Klamath Hydroelectric Project
FERC Project No. 2082

Klamath Hydroelectric Settlement Agreement
Interim Measure 7
J.C. Boyle Gravel Monitoring Report
2018-2019

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December 2019

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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). The Link River dam is owned by the U.S. Bureau of Reclamation and operated by PacifiCorp.

Figure 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 and further amended on November 30, 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 or habitat enhancement projects, including related monitoring, in the Klamath River upstream of Copco Reservoir and downstream of 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. 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 2019. This document describes the eighth year of monitoring (gravel placed in October 2018) under Interim Measure 7. The October 2019 gravel placement monitoring results will be reported in late 2020.

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 (date of placement through October of the following year). 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 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. In

addition, measurements of turbidity upstream and downstream of gravel placement were made to confirm compliance with State water quality standards.

2.2 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 visual surveys of the cross sections, scour monitors, and photographic observations were used to determine if placed gravel moved or not. Gravel was placed at two sites (Table 3-1) in October 2018; visual observations were used to evaluate gravel movement at these sites in fall of 2019.

In October 2019, gravel was placed at two sites in the bypass reach (RM 220.45 and 224.5). Gravel had been placed at both of these sites in past years. Based on previous years' monitoring, it was determined that scour monitors should be placed at the RM 224.5 site since gravel at this site just downstream of J.C. Boyle Dam only moves when there is sufficient spill at the dam. The site at the downstream end of the bypass reach (RM 220.45) is confined and flow includes spill as well as accretion inflows along the 4 miles of river between the sites. Based on past experience with added gravel at this downstream site, it was determined the photographic observations were sufficient to determine if placed gravel moves at the RM 220.45 site. The results of the October 2019 placement will be discussed in next year's monitoring report.

