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March 22, 2019

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
Mail Code: DHAC, PJ-12
888 First Street, N.E.
Washington, D.C. 20426

RE: Priest Rapids Hydroelectric Project No. 2114-174
License Compliance Filing – Article 401(a)(12) – 2018 Pacific Lamprey Management Plan Annual Report

Dear Secretary Bose,

Please find enclosed Public Utility District No. 2 of Grant County, Washington (Grant PUD) 2018 Pacific Lamprey Management Plan (PLMP) Annual Report consistent with the requirements of Article 401(a)(12) of the Priest Rapids Project License[1] and the Washington State Department of Ecology 401 Water Quality Water Quality Certification Condition of 6.2(5)(b) and 6.2(5)(d) for the Priest Rapids Project (Project).

The 2018 PLMP Comprehensive Annual Report summarizes the on-going activities undertaken at the Project in 2018, as identified in the PLMP, for the purpose of identifying and addressing Project impacts on Pacific lamprey. Any variations from the implementation schedule provided in the PLMP have been identified in this document. This report also describes, consistent with the 401 Certification, recent Pacific lamprey passage, behavioral, and survival investigations and measures undertaken in the Columbia River basin, as well as an evaluation to determine if these investigations and measures are: (i) consistent with similar measures taken at other projects; (ii) appropriate to implement at the Project; and (iii) cost effective to implement at the Project.

On January 10, 2019, Grant PUD prepared and disseminated the draft 2018 PLMP Annual Report to members of the Priest Rapids Fish Forum, which includes the Washington Department of Ecology (Ecology) U.S. Fish & Wildlife Service, Washington Department of Fish & Wildlife, Colville Confederated Tribes, Yakama Nation, the Columbia River Inter-Tribal Fish Commission, Bureau of Indian Affairs, the Confederated Tribes of the Umatilla Indian Reservation, and the Wanapum Indians. Comments were received by email on February 12, 2019 from the Yakama Nation (Appendix B) and they are provided in the response table (Appendix C). On February 21, 2019, Ecology approved the 2018 PLMP Annual Report (Appendix D).

[1] 123 FERC ¶ 61,049 (2008)

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FERC staff with any questions should contact Tom Dresser at 509-754-5088, ext. 2312, or at tdresse@gcpud.org.

Sincerely,

Ross Hendrick
Manager - License & Environmental Compliance

CC: Breean Zimmerman – Ecology
Priest Rapids Fish Forum

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2018
Pacific Lamprey Management Plan
Comprehensive Annual Report

Priest Rapids Hydroelectric Project (FERC No. 2114)

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Ephrata, Washington

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March 2019

Executive Summary

In accordance with the Priest Rapid Hydroelectric Project's (Priest Rapids Project or Project) License Order, issued by the Federal Energy Regulatory Commission (FERC) on April 17, 2008 (FERC 2008), and the 401 Water Quality Certification (WQC), issued by the Washington Department of Ecology (WDOE) on April 3, 2007 (WDOE 2007) and amended March 6, 2008 (FERC 2008), Public Utility District No. 2 of Grant County, Washington (Grant PUD) is required to develop, in consultation with the Priest Rapids Fish Forum (PRFF), a Pacific Lamprey Management Plan Comprehensive Annual Report (PLMP Comprehensive Annual Report) to be filed with FERC on or before March 31 of each year. The PLMP Comprehensive Annual Report summarizes the on-going activities undertaken at the Priest Rapids Project in 2018, as identified in the PLMP, for the purpose of identifying and addressing project impacts on Pacific Lamprey. Any variations from the implementation schedule provided in the PLMP have been identified in this document. This report also describes recent Pacific Lamprey passage, behavioral, and survival investigations and measures undertaken in the Columbia River Basin as well as an evaluation to determine if these investigations and measures are: (i) consistent with similar measures taken at other projects; (ii) appropriate to implement at the Project; and (iii) cost-effective to implement at the Project.

During the tenth year of implementation of the PLMP, Grant PUD continued, for a ninth year, its assessment of Pacific Lamprey behavior and passage efficiency through fishways at Priest Rapids and Wanapum dams to evaluate the efficacy of design enhancements installed during the 2009-2010 winter fish ladder maintenance outage. For the 2010 through 2018 migrations, Grant PUD monitored a total of 615 and 620 half-duplex passive integrated transponder (HDX-PIT) tagged lamprey at Priest Rapids and Wanapum dams, respectively. Fishway passage efficiency for lamprey ranged from 62.3 to 100.0% with a standard error range of 2 to 12% at Priest Rapids Dam over the 2010-2017 period and ranged from 44.4 to 100.0% with a standard error range of 2 to 35% at Wanapum Dam over the 2010-2013, 2015-2017 period (2014 intentionally omitted due to anomalous conditions associated with the Wanapum spillway fracture). The fishway passage efficiency for the entire 2010-2017 comprehensive dataset is 85.9% and 91.0% at Priest Rapids and Wanapum dams, respectively. Low passage efficiency estimates were associated with small sample sizes in some ladders in certain years. Fishway passage efficiency for 2018 is not yet available and will be included in the 2019 annual report.

During the 2018 adult Pacific Lamprey migration period, fish from tagging efforts downstream were used to evaluate Project passage efficiency and to estimate passage times through the fishways at Priest Rapids and Wanapum dams. Pacific Lamprey were HDX-PIT tagged and released at Bonneville Dam by University of Idaho and the Confederated Tribes of the Warm Springs. The median passage time at the Priest Rapids and Wanapum fishways was 49.1 hours and 49.2 hours, respectively. Median passage times were based off small sample sizes due to poor antenna performance. Entrance and exit antennas are scheduled to be refurbished during the 2018/2019 winter dewatering and maintenance period at both dams.

In April 2018, the PRFF agreed by consensus to the Grant PUD Adult Pacific Lamprey No Net Impact Trap and Transportation Statement of Agreement (SOA) and is included as Appendix A. As a result of the first year of the agreement, Grant PUD operated the mechanical lamprey traps at Priest Rapids Dam from July 31 to August 17. A total of 177 lamprey were trapped, transported, and released upstream of Rock Island Dam, at Kirby Billingsley Hydro Park. Grant PUD continued to operate the traps from August 20 to September 7 to provide lamprey for both

Grant PUD's and Public Utility District No. 1 of Douglas County's (Douglas PUD) translocation program. A total of 674 lamprey were transferred to Douglas PUD and released upstream of Wells Dam.

As in previous years, Grant PUD continues to participate in regional research and forums in the Columbia River Basin to promote coordination and information exchange.

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1.0 Introduction

1.1 General Description of the Priest Rapids Hydroelectric Project

Public Utility District No. 2 of Grant County, Washington (Grant PUD) owns and operates two hydroelectric dams on the Columbia River in the State of Washington; Wanapum and Priest Rapids, known collectively as the Priest Rapids Project (Project), and operated under the terms and conditions of the Federal Energy Regulatory Commission (FERC) Hydroelectric Project License No. 2114.

Wanapum Dam is located at river mile (RM) 415, south of the I-90 bridge at Vantage, Washington; approximately 38 miles downstream of the Rock Island Hydroelectric Project owned and operated by Public Utility District No. 1 of Chelan County, Washington (Chelan PUD) and 18 miles upstream of Priest Rapids Dam. The dam is 8,637 feet (ft.) long and 186.5 ft. high and includes a left and right bank fish passage structure, each with an upstream fish ladder. Wanapum includes ten turbine units with a nameplate capacity of 1,038 megawatts (MW) and a spillway with 12 bays. In April 2008, Grant PUD finished construction of the Wanapum Future Unit Fish Bypass (WFUFB) in the vacant slot of future turbine unit 11 to aid in downstream migration of salmonids. The Wanapum Reservoir is approximately 38 miles long and has a surface area of approximately 14,680 acres. Active storage volume of the Wanapum Reservoir is 160,400 acre-feet and total storage is 693,600 acre-feet. Seven perennial streams (Douglas, Tarpiscan, Johnson, Skookumchuck, Whiskey Dick, Quilomene, Trinidad, and Sand Hollow Wasteway) enter into the Wanapum Reservoir.

Priest Rapids Dam is located at RM 397; approximately 18 miles downstream of Wanapum Dam and the last dam on the Mid-Columbia River before it enters the Hanford Reach. The nearest town is Desert Aire, Washington, which is located approximately two miles upstream on the east-bank from Priest Rapids Dam. The Priest Rapids facility is 10,103 ft. long and 179.5 ft. high and includes ten turbine units with a generating capacity of 855.0 MW and a spillway with 22 bays. The Priest Rapids Reservoir is approximately 18 miles long and has a surface area of approximately 7,725 acres. Active storage volume of the Priest Rapids Reservoir is 48,600 acre-feet and total storage is 237,100 acre-feet. Two perennial streams (Crab and Hanson) drain into the Priest Rapids Reservoir.

1.2 History of Pacific Lamprey related to Activities at the Priest Rapids Hydroelectric Project

For more than a decade, Grant PUD has actively participated in the research of, protection, and mitigation for Pacific Lamprey related to the Columbia River hydro system and the Project area. The development of Grant PUD's Pacific Lamprey Management Plan (PLMP) has been a formalization of past research and implementation measures required in the Project's License Order as issued by the FERC on April 17, 2008 (FERC 2008), but is largely a continuation of prior activities. Grant PUD was the first mid-Columbia River utility to assess the passage of lamprey in and through its Project area (Nass et al. 2003) and to identify potential actions and modifications to improve successful passage (Final License Application, Grant PUD 2003) without compromising adult salmonid passage. Results of the 2001-2002 lamprey telemetry studies in the Project area formed the basis of proposed modifications which are being conducted as part of implementation of the PLMP. These past studies and measures are partly the result of participation at the regional level and cooperating with tribes, agencies, and other hydroelectric

operators to address resource challenges and their potential solutions. In particular, Grant PUD's past and present participation in the Columbia River Basin Lamprey Technical Work Group (CRBLTWG) has made them an integral part of the regional research foundation. As a founding participant, Grant PUD assisted in the development of the "Critical Needs and Uncertainties" document and provided information to support the Tribal Recovery Plan (Nez Perce Umatilla, Yakama, and Warm Springs Tribes 2011). More recently, Grant PUD has and continues to participate in and provide support to the U.S. Fish and Wildlife Service (USFWS) Lamprey Conservation Initiative and Summit (2012, 2017), the Yakama Nation Lamprey Recovery Planning efforts, and the Columbia River Inter-Tribal Fish Commission's (CRITFC) Tribal Restoration Plan (2011).

Past activities and future measures implemented by Grant PUD to mitigate for Project impacts to Pacific Lamprey are extensive and on-going. Many of the actions and measures recommended by tribal and agency lamprey experts to address hydroelectric project impacts on lamprey are, in general, a result of actions or fish ladder modifications that are currently or were previously implemented by Grant PUD. These include fish counting facilities that operate 24 hours a day, 7 days a week for the upstream migration period; during fishway dewatering procedures, implementation of fish collection protocols by qualified biologists to ensure safe recovery of all fish species present (Grant PUD 2010); and juvenile lamprey protection as a result of Grant PUD's avian predation and Northern pikeminnow control programs that have been proven to be effective at minimizing impacts to juvenile salmonid outmigrants.

Physical fish ladder and dam modifications include the use of "slotted" (hour-glass style) fishway entrances that provide differential velocity elevations with a range of high and low velocity corridors to suit different species, improved 24-hour video fish counting stations to collect reliable and accurate count data, and downstream migrant bypass systems to meet juvenile salmonid survival criteria. Grant PUD believes measures developed to reduce impacts to juvenile salmonids will benefit juvenile Pacific Lamprey as well. The slotted entrances were installed prior to the 2001-2002 lamprey study and have provided effective fishway entrance efficiency. In recent years, the U.S. Army Corps of Engineers (ACOE) have experimented with similar entrances at lower Columbia River dams (D. Clugston, ACOE, personal communication). The fish counting stations have undergone several staged modifications starting with the conversion from count board stations (visual) to dual orifice video stations, and in 2010, conversion to engineered crowders which utilize a single orifice video station and picket leads with 11/16 - inch gap spacing to accurately enumerate all adult lamprey. Significant improvements for downstream passage have been achieved by development of the WFUFB and the Priest Rapids top-spill bulkhead for juvenile salmon which presumably provides a high survival alternative passage route for juvenile lamprey.

Also during the 2010 migration, an additional assessment of lamprey passage was conducted using underwater video. In this study, cameras were placed to view newly installed aluminum plating on the diffusion grating, the floor through weir orifices, and on the fish count station. This monitoring activity produced observations that the plating at weir wall orifices was extensively used by lamprey and was a benefit to lamprey passage. For 19 complete passage events through an orifice, 95% of lamprey used the plating and 100% of the events demonstrated successful passage. The fish count crowder was also observed to promote guidance of lamprey through the counting chute. Of 123 events, 79% of lamprey were successfully guided by the structure to the chute and 40% of these used the plated ramp to stage below the chute.

