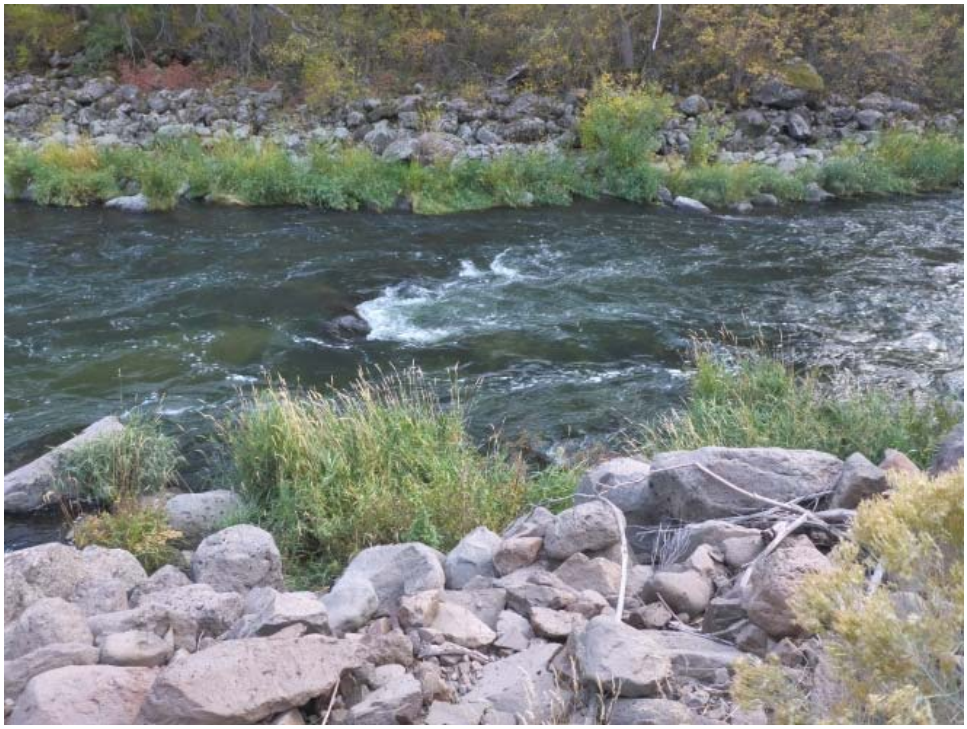


Figure 3.3-2. Photos of gravel site at RM 220.45, October 2017 (post-flows).
Note small amount of fresh/light colored gravel close to nearest shoreline; this was placed in 2017.

3.3.2 BLM Klamath Campground Site – Upstream location, RM 217.7

The RM 217.7 site is located in the peaking reach near the upstream end of the BLM campground and is accessed by a narrow dirt road through the campground (Figure 3.1-1). Gravel was shot from a truck into the river. Originally it was planned to put an additional 100 cubic-yards of gravel at this site, but overnight rains rendered the dirt access road impassable to the CAD trucks on the second day of placement, so the remaining gravel was added to RM 216.8 (see section 3.3.3).

Location: Peaking reach, upstream end of BLM campground.

Type of placement: CAD Truck

Habitat Description: Boulder/cobble pool riffle/glide. Average wetted width 115 feet; average local gradient 0.003.

2016 placement volume: 100 cubic yards

Four scour monitors were placed at the RM 217.7 site in 2016. None of the scour monitors were found in October 2017, and visual observations indicated that the majority of gravel had moved (Figures 3.3-3 and 3.3-4). Some particles of gravel remained between larger cobbles at the site.

Figure 3.3-3. Photo of placed gravel at RM 217.7, October 2016 (after placement).

Figure 3.3-4. Photo of gravel site at RM 217.7, October 2017 (post flows; water level is higher than Figure 3.3-3).

3.3.3 Old Bridge Site RM 216.8

The RM 216.8 site is located at the old bridge site (Figure 3.1-1). Gravel was placed at this site from a CAD truck in 2014, 2015, and 2016. This site was used in 2016 because wet, muddy road conditions after an overnight rain made further placement at the RM 217.7 site infeasible.