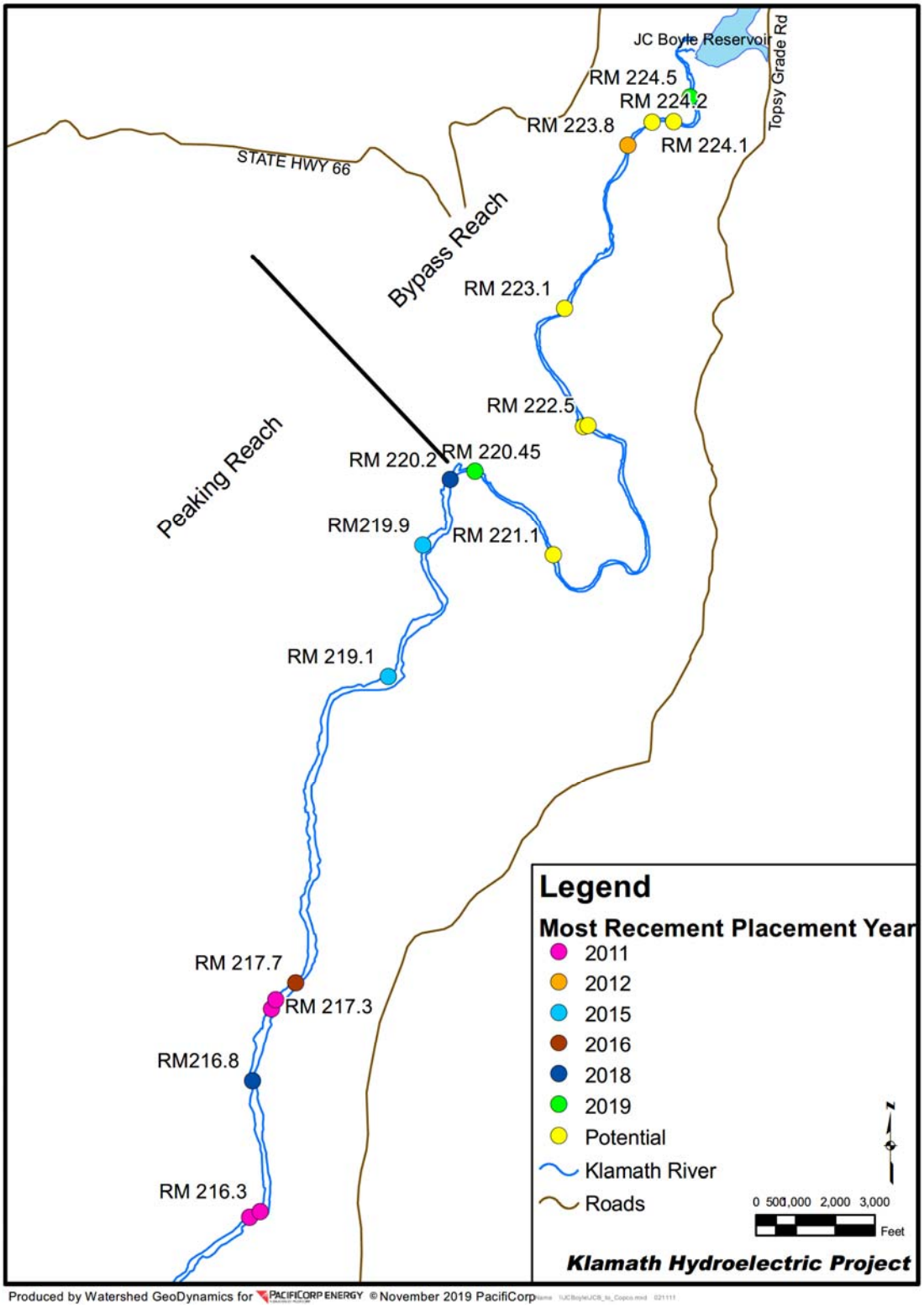
3 RESULTS

Since 2011, approximately 500 cubic yards of gravel has been placed in the Klamath River downstream of the J.C. Boyle Dam each year (Table 3-1, Figure 3-1). This monitoring report considers the gravel that was placed at the sites at RM 220.2, and 216.8 in October 2018.

Table 3-1. 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	October 2018	October 2019
Bypass Reach									
224.5	-	225	-	-	-	-	150		200
223.8	-	105	-	-	-	-	-		
220.45	-	-	-	-	-	300	20		300
Peaking Reach									
220.2	-	-	250	-	-	-	230	250	
219.9	-	250	250	250	250	-	-		
217.7	-	-	-	-	-	100	-		
217.3	250	-	-	-	-	-	-		
216.8	-	-	-	250	250	100	-	250	
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.

Figure 3-1. Gravel placement locations.

3.1 Post-Placement Flows

3.1.1 Peaking Reach Flows (sites downstream of RM 220.2)

Both of the October 2018 gravel placement sites are located in the peaking reach downstream of the J.C. Boyle Powerhouse (downstream from RM 220.2). Flows from the USGS gage downstream of the J.C. Boyle Powerhouse (USGS 1151070) recorded at 15-minute intervals were collected from the USGS website. These flows are a mix of approved and provisional data that have not been finalized by the USGS but are unlikely to change substantially. Post gravel placement flows (October 2018-October 2019) ranged from approximately 350 to 9,150 cubic feet per second (cfs) (Figure 3-2).

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 spill events in April and June 2019 (Figure 3-3). The peak spill in April was estimated to be 6,016 cfs at the upstream end of the bypass reach. Note that these data are provisional and may not be accurate because PacifiCorp does not rate data with any accuracy above 500 cfs at this gaging station location.

Spill during March 2016 and spring 2017 had moved much of the gravel placed in both the peaking and bypass reaches during previous years (2011-2017) as reported in the 2018 monitoring report (Meridian Environmental, Inc. and Watershed GeoDynamics 2019). The spill during April 2019 was the highest during the entire gravel monitoring period and moved previously added gravel throughout the river. New gravel deposits were observed downstream of several of the augmentation sites.

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). In October 2018, approximately 250 cubic yards of gravel were placed using conveyored aggregate delivery (CAD) trucks at the RM 216.8 and 250 cubic yards at the RM 220.2 site. No safety or placement issues were encountered other than the request to flag potential placement locations prior to start of work. Measurements of turbidity upstream and downstream of both locations were conducted during gravel placement; no exceedances occurred at either site.