Grant PUD's continued efforts have contributed to the state-of-the-science for Pacific Lamprey including: participation in regional forums and conferences; conducting telemetric passage evaluations and literature research; evaluating turbine intake emergency wheelgate slot exclusion screens; providing upstream and downstream fish passage facilities; support for full-duplex (FDX; salmon) and half-duplex (HDX; lamprey) passive integrated transponder (PIT) detection systems for project-specific and basin-wide assessments; trapping and hauling lamprey; and providing educational opportunities for the public to understand the ecological and tribal importance of lamprey in the Columbia River Basin.

As referenced in the FERC Order (Order Modifying and Approving Pacific Lamprey Management Plan, Article 401(a)(12) and Water Quality Certificate Condition 6.2(5)(b)), 127 FERC ¶ 62, 091), Grant PUD is required to develop, in consultation with the Priest Rapids Fish Forum (PRFF), and implement a comprehensive evaluation of adult lamprey passage at the Project. As outlined in its PLMP, Grant PUD implemented measures to improve lamprey passage in 2010. These efforts include conducting inspections of the Project passage facilities by the PRFF members, and the installation of passage-enhancing structures in the fishways at Priest Rapids and Wanapum dams. New structures included diffusion grate aluminum plating, ramps ascending perched orifices, and lamprey-friendly video fish count crowders; all specifically designed to facilitate lamprey passage. To facilitate tagging and fish husbandry research, Grant PUD expanded its fish handling facilities at Priest Rapids Dam by building innovative adult lamprey trapping and holding facilities for the most efficient and non-invasive processing of study fish. Following the installation of these structures, Grant PUD, in consultation with the PRFF, conducted a study of the effectiveness of these modifications during the summers of 2010 to 2012. The extensive half-duplex (HDX)-PIT array at Priest Rapids and Wanapum dams was operated to monitor the passage of lamprey originating from tagging activities conducted at dams downstream of Priest Rapids Dam. A total of 20 HDX-PIT arrays were operated each migration season from 2010-2014 to track lamprey through the Project area. All arrays were operational May through December in 2010 through 2012 and from March through December in 2013 and 2014. Further, yearly winter fishway maintenance operations recover adult lamprey during National Oceanographic Atmospheric Administration (NOAA) approved dewatering procedures. These lamprey are scanned for the presence of a PIT tag and released into the forebay of the respective dams. Passage times of HDX-PIT tagged adult lamprey at Priest Rapids and Wanapum dams were relatively consistent during the 2010-2013 period. Median passage times at Priest Rapids and Wanapum right bank were less than 10 hours while passage times through the left bank fishways were greater; 76.6 hours and 24 hours at Priest Rapids left bank and Wanapum left bank fishways, respectively. However, passage times of HDX-PIT tagged adult lamprey that volitionally ascended fishways in 2014 were different than previous years, possibly due to modified operations (lamprey trapping activities related to the trap-and-haul effort).

During the 2014 migration season, an Interim Fish Passage Operations Plan (IFPOP) was developed by Grant PUD in consultation with PRFF members as a result of the Wanapum spillway fracture. The IFPOP included the installation of Fishway Passage Exit Systems (i.e., weir boxes with lamprey ramps) in each Wanapum fish ladder (Priest Rapids Dam fish ladders were unaffected). The effectiveness of these exit systems was also evaluated. In addition to facilitating volitional passage, Grant PUD trapped and transported lamprey (n=2,263) collected from Priest Rapids and Wanapum dam fish ladders during the peak of the upstream adult lamprey migration. Captured fish were released to various locations within and upstream of the

Project area. Already tagged fish were released immediately upstream of the dam where they were trapped. Untagged fish were released above Rock Island Dam.

During the winter of 2014-2015 the HDX-PIT arrays at Priest Rapids and Wanapum dams were modified to refine detection resolution in the upper Priest Rapids left bank fishway for the purpose of determining whether a pattern of slower passage through that section in 2010-2013 continued to occur in 2015, and the total number of receivers was reduced to 16. The apparent delay at Priest Rapids left bank was associated with the upper fishway as fish ascended beyond the count station and past the Off-ladder Adult Fish Trap (OLAFT). To gain a better understanding of this phenomenon and provide increased detection resolution, two additional HDX-PIT detection stations were installed in the Priest Rapids upper left fishway in the vicinity of the OLAFT in early 2015. A total of 283 HDX-PIT tagged fish over two years (2015 and 2016) were released in the lower Priest Rapids left bank fishway to assess passage through the upper fishway. This effort was undertaken to assess whether the apparent delay noted in results from 2010-2013 persisted in 2015 after operations returned to normal following the events surrounding the Wanapum Dam spillway fracture in 2014.

In July and August 2015, 133 adult lamprey were captured with mechanical traps from the Priest Rapids Dam lower left and right bank fishways during the peak migration period in July and August 2015 and implanted with HDX-PIT tags. The fish were released in the lower Priest Rapids left bank fishway to assess passage through the upper fishway, and specifically to evaluate passage near the OLAFT. The median passage time of fish included in this effort from release in the lower fishway to the fishway exit was 13.9 hours. The median passage time through the upper fishway above the count station, past the OLAFT to the exit was 6.0 hours.

In 2016, another 150 adult lamprey were captured with mechanical traps from the Priest Rapids Dam lower left and right bank fishways during the peak migration period in July and August and implanted with HDX-PIT tags for the same purpose. The median passage time of fish included in this effort from release in the lower fishway to the fishway exit was 15.1 hours which was similar to that observed in 2015. As such, there did not appear to be a passage delay for adult lamprey in the Priest Rapids upper left bank fishway in 2016 and no further evaluations are planned.

In 2017, to maintain the comprehensive data set of lamprey passage efficiency through Priest Rapids and Wanapum dams with low numbers of run-of-river tags and in response to the PRFF expressed interest in estimating entrance efficiency at both dams, 100 HDX-PIT tagged adult lamprey were released downstream from both dams in August 2017. Fish were captured with mechanical traps at Priest Rapids Dam lower left and right bank fishways and implanted with HDX-PIT tags. Twenty-five tagged fish were then released downstream of each fish ladder at both dams. Entrance efficiency was estimated using the existing HDX-PIT arrays at each dam. Detection efficiency at entrance arrays is not optimal so any fish detected at any array within the ladder or at an upstream dam was considered to have entered the ladder. The final entrance efficiency at both left and right fish ladders at Priest Rapids and Wanapum dams was 96%. Only one fish from each release group was not detected at the dam it was released below or at an upstream location. The passage efficiency of all tagged fish (run-of-river and entrance efficiency test fish) through the left and right bank fishways were 96.2% and 100.0% (SE 0%) with median passage times of 24.4 and 4.5 hours, respectively. At Wanapum Dam, passage efficiency through the left and right bank fishways were both 100% with standard errors of 4.9% and 8.8% with median passage times of 5.9 and 20.4 hours, respectively.

During the 2018 adult Pacific Lamprey migration period, fish from tagging efforts downstream were used to evaluate Project passage efficiency and to estimate passage times through the fishways at Priest Rapids and Wanapum dams. Pacific Lamprey were HDX-PIT tagged and released at Bonneville Dam by University of Idaho and the Confederated Tribes of the Warm Springs. The median passage time at the Priest Rapids and Wanapum fishways was 49.1 hours and 49.2 hours, respectively. Median passage times were based off small sample sizes due to poor antenna performance. Entrance and exit antennas are scheduled to be refurbished during the 2018/2019 winter dewatering and maintenance period at both dams.

In addition to the yearly monitoring effort, in April 2018 the PRFF agreed to the Grant PUD Adult Pacific Lamprey No Net Impact Trap and Transportation Statement of Agreement (SOA) which specifies that Grant PUD deploy, operate, and maintain mechanical lamprey traps at Priest Rapids Dam for approximately 15 days during the peak lamprey migration period (Appendix A). Collected lamprey are transported and released above Rock Island Dam. As a result of the first year of the agreement, Grant PUD operated the mechanical lamprey traps at Priest Rapids Dam from July 31 to August 17. A total of 177 lamprey were trapped, transported, and released upstream of Rock Island Dam, at Kirby Billingsley Hydro Park. Grant PUD continued to operate the traps from August 20 to September 7 to provide lamprey for Grant PUD's and Public Utility District No. 1 of Douglas County's (Douglas PUD) translocation program. A total of 674 lamprey were transferred to Douglas PUD and released upstream of Wells Dam.

For the 2010 through 2018 migrations, Grant PUD monitored a total of 615 and 620 HDX-PIT tagged lamprey at Priest Rapids and Wanapum dams, respectively. Fishway passage efficiency for lamprey ranged from 62.3 to 100.0% with a standard error range of 2 to 12% at Priest Rapids Dam over the 2010-2017 period and ranged from 44.4 to 100.0% with a standard error range of 2 to 35% at Wanapum Dam over the 2010-2013, 2015-2017 period (2014 intentionally omitted due to anomalous conditions associated with the Wanapum spillway fracture). The fishway passage efficiency for the entire 2010-2017 comprehensive dataset is 85.9% and 91.0% at Priest Rapids and Wanapum dams, respectively. Reduced HDX-PIT tagging effort from downstream sources in 2015-2017 resulted in a smaller quantity of run-of-river tags detected at Priest Rapids Dam than in 2010-2014, an average of 27 tags as opposed to 76 tags a year. Downstream tagging resumed in 2018 and 73 tags have been detected to date. Low passage efficiency estimates were associated with small sample sizes in some ladders in certain years. Fish passage efficiency was estimated by year and fish ladder using a Cormack-Jolly-Seber model in Program MARK.

Median reservoir passage time through Priest Rapids reservoir for HDX-PIT tagged adult lamprey with detections at the Priest Rapids Dam exits and Wanapum Dam entrances ranged from 4.2 to 5.9 days during the 2010-2018 period (Table 1). Finally, fish tagged in a previous study year were occasionally detected during the migration period the following year (i.e., fish tagged at Bonneville Dam in 2012 but detected at Priest Rapids Dam in 2013). These fish were assumed to have overwintered in the Columbia River then resumed migration behavior the following year. These fish have generally made up between 2% to 5% of detected tags, annually, although no overwintering fish have been detected in 2017 and 2018. The presence of these fish suggests that estimating passage efficiency for adult lamprey requires a nuanced approach.

Table 1 Passage metrics of HDX-PIT tagged adult lamprey including quantity of fish detected, median fishway passage time, net fallback, median Priest Rapids reservoir passage time, and overwintering fish at Priest Rapids (PR) and Wanapum (WA) dams during 2010-2018.

Year	Number Detected		Median fishway passage time (h)			
	PR	WA	PR Left	PR Right	WA Left [1]	WA Right [1]
2010-2018	615	620	49.2	5.2	21.0	19.1

Notes:
1 2014 Wanapum passage data omitted due to abnormal Project operations resulting from the Wanapum Dam spillway fracture

Year	Number Net Fallback		Median PR Reservoir passage time (d)[1]	Number of tags from previous year (overwintering fish)
	PR	WA		
2010-2018	1	8	4.8	29

Notes:
1 2014 Priest Rapids reservoir passage data omitted due to abnormal Project operations resulting from the Wanapum Dam spillway fracture

In addition to the HDX and FDX-PIT tagging and monitoring, in 2015 100 adult lamprey were captured and implanted with both active acoustic tags (Vemco V7) and FDX-PIT tags and released into Priest Rapids Forebay at Desert Aire (RM 400.4; n=30) or in the Wanapum Forebay at RM 415.8 (n=35) or RM 419.9 (n=35). This was an experimental study (i.e., not required by the PLMP) to assess dam and reservoir passage behavior. Acoustic receivers deployed at fixed locations throughout the Project area were used to monitor the migration behavior of tagged individuals. Additionally, mobile tracking was used to locate tagged individuals in the study area. The objectives of the study were to estimate the proportion of tagged lamprey that 1) migrate upstream out of the Project area to the tailrace of Rock Island Dam, 2) overwinter in the study area and resume migration in spring 2017, 3) experience pre-spawn or predation mortality in the study area, 4) may engage in undetected spawning in reservoir tributaries, and 5) may engage in spawning in the tailrace of Wanapum and/or Rock Island dams. The median travel time to reach the Rock Island Dam tailrace was 3.6 days for fish released in the Wanapum Reservoir and 16.8 days for fish released in the Priest Rapids Reservoir. Travel rates to reach the Rock Island Tailrace ranged from 0.2-28.2 km/d for fish released in the Wanapum Reservoir and from 0.9-12.7 km/d for fish released in the Priest Rapids Reservoir. Three fish were never detected after release and were assumed to have either been mortalities or have failed acoustic tags.

In 2016, another 100 adult lamprey were captured during the peak migration and implanted with both acoustic tags (Vemco V7) and FDX-PIT tags. Release numbers and locations and monitoring were similar to 2015. These fish were monitored throughout 2017 until the acoustic tags expired in early August. A total of 81 fish were detected in the tailrace of Rock Island Dam (RM 453.0), although a proportion of those fish had subsequent downstream movement. Of the Priest Rapids forebay released fish, 67% were last detected having passed the Priest Rapids Reservoir. Of all 100 study fish, 56 % were last detected in the Rock Island tailrace or further upstream, having passed the Wanapum Reservoir. The median travel time to reach the Rock Island Dam tailrace was 2.8 days for fish released in the Wanapum Reservoir and 10.3 days for fish released in the Priest Rapids Reservoir. Travel rates to reach the Rock Island Tailrace ranged

from 0.2-39.7 km/d for fish released in the Wanapum Reservoir and from 1.0-15.4 km/d for fish released in the Priest Rapids Reservoir. Two fish had not been detected after release and were assumed to have either been mortalities or have failed acoustic tags.