Location: Peaking reach, RM 216.8 right bank looking downstream

Type of placement: CAD Truck

Habitat Description: Cobble/boulder riffle. Average wetted width 85 feet; average local gradient 0.004.

2016 Placement volume: 100 cubic yards.

The gravel that was placed at the RM 216.8 site was not observable because visibility was reduced by the deep water and swift current (Figures 3.3-5 and 3.3-6). It is assumed that all gravel was moved from the site by high flow conditions since this is a confined, higher gradient site at the outside of a bend, all factors leading to higher sediment transport rates.

Figure 3.3-5. Photo of placed gravel at RM 216.8, October 2016 (after placement).

Figure 3.3-6. Photo of gravel site at RM 216.8, October 2017 (post-flows).

3.4 SUMMARY OF 2016 GRAVEL PLACEMENT

Truck-based gravel placement at the RM 220.45 (bypass reach), RM 217.7 and RM 216.8 (peaking reach) sites occurred in October 2016. Wet campground road conditions after overnight rain made placement of additional gravel at the RM 217.7 site infeasible, so the remaining gravel targeted for RM 2017.7 was placed at RM 216.8. Visual observations at the sites showed that flows from October 2016 to October 2017 removed the majority of gravel from the October 2016 placement sites.

The high spring 2017 flows likely contributed to movement of gravel at all the sites, particularly the site in the bypass reach. The highest flow in the peaking reach (8,300 cfs) was less than the magnitude of flows (15,000 to 18,000 cfs) estimated to move the largest sized gravel added to the sites (3 inch median diameter); however the mix of gravel sizes added, the loose nature of the added gravel, and the multiple peak flows over a several month period in the spring of 2017 likely make it possible for at least some of the larger particles to be transported from the peaking reach sites.

3.5 FUTURE GRAVEL PLACEMENT SITES

Based on the placement and monitoring of gravel at the sites, it appears that gravel can always be added to the peaking reach RM 220.2, RM 219.9, and RM 216.8 sites in the future; normal operating flows are capable of transporting gravel added to these sites. Gravel can also be added to the RM 220.45 site (bypass reach) because previously added gravel has been transported away from this site by the high flows in Spring 2017, and only a small amount of gravel (20 cubic yards) was added in October 2017.

Gravel can also be added at the potential helicopter sites discussed in the gravel augmentation plan (Mason Bruce and Girard et al. 2011, Table 3.5-1).

No additional gravel should be placed at the RM 224.5 (bypass reach) site until monitoring confirms that the new gravel has moved from the site since gravel was added there in 2017. No additional gravel should be placed at the RM 217.3 or RM 216.3 (peaking reach) sites until higher flows (e.g., very large spill) occur that have the opportunity to move the placed gravel. Considering that estimated flows of 5,265 cfs in March 2016 moved only a portion of the gravel at these two sites, it may not be advisable to place additional gravel at these locations in the future.

Table 3.5-1. Potential for Future Gravel Placement.

Site (River Mile)	Placement Method	Most Recent Gravel Placement	Possible 2018 Placement?
224.5	CAD Truck	2017	No
224.2	Helicopter	-	Yes
224.1	Helicopter	-	Yes
223.8	Helicopter*	2012	Yes
223.1	Helicopter	-	Yes
222.5	Helicopter	-	Yes
222.1	Helicopter	-	Yes
220.45	CAD Truck	2017**	Yes
220.2	CAD Truck	2017	Yes
219.9	CAD Truck	2015	Yes
219.1	Helicopter	-	Yes
217.7	CAD Truck	2016	Yes
217.3	CAD Truck	2011	No
216.8	CAD Truck	2016	Yes
216.3	CAD Truck	2011	No

* The RM 223.8 site was placed by truck and culvert/chute in 2012, but placement using this method was very difficult; any future placement at this site should utilize helicopter placement.
** A very small amount of gravel (20 cubic yards) was placed at the RM 220.45 site in 2017.

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