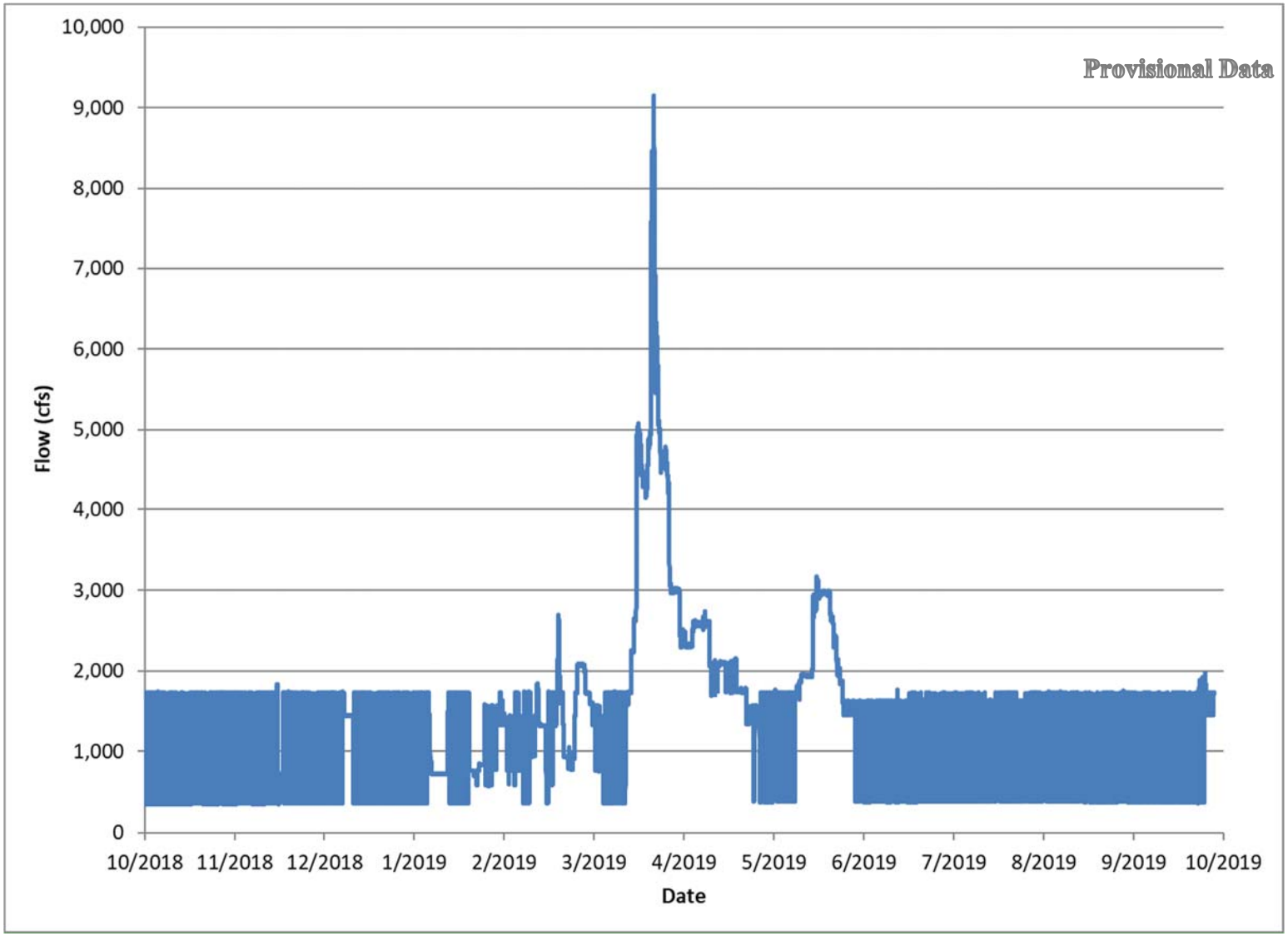


Figure 3-2. Mean daily flow in the Peaking Reach at USGS gage 1151070 downstream of J.C. Boyle Powerhouse, October 2018 – October 2019