In addition to conducting adult lamprey fishway and reservoir passage studies, Grant PUD has also coordinated with the PRFF, other PUDs, and tribes, to provide adult lamprey for ongoing regional studies for the past five years. For example, in 2018 a total of 674 fish were collected at Priest Rapids Dam by Grant PUD and transferred to Douglas PUD in support of their translocation program. These fish were subsequently released upstream of Wells Dam. Grant PUD has provided fish to support other adult lamprey studies for five consecutive years. In addition to providing fish, Grant PUD provided a total 500 HDX-PIT tags in 2016 and 2017 to the Confederated Tribes of the Warm Springs to increase the regional database of tagged lamprey in the Columbia River basin in addition to increasing the overall tagged lamprey at large and potentially increase the number of tagged lamprey at the Priest Rapids Project. All fish tagged with these HDX-PIT tags were released 3 river miles above Bonneville Dam.

In 2012, Grant PUD began monitoring of juvenile lamprey within the Project area as required by its PLMP. In June 2012, monitoring of juvenile lamprey was initiated to assess their presence/absence, habitat use, and relative abundance in areas affected by Project operations. In the Wanapum Reservoir, 36 potential shoreline habit locations were sampled. In the Priest Rapids Reservoir, 12 potential shoreline habitat locations were sampled. One juvenile lamprey was captured in the Priest Rapids Reservoir and another was observed, but not captured, in the Wanapum Reservoir. On November 13-16 and December 11-14, 2012, a field crew continued efforts to assess presence/absence, habitat use, and relative abundance of juvenile Pacific Lamprey in areas that may be affected by Project operations. Twenty-seven and 21 shoreline habit locations were sampled in the Wanapum and Priest Rapids reservoirs, respectively. Sampling was conducted at mid-range pool elevations of the FERC-allowed operational range; approximately 570.0 ft. above mean sea level (msl) at the Wanapum Forebay and between 485.3-487.5 ft. above msl at the Priest Rapids Forebay. No juvenile lamprey were collected. Additional sampling was completed on May 11 and 12, 2013. Ten potential shoreline habitat locations in the Wanapum Reservoir were sampled resulting in the collection of no juvenile lamprey sampled. The pool elevation at the Wanapum forebay was 569.0 above msl during this sampling event. On October 11 and 12, 2013, a final sampling of eight potential shoreline habit locations in the Priest Rapids Reservoir collected seven juvenile lamprey. An additional 10 lamprey were observed but not captured. The elevation of the Priest Rapids Forebay was 480.2 ft. above msl during this effort (near allowable minimum reservoir elevation per the FERC license). On March 4 – 7 and 13-14, 2014 a field crew assessed presence/absence of juvenile Pacific Lamprey in areas affected by the abnormal drawdown. Generally, sampling was difficult and at times not feasible due to deep mud exposed by low pool elevation (543.3-544.0 ft. above msl at the Wanapum forebay). Three juvenile lamprey were captured and another was observed during sampling on March 4 in the vicinity of Sunland Estates (RM 431). Small numbers of dead juvenile Pacific Lamprey were observed in the vicinity of Walling Canyon (RM 449), Crescent Bar (RM 441), and Sunland Estates. Given three years of sampling at varying reservoir elevations (2012-2014) have indicated that juvenile lamprey do not commonly occur within the Project operational zone.

Concurrent to evaluation and discussion of fish passage efficiency, Grant PUD and the PRFF (in addition to other regional forums) have engaged in numerous discussions since 2012 regarding the appropriate fish passage efficiency related to NNI (No Net Impact – Grant PUD PLMP,

Section 4.1) for Pacific Lamprey at Priest Rapids and Wanapum dams. The tribes recommend establishment of an adult dam passage standard of 80% by 2020 (Moser et. al. 2002; CRITFC 2011). In 2007, a subgroup of the CBFWA (Columbia Basin Fish and Wildlife Authority) Lamprey Technical Working Group was tasked with developing basin-wide adult lamprey passage standards and objectives for measurable and biologically relevant metrics (CRBLTWG 2007). This group had made significant progress on two phases to establish regional passage standards: identifying potential research metrics and determining which metrics were measurable with scientific rigor (CRBLTWG 2010b). These include passage efficiency into fishways, passage effectiveness through fishways, passage timing, fallback and fallout through floating powerhouse orifices. A significant proportion of the overall objective remains incomplete and has been complicated by limited passage information at specific facilities, varying data collection methods, and an incomplete understanding of lamprey life history. Despite these limitations, the CRBLTWG passage metric subgroup and the PRFF continues to meet regularly to further develop and discuss passage metrics and standards for Pacific Lamprey.

Grant PUD continues to be active with respect to investigations related to Pacific Lamprey passage research through its historical activities and proactive implementation of research and mitigation measures included in the PLMP. Grant PUD is committed to continue into the future in a similar manner. This report illustrates the continued allocation of effort and resources to achieve the goals and objectives of the PLMP.

1.3 Purpose of the Report

Grant PUD is required to submit the PLMP Comprehensive Annual Report (PLMP Comprehensive Annual Report) in accordance with the Project's License Order, issued by the FERC on April 17, 2008 (FERC 2008), and the 401 Water Quality Certification (WQC), issued by the Washington Department of Ecology (WDOE) on April 3, 2007 and amended March 6, 2008 (WDOE 2007; FERC 2008), which states:

> *<u>License Order:</u> The licensee shall file annually with the Commission by March 31, beginning 2010, their Annual Pacific Lamprey Management Report. The report shall include the reporting requirements identified under implementation measure 1 of the Biological Objectives and Implementation Measures under Appendix C of the Washington State Department of Ecology 401 Water Quality Certification. Additionally, the licensee's report shall include an updated implementation schedule and identify any variations from the schedule provided in the licensee's filed plan. The licensee shall prepare their report in consultation with the Priest Rapids Fish Forum and allow the Priest Rapids Fish Forum 30 days to review and comment on the report prior to filing with the Commission. The licensee's report shall include any resource agency and Tribe comments and the licensee's response to any comments. The Commission reserves the right to require changes to their plan based upon review of the report.*
>
> *<u>401 Water Quality Certification, Appendix C:</u> By March 31 following issuance of the New License, and each year thereafter for the term of the New License, [Grant PUD shall] provide an annual report summarizing activities undertaken to identify and address impacts of the Priest Rapids Project on Pacific Lamprey, including results of those activities. This report shall include a compilation of information on other Pacific Lamprey passage and survival investigations and*

measures being undertaken in the Columbia River Basin in order to determine if adult and juvenile measures being investigated and/or implemented at the Priest Rapids Project are: (i) consistent with similar measures taken at other projects; (ii) appropriate to implement at the Priest Rapids Project; and (iii) cost effective to implement at the Priest Rapids Project.

To fulfill the requirements, the report is structured as follows:

- Section 2.1: Background and existing information (i.e., through October 31, 2018) about Pacific Lamprey passage and survival investigations and measures undertaken in the Columbia River Basin.
- Section 2.2: Information from the reporting year (i.e., November 1, 2017 through October 31, 2018) about passage and survival investigations and measures being undertaken throughout the Columbia River Basin.
- Section 3.0: Status report on Pacific Lamprey activities underway at the Project, including identification of any variations from the schedule provided in the PLMP (Grant PUD 2009).
- Section 4.0: An evaluation of whether recent activities in the Columbia River Basin should be considered for the Project.
- Section 5.0: A summary of preliminary conclusions regarding Pacific Lamprey activities to date, anticipated activities in the Columbia River Basin, and future activities at the Project for the upcoming year.

1.4 Consultation

Pursuant to the reporting requirements, Grant PUD provided a complete draft of the PLMP Comprehensive Annual Report to the PRFF on January 10, 2019. Comments were received from the Yakama Nation on February 12, 2019. Washington Department of Ecology approved the 2018 PLMP Annual Report on February 21, 2019.

2.0 Pacific Lamprey Activities in the Columbia River Basin

2.1 Background and Existing Information

Pacific Lamprey (*Entosphenus tridentatus*) are indigenous to many of the tributaries of the Columbia (Jackson et al. 1997a, Jackson et al. 1997b) and Snake rivers (Close et al. 1995). Wydoski and Whitney (1979) reported that the Pacific Lamprey are one of three species of lamprey in the Columbia River Basin where river lamprey (*Lampetra ayresi*) and western brook lamprey (*Lampetra richardsoni*) have been known to exist. Western brook lamprey and river lamprey distributions overlap with the more common Pacific Lamprey but populations are concentrated to coastal tributaries and the lower reaches of the Columbia River (Kostow 2002).

The Pacific Lamprey is an important fish of cultural, utilitarian, and ecological significance (Close et al. 2002). Close et al. (1995) reported that Native American tribes of the Pacific Coast and interior Columbia River Basin harvested Pacific Lamprey for subsistence, ceremonial, and medicinal purposes. In addition, a commercial fishery for Pacific Lamprey also occurred during the 1940s and was used as food for livestock and cultured fish. Pacific Lamprey are important ecologically throughout their life in terms of nutrient cycling, both as predator and prey. As juveniles, lampreys are filter feeders of detritus and algae, and a food source for fish and birds

(Close et al 2002). In the past when they were more numerous, downstream migrants were likely an important food source to fish and birds and may have provided a buffer for juvenile salmon migrants. As adults, lamprey are opportunistic feeders and prey on a variety of fish species, thereby minimizing their impact on any particular one species. Adult Pacific Lamprey are also a prey item to marine mammals such as sea lions and likely attract predation away from adult salmon (Close et al. 2002). Pacific Lamprey carcasses are a food source to sturgeon, and decomposition provides marine-derived nutrients to riverine systems.

Adult lamprey counts have decreased at Columbia River Basin dams as compared with historical estimates, with the greatest declines occurring at the upper Columbia and Snake River projects. Passage counts of adult and juvenile lamprey at Bonneville, the Dalles, John Day, McNary, Ice Harbor, Rock Island, Rocky Reach, and Wells dams indicate a general decreasing trend; large declines occurred in the late 1960s and early 1970s (BioAnalysts 2000).

Based on the decreasing trend of adult Pacific Lamprey, conservation groups filed a lawsuit against the USFWS in May 2004 to compel USFWS to act on their January 27, 2003 petition to list four species of lamprey for protection under the Endangered Species Act (ESA), including Pacific Lamprey. On October 1, 2004, the USFWS initiated its 90-day finding process as part of a settlement with the conservation groups. On December 22, 2004, the USFWS announced that a petition to list four species of lamprey did not contain sufficient information to warrant further review at that time.

Although Pacific Lamprey are currently not ESA-listed, increased regional activity in the Columbia River Basin aimed at developing coordinated conservation and recovery strategies are proceeding. In addition to the ongoing efforts of the CRBLTWG and implementation activities associated with operations of FERC licensed and federal hydroelectric facilities (e.g., ACOE, Grant PUD, Chelan PUD, Douglas PUD, and Portland General Electric [PGE]), the USFWS-led Pacific Lamprey Conservation Initiative, continued its activities by developing a multistate, tribal and Federal Conservation Agreement that will serve as the basis for regional working groups tasked with the development and implementation of conservation actions (USFWS 2012). These initiative activities and recommendations are not regulatory requirements.

2.1.1 General Biology and Ecology

Elongate and snake-like in form, the Pacific Lamprey is a relatively poor swimmer in high velocity areas due to its anguilliform swimming motion as contrasted with the more efficient subcarangiform motion used by salmonids (Weihs 1982 as cited in Mesa et al. 2001). The lamprey does not have rigid fins, but rather dorsal and ventral fin-folds with minor cartilaginous ray-like supports. In addition, it lacks a swim bladder and must continue swimming (or attach to substrate), or it will sink.

Pacific Lamprey are cartilaginous, jawless, anadromous fish that develop morphologically and physiologically in three primary stages. First, Pacific Lamprey begin as larvae that hatch after approximately 19 days at 15°C (Close et al. 2002). After hatching, larvae drift freely downstream until encountering suitable substrate (silt and sand) and flow conditions (low velocities) for a sedentary lifestyle (Pletcher 1963 as cited in Close et al. 2002). Ammocoetes reside burrowed in fine sediment (Close et al. 2002) for a period of 4 to 6 years filter feeding on diatoms, algae, and detritus by pumping water through their branchial chamber (Beamish and Levings 1991). Beamish and Levings (1991) observed peak downstream movement of ammocoetes during May and June (Table 2) and determined ages to range from two to six years (using statolith analysis;

Volk 1986 as cited in Beamish and Levings 1991). In general, downstream movement of juvenile lamprey has been observed to coincide with high flow events.

Table 2 Annual timing of key biological events in the freshwater life history of Pacific Lamprey.

Annual Timing of Key Biological Events in the Freshwater Life History of Pacific Lamprey

Event	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ammocoete downstream migration[1]	Unk											Unk
Young adult downstream migration[1]	Unk											Unk
Metamorphosis / Transition[2]												
Parasitic feeding initiated[2]												
Entry into saltwater[2]												

[1] Beamish and Levings (2001)
[2] Beamish (1980)
Peak period = dark shade

Pacific Lamprey then enter a transformation phase characterized by morphological and physiological changes that begin in the latter period of substrate residence. The young adult stage continues during stream residence and into the period of downstream migration from their parent streams to the ocean. The causal mechanisms which initiate the transformation process, trigger emergence from the substrate, and result in migratory behavior are unknown or undocumented. Young adult lamprey are also termed macrophthalmia following major morphological changes, but prior to parasitic feeding (Hardisty and Potter 1971 as cited in Beamish 1980). Pacific Lamprey transform from ammocoetes to macrophthalmia from July to November (Hammond 1979 and Close et al. 2002). During transformation, the shape and angle of the head and mouth changes, and the gut develops to allow consumption of flesh and fluids (Hart 1973). The onset of transformation occurs over a relatively large range in lengths. Beamish (1980) observed characteristics associated with metamorphosis in lamprey ranging from 47 millimeters (mm) to 160 mm in length. As such, there is overlap in the length distribution of larval ammocoetes and macrophthalmia. Macrophthalmia migrate to the ocean between late fall and spring (Table 2).

Beamish and Levings (1991) determined age distributions for macrophthalmia to be 4 to 8 years using statolith analysis (Volk 1986 as cited in Beamish and Levings 1991). Metamorphosing lamprey moved into progressively more rocky and higher flow environments over time (Richards 1980 as cited in Beamish 1980), which may be related to their specific stage of transition. Concurrent downstream migrations of several different lamprey life-stages (including ammocoetes and young adults of many different stages of metamorphosis) has been observed, providing evidence of natural variation in the timing and developmental stage of migrating lamprey (Beamish and Levings 1991).

Juvenile Pacific Lamprey have been found to be largely nocturnal, with > 90% of their swimming activity restricted to hours of darkness (Moursund et al. 2000). This is consistent with prior reports that outmigrating individuals were more active at night while settling onto or into the substrate during the day (Hardisty and Potter 1971 as cited in Moursund et al. 2000; Beamish and Levings 1991). However, strict diel movement patterns appear to be restricted to the upper watershed areas, whereas the migration appears more or less continuous (night and day) in the lower parts of the river (Beamish and Levings 1991).

In the mid-Columbia River area, including the Project, juvenile lamprey are collected incidentally during juvenile salmon collection or salvage activities from April through June. At Priest Rapids and Wanapum dams, juvenile lamprey have also been observed during an evaluation of the emergency wheelgate slot exclusion screens (Wright et al. 2010). These results suggested that downstream run timing of juvenile lamprey coincides with spring runoff upstream of the Priest Rapids Project and throughout the Columbia River Basin and supports historical run timing trends of juvenile lamprey (Wright et al. 2010). Juvenile lamprey are also infrequently collected during the fish bypass operation of gatewell dipping (Grant PUD, unpublished data). A portion of these fish are counted and measured for length during juvenile salmonid survival and behavioral evaluations. All fish are subsequently released downstream of the Project. In some years, lamprey have been counted, but not identified beyond the genus level of classification (there are three species of lamprey in the Columbia River). In a separate operation, fyke net sampling at Wells Dam caught lamprey during the period March through August, with the highest catches occurring in May and June (BioAnalysts 2000). It is likely that these lamprey are Pacific Lamprey since this is the only species currently known to be distributed upstream of the Yakima River confluence.

Lamprey are considered adults once all transformations are complete and parasitic feeding begins; a process that is likely completed in salt water (Beamish and Levings 1991). In addition, laboratory research by Beamish (1980) surmised that completely transformed lamprey (i.e., adults) must move into a saline environment within a relatively short period of time, or they will die. Specifically young adults completing the transition to adulthood between June and September need to be in salt water by January. Physiological experiments showed that Pacific Lamprey in the Fraser River begin entering saltwater in December and continue through June (Beamish 1980). As an adult (100-700 mm), the animal is fully developed to handle life in salt water, which ranges from 1.5 to 3.5 years (Kan 1975 and Beamish 1980 as cited in Close et al. 2002).

In the ocean, Pacific Lamprey adults feed as external parasites on marine fish and mammals before returning to freshwater to spawn (Beamish 1980 and Close et al. 2002). Information on Pacific Lamprey migration patterns during ocean residency remains a significant data gap for researchers and managers although work has been published on the relationship between the abundance of Pacific Lamprey in the Columbia River and their common hosts in the marine environment (Murauskas et al. 2013). Recent efforts to understand Pacific Lamprey marine ecology include collections of individuals during their marine phase by fisheries observers and NOAA Fisheries surveyors off the WA/OR coasts in 2017 and 2018. These fish are being used to estimate marine size and condition, ocean growth rates, feeding success, and origins based on genetic and statolith analysis. Furthermore, the 2017 and 2018 ocean collection efforts included the release of two PIT tagged individuals (one in 2017, one in 2018) for the purpose of understanding ocean migration patterns.

Little is known about the ecology of Pacific Lamprey in estuarine systems. Weitkamp et al. (2015) conducted the first analysis of Pacific Lamprey in the Columbia River estuary, using data from two fish assemblage studies spanning three decades (1980-19801 and 2001-2012) and concluded that juveniles and adults in the estuary clearly were separated by size. Pacific Lamprey juveniles and adults were present in the estuary in winter and spring and depth in the water column also differed by lamprey species and age class. During 2008–2012, the study team documented wounds from lampreys on 8 fish species caught in the estuary. The most frequently

wounded fishes were non-native American Shad (*Alosa sapidissima*), subyearling Chinook Salmon (*Oncorhynchus tshawytscha*), Shiner Perch (*Cymatogaster aggregata*), and Pacific Herring (*Clupea pallasii*).

Given the basic understanding of the species biology and ecology (in freshwater), recent work on Pacific Lamprey has generally focused on topics such as developing more resolute site-specific information on the distribution and abundance of lamprey "populations", and lamprey physiology. However, in addition to site specific distribution and abundance activities, lamprey biologists and researchers have begun to collect the information and develop the necessary tools to address factors that may limit species persistence and recovery. Throughout the Columbia River Basin, various activities have been or are being implemented. Monitoring activities associated with documenting key habitat related to spawning, rearing, and overwintering have been conducted annually in the Deschutes, Hood, Willamette, and Umatilla rivers. In the Yakima and Umatilla watersheds, tracking adult movement patterns (via radiotelemetry) to overwintering and spawning areas and identifying passage bottlenecks has occurred. In-river and irrigation canal juvenile lamprey distribution and abundance sampling is also occurring in the Yakima basin. Juvenile distribution and abundance sampling, habitat, and/or larval trend and larval occupancy monitoring/sampling has or is occurring in the Chehalis, White Salmon, Wind, Washougal, Kalama, Wenatchee, Chelan, Okanogan, Klickitat, Entiat, Willamette, and Methow watersheds. On the Chewuch River (Methow watershed), larval trend monitoring associated with salmon-based restoration actions is currently ongoing. Surveys to assess juvenile distribution and relative abundance have also been conducted in several of the mid- and lower Columbia River reservoirs in addition to larval lamprey assessments using deep water sampling methodologies at Bureau of Reclamation (BOR) facilities in the Yakima basin. Past and current activities on the general biology and ecology of Pacific Lamprey includes monitoring adult harvest and escapement at Willamette Falls; translocation activities in the Willamette, Umatilla, Yakima, Wenatchee, Okanogan, and Methow watersheds; estuary research; marine phase research; the development of a lamprey identification guide; assessing carcass fates in food webs; using network theory to evaluate lamprey behavior; traditional ecological knowledge activities; lamprey outreach and education; continued research and development of artificial propagation techniques and best management practices; testing larval lamprey movements and effects on survival in response to dewatering events; and eDNA sampling including the Basin-wide Lamprey Inventory and Monitoring Project (BLIMP) which has developed an eDNA marker for Pacific Lamprey and a preliminary set of range-wide occurrence probability maps to assist with future surveys. (see Section 2.2: Updated Information for additional details).

2.1.2 Migration in Rivers

The upstream migration of adult Pacific Lamprey in the Project area (RM 397-453) typically occurs from May through November, with peak migration occurring in August (Nass et al. 2003). In the lower Columbia River (Bonneville Dam, RM 146), this timing is shifted earlier by approximately one month (Ocker et al. 2001). Similarly, peak migration past dams upstream of Priest Rapids occur two to four weeks later. As expected, numbers of lamprey observed at successive dams decreases as fish enter tributaries or cease migration to overwinter, however the inherent challenges of counting lamprey is apparent in the years when counts at upstream facilities are higher than downstream facilities. Timing of freshwater entry is closely tied to water temperatures and somewhat with discharge. Keefer et al. (2009a) reported that few

lamprey pass Bonneville Dam before water temperatures reach 15°C and half the run, on average, pass by the time water temperatures reach 19°C.

Median upstream migration rates have been estimated at 10 RM/day and 13.7 RM/day on the Columbia River (Jackson et al. 1997b and Vella et al. 2001, respectively), and 6.8 RM/day on the John Day River (Bayer et al. 2001). HDX-PIT tagged lamprey migrated at rates of 7.7 RM/day to 8.5 RM/day between Bonneville and McNary dams (~146 miles). As with timing, migration rates were correlated with water temperatures and inversely related to discharge (Keefer et al. 2009b). At Priest Rapids and Wanapum reservoirs, median upstream migration rates were 3.0 RM/day and 6.8 RM/day, respectively (Nass et al. 2003). Pacific Lamprey that are migrating upstream are likely heading to holding and/or spawning areas to overwinter. In general, upstream migration has been documented to cease in mid-September (Beamish 1980 as cited in Close et al. 2002), and resume in mid-March of the following spring if the final spawning destination has not been reached (Bayer et al. 2001). Note however that migration periods may vary by region (e.g., Columbia River, coastal, etc.).

In general, spawning occurs from spring to summer (March to July) following the upstream migration year (Beamish 1980 as cited in Close et al. 2002; Ralph Lampman, Yakama Nation, personal communication). Lamprey prefer low-gradient reaches, with gravel-cobble-sand substrate for spawning (Mattson 1949 and Kan 1975 as cited in Close 1995). Further, spawning typically occurs in lotic habitat with velocities ranging from 3 to 4 feet per second (ft/sec) and in depths ranging from 1 to 3.3 ft (Kan 1975). Both sexes begin moving rocks with their buccal funnel to create nests in excavated depressions (Pletcher 1963). Courting consists of a male approaching a female with a gliding motion to stimulate the female. A male attaches his buccal funnel to a female's head, and then wraps his body around the female to provide mixing of simultaneously released gametes. Each spawning act releases approximately 100 to 500 eggs (Pletcher 1963). Nest dimensions are approximately 12 inches wide, 1 to 2 inches deep, and oval in shape. Pacific Lamprey die after spawning (Hart 1973) within 3 to 36 days (Kan 1975).

Pacific Lamprey do not appear to have natal homing tendencies (return to a place of origin), and will migrate to other locations (Hatch et al. 2001). Distribution is more uncertain in the mid-Columbia area above Priest Rapids Dam compared to the lower Columbia, but since 1958 the furthest upstream extent on the Columbia River has been Chief Joseph Dam where there are no fish passage facilities.

Recent work on adult lamprey migration in rivers has used active tag technology including radio-telemetry and juvenile salmon acoustic telemetry system (JSAT) tags. These studies have occurred or are occurring in reservoirs of the ACOE projects in the Lower Columbia and Snake rivers and in the Willamette River. In the mid-Columbia, an acoustic telemetry study was implemented at Wells Dam in 2016 to evaluate a key assumption of hydroelectric project passage assessments which is that tagged fish (translocated from downstream) will exhibit upstream migratory behavior and are motivated to approach and attempt to pass the dam (Robichaud and Kyger 2018). In past years, assessments have been dependent upon study fish from downstream due to extremely low returns to Wells Dam and previous studies have shown that half or less of tagged, translocated lamprey released downstream of the dam interact with the dam. Results of this study supported previous studies with 14 fish (17% of the 83 tracked fish) interacted with Wells Dam fishways (i.e., were detected at receivers deployed at or inside the fishway entrances). Additional large-scale monitoring programs have also utilized (HDX-PIT tags in combination with multi-entity coordination to take advantage of the individual monitoring

programs occurring throughout the mainstem Columbia River. More recently, FDX-PIT tags have also been used in passage and migration assessments for adults; specifically at the Priest Rapids Project in 2015, and Rocky Reach Dam in 2016 and 2017 (see Section 2.2: Updated Information for additional details).