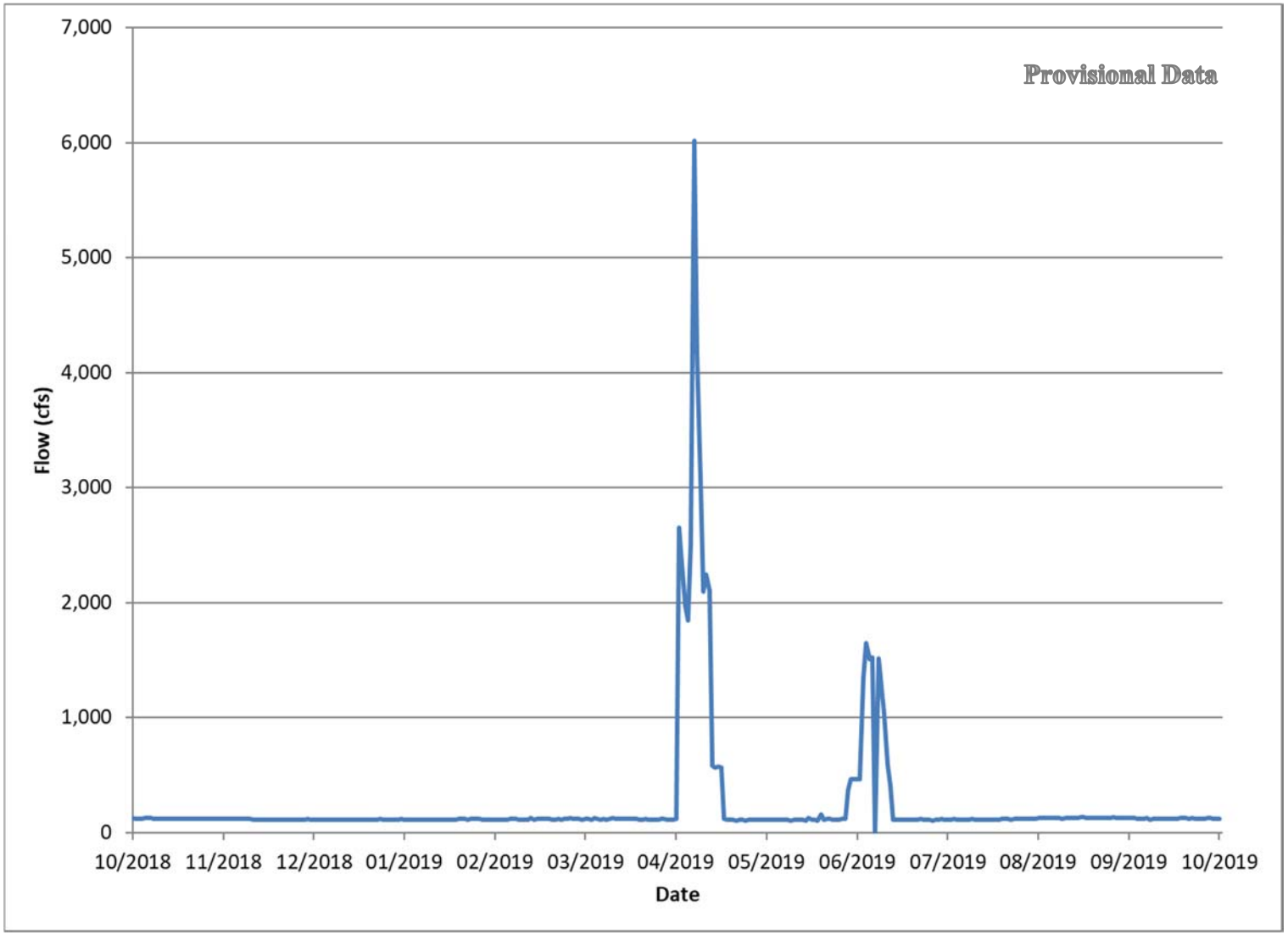


Figure 3-3. Mean daily flow in the Bypass Reach at PacifiCorp gage downstream of J.C. Boyle Dam October 2018–October 2019 (at flows greater than 500 cfs these gage values may not be precise)

Table 3-2. Implementation monitoring questions, October 2018 placement.

Monitoring Question	2018 Results
How may cubic yards of gravel were placed at each site?	RM 216.8 – 250 cubic yards RM 220.2 – 250 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 safety issues were encountered.
Were any problems encountered during placement?	No problems were noted.
Are there any recommendations to improve placement methods in the future?	Flag potential placement along the roadway access locations prior to start of work.

Two additional recommendations were made during October 2018: provide a longer lead time on placement locations and volumes; and arrange with power scheduling in advance to provide a low flow window in the peaking reach to allow easier gravel monitoring.

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. Gravel had been added at both of the 2018 placement sites in previous years, and high flows/spill or normal operating flows had previously moved gravel from these areas. Results of effectiveness monitoring for the 2018-2019 period at both sites are described below.

3.3.1 Old Bridge Site RM 216.8

The RM 216.8 site is located at the old bridge site (Figure 3-1). Gravel was placed at this site from a CAD truck in 2014, 2015, 2016, and 2018.