Information regarding juvenile migration in rivers is relatively limited. Much of the information available has been collected anecdotally during tributary operations targeting juvenile salmonid outmigrants and is consistent with previous information regarding timing and the environmental variables associated with such movements. Juvenile lamprey have been observed using dual frequency identification sonar (DIDSON) during an evaluation of the emergency wheelgate slot exclusion screens at Priest Rapids and Wanapum dams (Wright et. al. 2010). These results suggested that downstream run timing of juvenile lamprey coincides with spring runoff upstream of the Priest Rapids Project and throughout the Columbia River Basin and supports historical run timing trends of juvenile lamprey (Wright et. al. 2010).

Over the past decade the lack of available tag technology has limited researchers and fish managers' ability to collect more detailed information to better understand and address challenges of juvenile lamprey movement. BioAnalysts (2000) summarized anecdotal information on the distribution of juvenile lamprey in tributaries of the mid-Columbia, which include the Wenatchee, Entiat, Chelan, and Methow rivers. Recent evidence indicates the presence of lamprey in the Similkameen River, a tributary of the Okanogan River (T. Holder, Washington Department of Fish and Wildlife, personal communication) previously thought unused by Pacific Lamprey. Further, juvenile Pacific Lamprey have been captured in rotary trapping operations on the Okanogan River near Malott (M. Rayton, Colville Tribes Fish & Wildlife, personal communication). Juvenile lamprey outmigration monitoring via rotary screw trapping is also occurring at RM 2.5 of the Umatilla River from November to May to support translocation activities. Regional entities such as the Fish Passage Center have evaluated available juvenile lamprey PIT tag data in the Columbia River Basin toward improving understanding of this life stage and regularly collect data of lamprey incidentally collected at juvenile salmonid collection/bypass facilities at mainstem dams. A recent juvenile lamprey data synthesis (Mesa et al. 2015) summarized data and research related to the presence, numbers and migration timing characteristics of juvenile (eyed macropthalmia) and larval (ammocoetes) Pacific Lamprey *Entosphenus tridentatus*, in the Columbia River basin. Included were data from various screw trap collections, data from historic fyke net studies, catch records of lampreys at juvenile bypass systems (JBS) facilities, turbine cooling water strainer collections, and information on the occurrence of lampreys in the diets of avian and piscine predators. Key data gaps and uncertainties that should be addressed in a juvenile lamprey passage research program were identified. The goal of the work was to summarize information from disparate sources so that managers can use it to prioritize and guide future research and monitoring efforts related to the downstream migration of juvenile Pacific Lamprey within the Columbia River basin.

Given the high number of irrigation diversions in the Columbia River Basin and the recognition that poorly designed or unscreened diversions can result in fish mortality, researchers continue to evaluate the efficacy of different irrigation diversion screen panels and the effectiveness of fish screen materials to prevent juvenile lamprey impingement and entrainment at these locations. In 2012, the USGS tested the effectiveness of five common fish screen materials for excluding lamprey ammocoetes: interlock (IL), vertical bar (VB), perforated plate (PP), and 12-gauge and 14-gauge wire cloth (WC12) and (WC14) (Rose and Mesa 2012). The results of the study

indicated that wire cloth screens should be replaced with perforated plate and vertical bar, or interlocking bar screens to reduce lamprey entrainment at water diversions. To further explore the potential effects of irrigation diversion screens on ammocoetes, researchers designed and built a large, recirculating flume that could evaluate larval lamprey passage, including entrainment risk, passage time, and impingement frequency and duration at two water velocities for each screen type (Mesa et al. 2017). Further testing is currently ongoing with a series of laboratory-based experiments, specifically addressing the question of how the angle of a screen influences the safe and effective passage of juvenile lampreys (see Section 2.2: Updated Information for additional details).

Furthermore, to begin understanding the potential impacts of irrigation diversions on juvenile lamprey, researchers have been conducting surveys in irrigation canals in the Yakima and Wenatchee watersheds since 2010 (see Section 2.2: Updated Information for additional details).

2.1.3 Population Status

2.1.3.1 Distribution

Pacific Lamprey are native to the Columbia River Basin and their spawning migration extends into many inland rivers draining Oregon, Washington and Idaho (Kan 1975; Hammond 1979). Collections and historic observations of Pacific Lamprey are common in the Columbia River below the mouth of the Deschutes River. Areas include numerous small tributaries such as Fifteenmile Creek, Gnat Creek, Elochoman River, and larger tributaries such as the Lewis, Willamette, and Klickitat rivers. Lamprey probably used all accessible watersheds in the Lower Columbia, including mainstem and slough habitats. A comparison of counts at Bonneville Dam to harvest at Willamette Falls during the 1940s indicates that Pacific Lamprey were probably more abundant in the Willamette subbasin at that time than they were anywhere upriver of the Columbia River Gorge (Kostow 2002).

Watersheds upstream of the Columbia River Gorge, specifically noted in historic collections and observations, include the Deschutes extending into the Crooked River above Pelton/Round Butte Dam, John Day, Umatilla, Walla Walla, Yakima, Entiat, Okanogan and Kootenay Lake. In the Snake River Basin, collections and historic observations have been made in the lower Palouse, Clearwater, Salmon, Grand Ronde, Imnaha, and upstream to at least the Powder River. Historic records are too sparse to determine the full extent of historic occupation of these basins; however recent work has focused on collecting more current distribution information and a report documenting the current status of Pacific Lamprey in some of these river basins was published in 2011 (IDFG 2011). A study conducted by Idaho Fish and Game from 2000 to 2006 determined that Pacific Lamprey currently occupy only about 25% of their historic distribution in the Snake River Basin (Hyatt et al. 2006). In the upper Columbia River Basin, distribution information has or is being collected in the Wenatchee, Entiat, Chelan, Okanogan and Methow rivers while past adult translocation activities by the Nez Perce Tribe indicated that juvenile lamprey in Asotin, Lolo, Newsome and Orofino creeks in the Snake River were primarily the progeny of translocated adults (Chris Peery, USFWS, personal communication).

The current distribution of Pacific Lamprey is substantially reduced from the historic distribution. Lamprey have been lost from all areas that are blocked by impassible barriers. These barriers include the Willamette subbasin dams, and other high dams such as Dworshak (Clearwater), Hells Canyon complex (Snake), and Chief Joseph Dam (Columbia) that block upstream passage by all migratory fish. Lesser barriers that may pass salmonids also block

upstream passage by lamprey, including smaller dams, small water diversion dams, culverts, tide gates and numerous other barriers. Adult Pacific Lamprey are known to pass through the Project, but no radio-tagged lamprey were observed to use tributaries in the Project area (Nass et al. 2003).

2.1.3.2 Abundance

Historically, Pacific Lamprey returns to the Columbia River had been in significant decline in abundance as evidenced by counts at dams on the lower Columbia and Snake rivers (Close et al. 1995; Vella et al. 1999; Close et al. 2002). Starke and Dalen (1995) reported that adult lamprey counts at Bonneville Dam that regularly exceeded 100,000 fish in the 1960s were estimated at approximately 22,000 in 1993. However, recent counts at Bonneville Dam in the Columbia River have ranged from approximately 38,000 (in 2015) to 82,000 fish (in 2017). Specific reasons for declines in adult returns are not fully understood, but have been related to similar factors contributing to the decline of Pacific salmon. Close et al. (1995, 2002) identified several factors that may account for the decline in lamprey counts in the Columbia River Basin. This includes reduction in suitable spawning and rearing habitat from flow regulation and channelization, pollution and chemical eradication, reductions of prey in the ocean, and juvenile and adult passage problems at dams. Comparison of counts between dams and between years is complicated by variable and inconsistent sampling protocols (BioAnalysts 2000), potential over-wintering between dams, changes in personnel, and counting station passage efficiency (the ability of count station equipment to force individuals through a counting area for observation). Annual counts of adult Pacific Lamprey passing select mainstem dams in the Columbia River Basin are summarized below in Table 3.

Efforts are underway to improve estimates of the number of adult lamprey passing dams using nighttime video at count stations (Clabough et al. 2009). Adding nighttime passage through count windows increased estimated escapements at Bonneville Dam by 42% in 2007, but decreased the estimated escapement to a negative value in 2008. The net downstream movement observed at Bonneville Dam in 2008 indicates that fish were passing by unmonitored routes such as through picketed leads at count stations. At The Dalles, adding nighttime counts increased estimated escapement by 42% in 2007 and by 70% in 2008. Douglas PUD has also begun addressing accuracy of lamprey counts through structural improvements at the Wells Dam counting windows.

In addition to adult dam counts, the lack of ammocoetes in surveys in the Snake River basin and in Upper Columbia River tributaries may be an indication of the decline of Pacific Lamprey.

Table 3 Annual counts (via Columbia River Data Access in Real Time [DART]) of adult Pacific Lamprey at select Columbia and Snake basin dams.[1]

Year	McNary	Priest Rapids	Wells	Ice Harbor	Lower Granite
2008	1,530	5,083	7 [2]	264	61
2009	676	2,713	9	57	12
2010	825	1,114	2	114	15
2011	868	3,868	1	269	48
2012	971	4,025	3	494	48
2013	1,570	5,968	21	328	19
2014	1,783	7,579	7	721	82
2015	1,748	6,749	0	764	50
2016	1,612	8,139	7	875	106
2017	2,549	26,012	287	1,438	346
2018[3]	1,566	11,758	175	1,019	207

Notes:

1 Ice Harbor and McNary day counts only. 24-hour counts at Wells (since 1998) and Priest Rapids (since 2008). Lower Granite counts have been conducted 24 hours a day since 2009.

2 The Pacific Lamprey adult passage counts at Wells Dam are not reflective of actual run size during 2008. Trapping, monitoring, and research efforts at Wells Dam artificially lowered the passage numbers for Pacific Lamprey; i.e., more fish would have passed without tagging and trapping efforts.

3 Counts through November 20, 2018.

2.1.3.3 Population Structure

Genetic stock information suggests there is uncertainty among different Pacific Lamprey stocks regionally. Powell and Faler (2001) determined that Pacific Lamprey do not appear to have genetically different stocks, at least between some lower and mid-Columbia River basins. These observations are similar to results by Goodman (2006) that found no evidence of mitochondrial DNA divergence in 81 collections of Pacific Lamprey from two of the geographical regions common to the Columbia River and Klamath Mountain Province. Conversely, Lin et al. (2008) found significant differences among collections within those regions using approximately 180 amplified fragment length polymorphisms (AFLP) loci. These results detected significant genetic differences among adult Pacific Lamprey returning to streams separated by as little as 54 miles (between the Deschutes River and John Day Dam). The differences between these studies may reflect the increased power of using approximately 180 AFLP loci versus a single mitochondrial DNA locus or differences in polymorphisms due to sampling of adult migrants versus ammocoetes. The geographical scale over which genetically meaningful management units (e.g., stocks, populations, or evolutionarily significant units) occur in this species could not be identified based on the results of Lin et al. 2008. Work based upon microsatellite analysis of 21 sites along the west coast of North America found low levels of genetic differentiation, providing support for a lack of natal homing in Pacific Lamprey. The report noted that Pacific Lamprey from most of the sites examined in this study can be managed as one unit but recommended future investigations to confirm whether this conclusion is applicable to all sites (Docker 2010). The most recent genetic analyses have continued to add uncertainty to Pacific Lamprey population structure. Spice et al. (2012) evaluated the hypothesis of natal homing in Pacific Lamprey and had results that were inconsistent with philopatry, suggesting that anadromous lampreys are unusual among species with long migrations, but suggest that limited dispersal at sea precludes panmixia. Work done by Hess et al. (2012) may provide context for observed

genetic divergence among collections and thus, could reconcile previous findings of population genetic heterogeneity within a species that displays extensive gene flow.

One recovery strategy for Pacific Lamprey is the translocation of pre-spawn adults from downstream Columbia River locations and supplementation with hatchery spawned ammocoetes into suitable habitat upstream. Cummings (2007) found that trapping and translocating adult lamprey did not appear to affect their migration success but the implications to population structure are currently unknown. Since the late 1990's and 2006, the Umatilla and Nez Perce tribes, respectively, have been implementing Pacific Lamprey translocation programs as a conservation measure to maintain some level of lamprey production in target spawning streams. In 2012, the Yakama Nation began implementing translocation programs in mid-Columbia River tributaries (see Section 2.2: Updated Information for additional details about active efforts).

In 2009, the CRBLTWG was asked to develop a review paper on lamprey translocation and artificial propagation. Due to the uncertainty surrounding the potential implications related to unknown genetic stock structure related to translocation and differing opinions by CRBLTWG members, the CRBLTWG concluded that it would not be able to endorse a position or shared opinion at that time and instead completed a literature review paper outlining the potential benefits and risks of translocation (CRBLTWG 2010a). However, translocation activities are currently occurring in several Columbia River Basin watersheds as described in Section 2.1.1 above.

2.1.4 Adult Passage at Hydroelectric Facilities

Radio-telemetry studies of adult lamprey migration patterns past dams and through reservoirs in the lower Columbia River during 1997 to 2002 provided the earliest data sets on lamprey passage timing, travel times, and passage success at hydroelectric projects (Vella et al. 2001; Ocker et al. 2001; Moser et al. 2003a; Moser et al. 2003b). While these studies have shown that 87 to 96% of the radio-tagged lamprey released migrate upstream and are detected at Bonneville Dam, less than 50% of the lamprey which encounter an entrance actually pass the dam. Passage times at lower Columbia River dams (2 to 4 days) were considerably longer compared to salmonids (1 day). Similarly, during 2005 to 2008, at McNary and Ice Harbor dams overall passage efficiencies ranged 58 to 89% and 50 to 59.1%, respectively. Median passage time from the first approach until exit into the forebay for adult lamprey ranged from 1 day to 2 days for both dams (Cummings et al. 2008). Despite different estimation techniques, HDX-PIT tag results of Daigle (2008) were generally consistent with previous study results for Bonneville, McNary and Ice Harbor dams. Recent evaluations (Keefer et al. 2009c; 2009d) indicated significantly lower passage success from release to passage of John Day Dam for radio-tagged lamprey compared to HDX-PIT-tagged lamprey (2.3 to 4.5% versus 17 to 18%), suggesting previously reported passage estimates were conservative.

Recent radio-telemetry studies at Bonneville Dam have expanded our understanding of adult lamprey behavior and passage performance in the lower Columbia River (Johnson et al. 2009a; Keefer et al 2009c; 2009d). For 2007 and 2008, 68 and 74%, respectively, of lamprey released to the tailrace were known to have returned to the dam. Of these, 32% successfully passed in both years (Johnson et al 2009a; 2009b; Keefer et al. 2009d). Entrance efficiencies (ranged 51 to 76%) were generally poorer than previous years although passage times (around 3.0 d median) was relatively good in 2007and 2008. Researchers speculated performance may have been related to smaller lamprey returning in 2007 and 2008 compared to earlier years.

In recent years passage efficiency has been estimated for radio and HDX-PIT tagged individual adult Pacific Lamprey at Columbia and Snake River dams (Blue Leaf Environmental and Grant PUD 2018; Stevens et al. 2015; Keefer et al. 2015; LGL and Douglas County 2014; Keefer et al. 2011, 2012, 2015). Sample sizes for these studies has varied widely based on availability of lamprey in different regions of the Columbia River basin (CRB). Passage efficiency estimates (Table 4) were also highly variable by year and dam (i.e. 69% in 2010 and 89% in 2009 at McNary Dam; 60-82% for studies in 1997-2002 and 2005-2010 at Ice Harbor Dam) but it is important to note that passage metrics were not necessarily standardized between studies.

Table 4 Passage efficiency estimates for tagged individual adult Pacific Lamprey at Columbia and Snake River dams.

River	Site	Year	Passage Efficiency	Technology employed	Reference
Columbia	Wells	2013	9.5%[1]	Radio	Robichaud and Kyger (2014)
		2007-2008	33.0%	Radio	LGL and Douglas County PUD (2008)
		2004	25.0%	Radio	Nass et al. (2003)
	Rocky Reach	2017	97.7%	FDX-PIT	Harper and Hemstrom (2018)
		2016	98.8%	FDX-PIT	Harper and Hemstrom (2018)
		2014	66.0%	HDX-PIT	Blue Leaf Environmental (2015)
		2004	55.5%	Radio	Stevenson et al. (2005)
	Wanapum	2017	100.0% (SE 5-9%)	HDX-PIT	Section 1.2 of this report
		2016	95.7-100.0% (SE 2-6%)	HDX-PIT	Blue Leaf Environmental and Grant PUD (2018)
		2015	90.4-94.5% (SE 4-12%)	HDX-PIT	Blue Leaf Environmental and Grant PUD (2018)
		2014	Not included due to spillway fracture and resulting abnormal fishway operations		
		2013	59.9-85.8% (SE 4-27%)	HDX-PIT	Blue Leaf Environmental and Grant PUD (2018)
		2010-2012	67.0%	HDX-PIT	Blue Leaf Environmental and Grant PUD (2018)
	Priest Rapids	2017	96.2-100.0% (SE 0%)	HDX-PIT	Section 1.2 of this report
		2016	100.0% (SE 2%)	HDX-PIT	Blue Leaf Environmental and Grant PUD (2018)
		2015	73.6-77.2% (SE 3-10%)	HDX-PIT	Blue Leaf Environmental and Grant PUD (2018)
		2014	80.0%	HDX-PIT	Blue Leaf Environmental and Grant PUD (2018)
		2013	75.1-100.0% (SE 3-8%)	HDX-PIT	Blue Leaf Environmental and Grant PUD (2018)
		2010-2012	62.3-100% (SE 5-12%)	HDX-PIT	Blue Leaf Environmental and Grant PUD (2018)

River	Site	Year	Passage Efficiency	Technology Employed	Reference
Columbia	McNary	2010	69.0%	Radio	Keefer et al. (2011)
		2009	89.0%	Radio	Keefer et al. (2011)
		2008	74.0%	Radio	Keefer et al. (2011)
		2007	70.0%	Radio	Keefer et al. (2011)
		2006	80.0%	Radio	Keefer et al. (2011)
		2005	72.0%	Radio	Keefer et al. (2011)
	John Day	2014	73.0%	HDX-PIT	Keefer et al. (2015)
	The Dalles	2014	58.0%	HDX-PIT	Keefer et al. (2015)
	Bonneville	2014	56-60.0%	HDX-PIT	Keefer et al. (2015)
Snake	Ice Harbor	2014	22.0%	Radio + HDX-PIT	Stevens et al. (2015)
	Lower Monumental	1997-2002; 2005-2010	60-82.0%	Radio	Keefer et al. (2012)
		2014	50.0%	Radio + HDX-PIT	Stevens et al. (2015)
	Little Goose	2014	56.0%	Radio + HDX-PIT	Stevens et al. (2015)
	Lower Granite	2014	62.0%	Radio + HDX-PIT	Stevens et al. (2015)

Notes:

1 Given extremely low counts at Wells Dam in recent years, this assessment utilized adults captured at Bonneville and Priest Rapids dams and held at Prosser Hatchery for an extended period of time prior to transport, tagging and release at Wells Dam. Active upstream migration of these study fish appeared to be low and the protracted holding period at Prosser Hatchery remains a potential explanation for low encounter rates at Wells Dam.

In the mid-Columbia at Wanapum, Priest Rapids, Rocky Reach, and Wells dams, the results have been more varied, in part due to the use of slightly different metrics (Table 4; Nass et al. 2003; Stevenson et al. 2005; LGL Limited and Douglas PUD 2008).

During a 2008 study at Wells Dam, 18 lamprey were released into the Wells Project tailrace. Twelve of the 18 lamprey yielded sufficient data for analysis. Over the study period, 11 of 12 (91.7%) lamprey approached a fishway entrance with several lamprey making multiple approaches. Only two tailrace-released lamprey successfully entered a fishway and both failed to ascend into the forebay. Overall, 2008 study results indicate that any potential areas of impediment at Wells Dam are restricted entirely to the entrance and lower fishway, as upper fishway passage efficiency (releases in the fishway) was 100% for the two consecutive study years (LGL Limited and Douglas PUD 2008). In 2013, another fishway passage study was conducted at Wells Dam with adult lamprey translocated from Bonneville and Priest Rapids dams (due to low numbers at the dam). Results of the assessment are summarized in Table 4 above however; translocated study fish may have impacted the encounter rate of study fish at Wells Dam.

At Priest Rapids and Wanapum dams, the proportion of fish that approached the fishway that exited the ladders was 70% at Priest Rapids, and 51% at Wanapum Dam in 2002 (Nass et al. 2003). Fishway passage efficiencies (entrance to exit) were substantially higher at 87% and 82% for the same study despite substantial delays or termination of active migration near the first weir walls and old style counting stations which have subsequently been modified to include lamprey-specific crowder structures at both Priest and Wanapum dams. Design enhancements (plating and ramps at Priest Rapids Dam) installed during the 2009-2010 winter fish ladder maintenance outage, are also anticipated to address these areas and improve volitional passage efficiency. To test these design enhancements, Grant PUD, in consultation with the PRFF, has been evaluating lamprey passage behavior at the Project using an extensive HDX-PIT array (originally 20 receivers, reduced to 16 in 2015, and further reduced to 10 total receivers in 2018) at Priest Rapids and Wanapum dams since 2010. The fishway passage efficiency for the entire 2010-2017 comprehensive dataset is 85.9% and 91.0% at Priest Rapids and Wanapum dams, respectively. Complete results are reported in Section 1.2.

Other regional studies and experiments included an experimental fishway at Bonneville Dam in 2004-2006 evaluated lamprey response to: 1) a fishway ramp and the effects of ramp flow volume, ramp angle, and attraction flow at the ramp entrance; 2) a divided fishway with differing flow velocities at each channel entrance; 3) two styles of mid-ramp lamprey "rest boxes"; and 4) three methods of attracting lampreys to the ramp entrance (water jets, air bubble streams, and waterfalls [Keefer et al. 2008]). In the ramp tests, the majority of tagged fish ascended the ramp under all treatment conditions but lamprey passage times differed significantly in response to flow levels. When the fishway was divided, lamprey preferentially used channels adjacent to the flume walls, and this preference increased as flow through the outside channels decreased. Lamprey passage times also increased with concentrated flow through the center channel. With the differing types of "rest boxes", there was little difference in lamprey behavior between rest boxes under various flow treatments, and fish that ascended the ramp appeared to be unaffected by either rest box type. Finally, regarding the various methods of attraction to the ramp entrance, lamprey passage efficiency was highest during the water jet treatment, but differences among tests were not statistically significant.

A potential physiological problem facing successful passage of Pacific Lamprey at dams may be related to their unique method of movement as it relates to specific areas within fish ladders. Typically, lamprey move through an adult fishway in a repeated series of motions consisting of attaching to the ladder floor with their mouths, surging forward, and re-attaching. Adult lamprey have an estimated critical swimming speed of about 2.8 ft. per second at 15°C (Mesa et al. 2003) and a burst swimming speed calculated at 6.9 ft./sec (Bell 1990). Fishway operational criteria at Wanapum and Priest Rapids dams include average velocities over submerged weirs that are approximately 2 to 4 ft./sec and 4 to 6 ft./sec through the slotted entrance gates near the surface. The design of the slotted entrance gates is such that the velocity gradient will be near zero at the bottom while maintaining average water velocities to the surface of the water column (M. Nicholls, Grant PUD, personal communication). Average velocity through the orifices is approximately 6 to 7 ft./sec. The physiological response of adult Pacific Lamprey to exhaustive exercise may be immediate, sometimes severe, but short-lived (Mesa et al. 2003). These data suggest that lamprey may have difficulty negotiating fishways that operate according to criteria established for salmonids.

In an effort to improve monitoring of Pacific Lamprey in the basin, HDX-PIT tag monitoring sites were deployed at dams beginning in 2005. HDX-PIT tags were selected for Pacific Lamprey passage evaluations to avoid potential tag collisions with the FDX-PIT tags used to monitor salmonids in the basin. In 2005, HDX detectors were installed at Bonneville Dam to evaluate lamprey passage systems (LPS) in the Bradford Island makeup water channel and at the entrance to the Washington-shore main ladder. Detectors were also installed at McNary and Ice Harbor dams to monitor lamprey in a parallel study (Cummings 2007). In 2006, additional detectors were installed at the tops of ladders at The Dalles and John Day dams. Daigle (2008) concluded that the prototype HDX detectors used in 2005-2006 appeared to be reasonably efficient (e.g., 20-100%) at detecting tagged lamprey passing antennas. Studies comparing the use of radio-telemetry and the HDX-PIT tags were conducted in 2007-2009. Study results indicated higher escapement rates for HDX-PIT tagged fish versus radio-telemetry tagged fish at and between dams. Larger fish of both tag types were significantly more likely than smaller fish to pass through most monitored dam-to-dam reaches. The results suggest a tradeoff between tagging effects and the collection of high resolution, fine-scale data provided by the active radio telemetry system (Keefer et al. 2009a, 2009b and 2010).

Since the cumulative evidence on adult lamprey passage at dams has indicated that fishway entrances may be a major passage bottleneck, a significant effort was undertaken by the ACOE to develop and evaluate new entrance designs and operations. In 2007, a study was undertaken at Bonneville Dam to evaluate the use of reduced water velocities at entrances at night to improve entrance rates for lamprey (Johnson et al. 2009a). Lowering entrance head levels to 0.5 ft. (4 ft/sec target velocity level) from 2200 to 0400 hrs at Powerhouse 2 improved entrance efficiencies from 2% at normal velocity to 26% at the lowered velocity at the north-shore entrance, although the number of lamprey attracted to the entrance appeared lower during reduced velocities (i.e., net entrances may not have been different). There was also evidence that the time to enter during the lower velocity was improved. In 2008, when Powerhouse 2 entrances were placed in standby mode (0 ft./sec velocity) at night, entrance efficiencies were 2 and 12% at the north and south-shore entrances versus 9 and 30% during normal conditions, respectively (Johnson et al. 2009b). Lamprey were also more likely to drop out of the fishways during the standby operations. In 2009, the telescoping weir bulkheads at the Cascade Island fishway entrance at Bonneville Dam were replaced with a variable-width entrance bulkhead. Bollard structures were also added out- and inside the fishway to provide an area of low velocity along the floor as a potential route for lampreys to enter. Preliminary results from radio- and HDX-PIT tag monitoring indicated that lamprey entrance use was improved in 2009 at the Cascades Island entrance but further analyses are planned. In 2009 and 2010, Douglas PUD utilized DIDSON to evaluate lamprey entrance efficiency at the Wells Dam fishways in response to three alternative entrance flow velocities. Although number of observations were low, the data indicated that adult lamprey were able to volitionally enter fishways under reduced nighttime flows (P.N. Johnson et al. 2011). The Wells Dam 2013 passage study conducted by Douglas PUD also included a treatment with alternative entrance flow velocities.