Location: Peaking reach, RM 216.8 river-right bank looking upstream

Type of placement: CAD Truck

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

2018 Placement volume: 250 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 3-4 and 3-5). It is assumed that all gravel was moved from the site by high flow conditions since this site is confined and higher gradient at the outside of a bend. When these factors are combined, they lead to high sediment transport rates.

Figure 3-4. Peaking Reach, photo of placed gravel at RM 216.8, October 2018 (after placement).

Figure 3-5. Peaking Reach, photo of gravel site at RM 216.8, October 2019 (post-flows).

3.3.2 Downstream of Powerhouse Site, RM 220.2

The RM 220.2 site is located in the peaking reach just downstream of the powerhouse (Figure 3-1). Approximately 250 cubic yards of gravel were placed at this site in 2018 from a CAD truck located on the river-right bank of the river.

Location: Peaking reach, RM 220.2, river-right bank looking downstream

Type of placement: CAD Truck

Habitat Description: Boulder/cobble riffle. Average wetted width 90 feet.

2018 Placement volume: 250 cubic yards.

All of the 2018 in-river gravel was moved from the RM 220.2 site prior to October 2019 (Figures 3-6 and 3-7). Previous gravel placed at this site had been moved by normal peaking flows, so the 2018-2019 results were consistent with previous observations of gravel movement at the site. Note that there is a small amount of gravel that remains on the streambank above the high flow waterline that is residue from the October 2018 CAD gravel placement (Figure 3-7).

Figure 3-6. Peaking Reach, photo of gravel site at RM 220.2, October 2018 (after placement).

Figure 3-7. Peaking Reach, photo of gravel site at RM 220.2, October 2019 (after high flows).

3.4 Summary of 2018 Gravel Placement

Visual observations at the sites showed that flows between October 2018 and October 2019 moved most gravel at the October 2018 placement sites.

The high flows in Spring 2019 contributed to movement of gravel at most sites, particularly the site in the bypass reach. The highest flow in the bypass reach was 6,016 cfs. The highest flow in the peaking reach (9,150 cfs) was less than the magnitude of flows (15,000 to 18,000 cfs) predicted to be necessary to move the largest sized gravel added to peaking reach sites (3 inch median diameter; PacifiCorp 2005); however the mix of gravel sizes added and the loose nature of the added gravel appear to make it possible for the majority of the larger particles to be transported from the 2018 peaking reach site.

3.5 Future Gravel Placement Sites

Based on the placement and monitoring of gravel at all the sites (Figure 3-1), future gravel can be added at all sites except the RM 220.45 and RM 224.5 sites where gravel was just added in 2019 in the bypass reach and the RM 216.3 site in the peaking reach where slower velocities limit gravel movement (Table 3-3).

Table 3-3. Potential for Future Gravel Placement.

Site (River Mile)	Placement Method	Most Recent Gravel Placement	Possible 2020 Placement?
Bypass Reach			
224.5	CAD Truck	2019	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	2019	No
Peaking Reach			
220.2	CAD Truck	2018	Yes
219.9	CAD Truck	2015	Yes
219.1	Helicopter	-	Yes
217.7	CAD Truck	2016	Yes
217.3	CAD Truck	2011	Yes
216.8	CAD Truck	2018	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.

Gravel can be added to the peaking reach RM 220.2, RM 219.9, and RM 216.8 sites at any time in the future; normal operating flows are capable of transporting gravel added to these sites downstream away from the sites. The high flows in Spring 2019 appear to have moved the majority of previously added gravel away from the RM 217.3 and RM 217.7 sites during the past year. These sites could be considered for future gravel placement with the understanding that very large flows are needed to move gravel downstream, so added gravel may remain at the site for several years before being transported. In addition, the access to the RM 217.7 site is narrow and traverses very soft ground; it can only be accessed by CAD truck during dry soil conditions, so it may not be accessible if the ground is wet during the placement period.

No additional gravel should be placed at the RM 216.3 (peaking reach) site until higher flows (e.g., very large spill) occur that move the placed gravel. Considering that estimated flows of 5,265 cfs in March 2016, 8,300 cfs in March 2017, 5,730 cfs in April 2018, and 9,150 cfs in April 2019 moved only a portion of the gravel at this site, it may not be advisable to place additional gravel at this location in the future.

Gravel can be added at any of the potential helicopter sites in either the bypass or peaking reaches as discussed in the gravel augmentation plan (see Mason Bruce and Girard et al. 2011) since gravel has not been previously added at these sites.

4 REFERENCES

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