In recent years, Columbia River Basin hydroelectric facilities have begun modifying fishways and fishway operations to facilitate the upstream passage of adult lamprey. ACOE and utilities with hydroelectric facilities or dams in the basin are in various phases of design and implementation of passage improvements that include variable width weirs, bollard arrays, ¾-inch diffuser grating, LPS in various fishway locations, lamprey entrance flume systems, lamprey orifices in control section weir walls, diffuser grating plating, ramps at perched orifices,

rounded edges of fishway walls, temporary velocity reductions at fishway entrances, and lifting picket leads at count stations. In particular, given their adaptability, the use (and evaluation) of LPS have been implemented to facilitate adult lamprey passage on dams and diversions on the Umatilla and Yakima rivers. Operational changes that continue to be implemented at some mainstem hydroelectric facilities include reduced water velocities at entrances, lifting picketed leads, improving collection and counting accuracy, and compliance with established fishway operations criteria. Researchers have also begun testing passage efficiency of an experimental vertical climbing wall, implementing passage evaluations on the Clackamas, Yakima, and Columbia rivers (see Section 2.2: Updated Information for additional details).

2.1.5 Juvenile Passage at Hydroelectric Facilities

Juvenile lamprey moving downstream may pass through a hydroelectric structure using several different routes, including the powerhouse (turbines), spillway (bottom or top discharge tainter gates), powerhouse gatewell slots (fish bypass collection area), and adult fishways. Potentially high juvenile lamprey turbine entrainment rates are likely given the tendency of juveniles to swim low in the water column (Long 1968 as cited in Moursund et al. 2000). Fyke net capture data from Wells (Douglas PUD) and Rocky Reach (Chelan PUD) further confirm that juvenile lamprey tend to pass via turbines in the lower half of the water column (BioAnalysts 2000). At the Project, turbine intake emergency wheelgate slot exclusion screen evaluations also observed small numbers of juvenile lamprey in the vicinity of turbine intake areas (Mike Clement, Grant PUD, personal communication).

The lamprey's ability to survive turbine passage, including response to changes in pressure, turbulent flow, and shear stress are not clearly understood. Another concern is how juvenile lamprey respond to diversion screens which are designed to bypass or divert fish into or toward preferred fish passage routes. For example, investigators reported large numbers of juvenile lamprey impinged between individual bars of fixed bar screens at The Dalles and McNary dams (Hatch and Parker 1998). The necessary tag technology to evaluate the potential impacts to juvenile lamprey passage through hydroelectric facilities continues to be developed but is not yet available (see Section 2.1.5.3). Increased efforts that include developing marking methodologies for juveniles and the synthesis of available information (e.g., juvenile bypass facilities, screw trap operations, existing reports/studies, etc.) have been implemented to provide a basin-wide perspective on juvenile lamprey passage and movements and to identify information gaps. Operational and structural modifications being implemented at hydroelectric facilities include delayed deployment of extended length screens during juvenile outmigration, JBS modifications, and salvage operations during ladder outages, and compliance with fish bypass criteria. (see Section 2.2: Updated Information for additional details).

2.1.5.1 Effects of Hydrologic Pressures on Juvenile Lamprey

Moursund et al. (2000 and 2001) subjected lamprey to an abrupt pressure spike (using a hyperbaric chamber) in order to simulate turbine passage. Lamprey were examined for injuries immediately after the trial, and then again after 48 hours. Test lamprey showed no immediate or latent injuries. Juvenile lamprey hardiness likely results from their lack of swim bladder, the flexibility associated with an anguilliform body type and cartilaginous skeleton, and the reduced size of vulnerable structures, such as eyes. In 2011, continued testing by Pacific Northwest National Laboratory (PNNL) on the effects of rapid and prolonged decompression simulating hydroturbine passage were conducted on juvenile Pacific Lamprey. Generally, no mortalities or

barotrauma were observed for lamprey exposed to these decompression scenarios (Colotelo et al. 2012).

2.1.5.2 Effects of Bar Screens on Juvenile Lamprey

Swim trials in a laboratory flume showed that juvenile Pacific Lamprey are fair to weak swimmers as compared to salmonids, with an average burst speed of 2.3 ft./sec (Moursund et al. 2000). Sustained juvenile lamprey swim speeds averaged 0.75 ft/sec over a five-minute interval and 0.5 ft/sec over a 15-minute interval (Moursund et al. 2000).

In laboratory conditions at PNNL in 2000, lamprey interactions with bar screens using an oval flume fitted with 1/8-inch spaced wedge-wire screen were examined. Lamprey were exposed to the screen at water velocities ranging from 0 to 2 ft/sec. Observations were recorded using video cameras and infrared illuminators. At all water velocities greater than zero, the lamprey made contact with the bar screen within one minute of their entry into the water column upstream of the screen. At water velocities up to 1 foot per second, they were able to push off the screen and disperse throughout the test flume. At water velocities greater than 1.5 ft./sec, all lamprey made immediate contact with the screen. Seventy percent became impinged within one minute of the exposure. After 12 hours of exposure, 97% of the lamprey were impinged on the screen (Moursund et al. 2000).

Physical model data obtained by the U.S. Army Engineer Research and Development Center suggest that the average perpendicular flow velocity at a typical turbine bypass screen is 2.4 ft/sec. Field measurements directly on a screen face at John Day support the model data (Weiland and Escher 2001). They also suggest this velocity exceeds the velocities that caused impingement of juvenile lamprey during laboratory tests and was also higher than the average burst speed of the test population. On an extended-length submerged bar screen, local velocities was as high as 10 ft/sec and occurred at the upper end of the screen (Weiland and Escher 2001).

As part of the series of laboratory studies conducted by PNNL in 2000, the effects of screen alignment and angles on lamprey impingement were evaluated. 1999 laboratory flume tests utilized 1/8-inch wedge-wire screen oriented perpendicular to the flow and having vertical bars. Testing in 2000 included having vertical and horizontal bars and screen orientations at 10 degrees from vertical. The angled screen provided upward sweeping velocities that were not present in the previous perpendicular tests. Trials were conducted at velocities from 2 to 5 ft./sec. The findings showed lamprey were far more susceptible to become impinged on horizontal bars than on vertical ones. At water velocities of 4 ft/sec, 50% of lamprey became impinged on the horizontal bars but none were stuck on the vertical bars. At 5 ft/sec, 55% of the lamprey were impinged on the horizontal bars but just 25% became impinged on the vertical bars (Moursund et al. 2001). General findings showed that an increase in either water velocity or the duration of conditions favoring impingement increases the lamprey's chances of permanently becoming stuck on the screens.

Alternative screening material was also tested by PNNL. Previous testing of 1/8-inch square nylon mesh was tested against 3/32-inch bar screen. The narrower spacing was expected to reduce the amount of space for lamprey to work their tails in and become impinged. Testing results showed that while 70% of the juvenile lamprey were permanently impinged on the 1/8-inch bar screen at velocities up to 4 ft./sec, none remained stuck on the bars having the smaller 3/32-inch spacing, and just 15% were permanently impinged on the 1/8-inch square mesh (Moursund et al. 2001).

2.1.5.3 Need for Active Tag Technology

A review of the most recent research addressing juvenile lamprey at hydroelectric facilities concludes that there is a current lack of methods and technology to effectively quantify survival of juvenile lamprey migrating through hydroelectric facilities (Douglas PUD and LGL 2008). Furthermore, no studies exist that determine a level of mortality attributed to a project's operations. This is due to the lack of miniaturized active tag technologies to overcome two study limitations: 1) macrophthalmia are relatively small in size and unique in body shape; and 2) migrate low in the water column resulting in the rapid attenuation of active tag signal strength. In 1999, the ACOE funded Oregon State University to assess the applicability of available tag technology to monitor juvenile lamprey macrophthalmia outmigration (Schreck et al. 2000). Results from this effort indicated that the smallest currently available radio-tag is still too large for implantation in the body cavity of a juvenile lamprey (Schreck et al. 2000). Additionally, external application was not effective as animals removed tags within the first week and fish performance and behavior were affected (Schreck et al. 2000). Internal implantation of PIT tags is currently the most viable option for tagging juvenile lamprey; however this methodology presents severe limitations due to the limited range of detection systems, and the ability to tag only the largest outmigrating juvenile lamprey (Schreck et al. 2000). Since the 1999 assessment, there have been some improvements in tag technology with several studies associated with developing biological criteria for active tags and standard protocols for PIT-tagging juvenile lamprey. With 8mm Pico tags, lamprey ammocoetes greater than 70mm have recently been tagged (R. Lampman, Yakama Nation, personal communication).

Recent funding from the ACOE and Department of Energy has been made available to design, prototype and evaluate an acoustic microtransmitter that can be used to study the behavior and survival of juvenile lamprey. In 2016, PNNL completed the design of a juvenile lamprey acoustic micro-transmitter that is 2 mm in diameter and 12 mm in length and weighs 0.08 g in air. The prototype tag lasts 20 to 30 days at 5-s ping rate interval. The biological tagging results from implanting juvenile Pacific Lamprey showed that implantation is not likely to have an adverse impact on fish survival over a 28-day holding period. Additionally, there was minimal tag loss due to shedding for fish greater than 130 mm in length. The surgical procedure was effective at placing tags within the body cavity without causing significant hemorrhaging or fungal infections at the tagging site. Sustained swimming tests showed no significant differences in swimming ability when comparing implanted fish to control fish for all size classes (120–160 mm) tested. In the spring of 2017, PNNL tagged 100 juvenile lamprey >140 mm and collected from McNary and John Day dam smolt collection facilities with the new Juvenile Lamprey Eel Acoustic Tag (JLAT) and released in April and May near Irrigon, Oregon. Their migration downstream was monitored using four sets of autonomous acoustic receivers spanning~ 7 km of the river. The pilot field trial demonstrated the feasibility of studying juvenile lamprey behavior and survival using this new tag (Deng et al. 2018). (see Section 2.2: Updated Information for additional details).

2.1.5.4 Gatewell Exclusion Screen Evaluation

During the spring and early summer months of 2010, turbine intake emergency gatewell exclusion screens were monitored at Priest Rapids and Wanapum dams (Grant PUD 2011). Prior to the juvenile salmonid outmigration, a DIDSON camera was installed on the end of the screen that allowed 69% of the screen surface to be effectively imaged. Fishes were enumerated as they passed within the insonified area near the screen, and interactions with the screen were classified

by type (contact or non-contact). A total of 18 days of data collection throughout the spring and summer salmonid migration periods were analyzed at each dam. These results showed that fishes observed had a low level of interaction with the screens and a very low level of multiple or extended contact. At Wanapum Dam, 10,632 fishes were observed near the exclusion screen with 784 (7.4%) coming in contact with the screen and at Priest Rapids Dam, 29,340 fishes were observed with 360 (1.2%) contacts with the screen (Wright et. al., 2010). Although the study was originally developed to evaluate juvenile salmonid outmigrants, small numbers of lamprey were also observed at monitored locations at both Wanapum (n=31) and Priest Rapids (n=161) dams (Wright et. al., 2010). During the study period (May 12 to July 15, 2010) no negative impacts or screen impingement events were observed at these locations (Mike Clement, Grant PUD, personal communication).

2.2 Updated Information

Pursuant to the requirements of Grant PUD's PLMP (Grant PUD 2009) and specifically for this comprehensive annual report (as described in Section 1.2 above), recent Pacific Lamprey passage and survival investigations and measures undertaken in the Columbia River Basin are summarized in Table 5. For the purposes of this comprehensive annual report, the "updated" information includes activities that are either occurring or are being reported on during the current reporting period of November 1, 2017 through October 31, 2018. Worth noting is that the table only includes activities that have been implemented through the end of the reporting period. Efforts that are proposed or planned for future implementation or are proposed as a potential measure are not identified in this section. Proposed and planned efforts are, however, addressed in Section 4.0 which contains a comprehensive evaluation of all regional activities (implemented, planned and proposed) and assesses their applicability to the Project.

Information contained in the table includes the activity, project and river in which the activity occurred, results or status of activity, lead entity and information source.

Table 5 Pacific Lamprey activities in the Columbia River basin in 2018.

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	General Biology, Ecology, Behavior, and Population Status					
1.	Monitoring entrance timing, escapement, and movement patterns	No associated hydro project	Fifteenmile Creek	In 2016, adult Pacific Lamprey abundance in Fifteenmile Creek was estimated at 3,433 (2,758 – 4,270). Tagging efforts at Cushing Falls between May and July produced a total of 162 tagged lamprey. 109 were detected moving upstream, 16 moved downstream after tagging and 4 were caught in the tribal fishery. Staffing issues prevented an adequate number of lamprey being tagged at Cushing Falls in 2017 to produce a valid population estimate. Eighteen were tagged and several were detected upstream of Cushing Falls. Approximately 150 were tagged at Bonneville Dam. Antennas were reinstalled in April due to high flows. Twelve of those tagged were detected on one or more Passive Integrated Transponder (PIT) antenna; the majority (82%) staying within Fifteenmile Creek and only 2 (18%) entering Eightmile Creek. Several tagged at Bonneville in 2016 were also detected at one or more antenna during May, 2017 as they resumed and finished their spawning migration. Harvest creeling was conducted during May and June and harvesters were present on more than one occasion, however, a valid harvest estimate was not possible due to the low number of data points collected caused by the same staffing issues that affected the tagging efforts. In 2018 approximately 500 lamprey were tagged at Cushing Falls. Low water levels allowed tagging to begin in early May and concluded in late June. Harvest creeling occurred during this same time frame. Harvesters were present on numerous occasions and a harvest estimate will be calculated this year as will an escapement estimate. Antennas were in operation from	Confederated Tribes of the Warm Springs (CTWS)	Evaluate Status and Limiting Factors of Pacific Lamprey in the Lower Deschutes River, Fifteenmile Creek and Hood River (Johnsen and Baker 2018)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				April through October and have detected a large number of lamprey that were tagged in both 2017 and 2018. Detection data is still being processed.		
2.	Adult lamprey monitoring and juvenile lamprey density and distribution surveys	No associated hydro project	Deschutes and tributaries	Since 2016, CTWS has engaged in ongoing adult lamprey monitoring and juvenile lamprey density and distribution surveys. In 2018, creeling occurred on 53 days (out of 87) between July 5th and October 7th, with a total number of 4,691 lamprey being creeled. Harvesters collected between 2 and 425 lamprey each night. Accounting for the days when a creeler was not present, a harvest estimate of 5,190 (95% CI, 5,068 to 5,312) was calculated for 2017. A total of 1,637 lamprey were PIT tagged at Sherar's Falls in 2017, of which 272 were recaptured either by CTWS personnel or by Tribal harvesters. An escapement estimate of 24,017 (95% CI, 21,336 to 27,034) was thus calculated. Lamprey were detected at PIT antennas within the Deschutes River, including a newly installed antenna within the fish ladder at Sherar's Falls, within the lower Warm Springs River and Shitike Creek, and in Beaver Creek (tributary to Warm Springs River). No detections occurred in the upper Warm Springs River, upper Shitike Creek or in Badger Creek. Most detections were from lamprey tagged in 2017, though one was from a lamprey tagged in 2015. Lamprey entering Warm Springs River averaged 20 days from tagging at Sherar's Falls to detection. Entrance into Shitike Creek averaged 35 days from the date of tagging. Density surveys for ammocoetes were conducted during the fall months of 2017 in Warm Springs River, and Shitike, Beaver, and Badger creeks. Densities were highest in Shitike Creek (avg 23/m^2) and averaged 17/m^2 in Warm Springs River, Beaver Creek, and Badger Creek. Total counts of ammocoetes collected were lowest in Badger Creek (71) and were 136, 139,	CTWS	Personal communication with Andy Johnsen,, CTWS (10/10/18) Evaluate Status and Limiting Factors of Pacific Lamprey in the Lower Deschutes River, Fifteen Mile Creek, and Hood River (Johnsen and Baker 2017)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				and 151 in Warm Springs River, Beaver Creek, and Shitike Creek respectively. Creeling and PIT tagging began in mid-June and expected to end in mid-October when water levels are likely to rise to unsafe collecting levels. To date, over 3,500 lamprey have been creeled and over 1,700 have been PIT tagged. Recapture rates have been higher enough to produce a valid escapement estimate will be possible once tagging efforts cease for the year. A valid harvest estimate will also be possible for 2018. Lamprey have been detected on antenna sites in the Deschutes River, Warm Springs River, Shitike Creek, and Beaver Creek, including some tagged in 2017. Several have also been detected on the antenna within the newly installed lamprey passage system (LPS) at the Warm Springs National Fish Hatchery. Density surveys for juveniles are currently being conducted in Warm Springs River and Shitike, Badger, and Beaver creeks. Results will be compared to those found in previous years. End of distribution surveys will also occur on Warm Springs River as it has not been near as consistent as those in its tributaries over the recent years.		
3.	Conduct adult lamprey movement study using radio telemetry	Bureau of Reclamation (BOR) projects in Yakima	Yakima	In 2016, the Annual Report for Phase 3 of the U.S. Fish and Wildlife Service (USFWS) adult Pacific Lamprey passage study in the Yakima River was completed and released. Lamprey passage efficiency at Cowiche Dam was relatively high (79%), whereas at Roza Dam (0%) no tagged lamprey detected passing the complete fishway (including the Adult Fish Facility). Work is ongoing on a manuscript summarizing three years of adult Pacific Lamprey mark-recapture data, and developing dam-specific passage efficiencies, inter-dam	USFWS	Personal communication with RD Nelle, USFWS (10/25/18) Passage of Radio-tagged Adult Pacific Lamprey at Yakima River Diversion Dams 2014 Annual

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				survival estimates and detection and uncertainty estimates.		Report Phase 3: Roza and Cowiche Dams (Grote et al. 2016)
4.	Determining adult escapement and adult harvest monitoring	Willamette Falls	Willamette	The CTWS estimated escapement and total abundance of Pacific Lamprey at Willamette Falls in 2017. A mark-recapture estimate of escapement through the fish ladder was 80,848 (95% CI 35,765 – 159,320, 40.4% coefficient variance). With a return rate to the ladder of 29.2%, the abundance below the falls was calculated at 196,458, giving a total abundance of 277,577. Harvest at Willamette Falls in 2017 was 6,170 lamprey. Alternate passage routes that were monitored included two lamprey ramps installed by Portland General Electric (PGE) on July 13, 2017 and the West Side Lamprey Structure (WSLS) that was put into service on June 5, 2017. Lamprey began passing over the downstream ramp on July 14, when water began spilling over the ramp, and continued through July 30, 2017, for a total of 2,293 passing but, only 7 lamprey passed over the upstream ramp, for a total of 2,300 lamprey counted at both ramps. Flow into the WSLS was disrupted between June 17 and July 13. Twenty-five hundred lamprey successfully passed the WSLS with 11 that fell back. Estimated escapement and total abundance of Pacific Lamprey at Willamette Falls was likely underestimated in 2017. The Lincoln-Peterson estimator underperformed because of so few recaptured lamprey. There were two issues that affected our ability to more effectively tag and recapture lamprey, including altered flow patterns through Willamette Falls due to maintenance and construction activities and the presence of increasingly large numbers of California sea lions at the falls and in the ladders. Using the	CTWS	Willamette Falls Lamprey Escapement Estimate, 2018 Annual report to BPA, project number 2008-308-00, p. 27, Confederated Tribes of the Warm Springs Reservation of Oregon, Warm Springs, OR (Baker and McVay 2018)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				relationship between total abundance estimated at Willamette Falls and daytime counts of Pacific Lamprey at Bonneville Dam from 2010 to 2014 and the 2017 daytime count of lamprey at Bonneville Dam of 82,567, the total abundance of lamprey at Willamette Falls should have been over 800,000, rather than 277,577. Results in 2018 should be improved as PGE has completed capital improvement projects that affect vehicle access to the fish ladder and Oregon Department of Fish and Wildlife repaired sea lion exclusion gates at the fish ladders.		
5.	Techniques for estimating Pacific Lamprey escapement and abundance	Willamette Falls	Willamette	Pacific Lamprey has declined substantially across the Pacific Northwest in the last several decades and garnered considerable conservation attention. Particular emphasis has been placed on restoring upstream passage and developing long term monitoring programs for the species. Since 2010, adult Pacific Lamprey abundance and escapement has been monitored at Willamette Falls using capture-recapture techniques and a relatively simple closed-population estimator. The purpose of this research was to potentially improve the accuracy of escapement and abundance estimates by quantitatively evaluating the current estimation method at the falls as well as several alternative estimation techniques. We used existing information regarding lamprey passage behaviors at the falls to simulate variable migration and passage scenarios for the species. Simulated datasets were then used to examine the robustness of the current estimator of escapement and abundance, a pooled Lincoln-Petersen estimate with Chapman's modification, as well as two alternative model-based estimators. The alternative estimators were based on an integrated Huggins-type closed capture-recapture model and a substantially more complex daily escapement model, both of which were fitted within an objective Bayesian framework using Markov Chain	Oregon State University (OSU)	Personal communication with Steven Whitlock, OSU (10/12/18) Refining Techniques for Estimating Pacific Lamprey Escapement and Abundance at Willamette Falls. OR. (Whitlock and Peterson 2017)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Monte Carlo (MCMC) simulation. All three estimators performed similarly across scenarios with regards to estimating escapement and total abundance. The daily escapement model produced estimates of below-falls abundance with substantially lower bias than the pooled estimators and provided the added benefit of explicit daily estimates of escapement and probability of passage. These results suggest that the current approach to estimating escapement is viable, but that the daily escapement model can be used to provide more detailed information.		
6.	Portland Harbor Superfund restoration monitoring: larval Pacific Lamprey	No associated hydro project	Willamette	Larval Pacific Lamprey occupancy was evaluated at the Alder Point restoration area as well as six reference areas. The five additional restoration sites were not sampled. A generalized random tessellation-stratified approach was used to delineate sample quadrats (30 m X 30 m) in a random, spatially-balanced order from Willamette Falls downstream to the confluence with the Columbia, and including the Multnomah Channel. Pacific Lamprey were detected in several reference sites and at Alder Point.	USFWS	Personal communication with Joe Skalicky, USFWS (10/19/18) Evaluation of Larval Pacific Lamprey Occupancy in Portland Harbor Superfund Area Restoration Sites, 2017 Annual Report (Skalicky et al. *in prep.*)
7.	Abundance of larval lamprey in the mainstem Columbia River	No associated hydro project	Columbia	In 2018, the first year of seasonal sampling at three tributary mouths each above and below Bonneville Dam using a deepwater electrofisher was initiated. A generalized random tessellation-stratified approach was used to delineate sample quadrats (30 m X 30 m) in a random, spatially-balanced order in a radius from each tributary mouth. The Klickitat, Wind, and White Salmon river mouths as well as the Washougal, Sandy, and Kalama river mouths were sampled in Winter, Spring, and Summer. Preliminary results indicate a	USFWS	Personal Communication with Judith Barkstedt, USFWS (10/19/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				seasonal difference in larval lamprey densities in the river mouths.		
8.	Assessment of lamprey in a reservoir drawdown.	Leaburg-Walterville	McKenzie	In March 2018, Leaburg Reservoir was drawn down at a rate of 1.8 in/hr within a 48 hour period. Larval lamprey abundance in a dewatered area was assessed before the dewatering and after rewatering. 40 sites within a 1,100 m^2 area shoreline were chosen using a Generalized Random Tesselation Stratified (GRTS) approach. Preliminary analysis shows lamprey abundance in the affected area was significantly reduced. Preliminary results indicate that about 50% of the lampreys remain in sediments and 50% emerged from the burrows during dewatering.	USFWS	Personal Communication with Joe Skalicky and Julie Harris, USFWS (10/19/18)
9.	Pacific Lamprey passage assessments at manmade barriers	No associated hydro project	N/A	In July 2018, fishway and barrier assessments were conducted at 3 hatcheries in the Lower Columbia Regional Management Unit (RMU) for adult Pacific Lamprey. All facilities were found to have significant passage issues for lamprey.	USFWS	Personal Communication with Joe Skalicky (10/19/18)
10.	Thermal tolerance of larval Pacific Lamprey	No associated hydro project	Umatilla	This project's objective is to determine the thermal tolerance of larval lamprey in laboratory experiments in both constant and fluctuating temperatures. Initial results suggest larval lamprey are tolerant of warm temperatures. A field portion of this effort began in 2018 to compare the occupancy of larval lamprey in different temperatures using an eastern Oregon stream as a model system.	USFWS	Personal Communication with Tim Whitesel (10/19/18)
11.	Physiological response of larval Pacific Lamprey to chronic temperature and oxygen stress	No associated hydro project	N/A	Freshwater habitats in the Pacific Northwest of the United States are becoming warmer due to climate change and lower in oxygen due to eutrophication. These stressors are known to have negative synergistic effects on fish physiology, but the capacity to endure these stressors depends on the species itself. The Pacific Lamprey (*Entosphenus tridentatus*) is endemic to the river and lake systems of the Columbia River basin, playing an important role in the ongoing health of the system, yet have had a steady decline in abundance. The	OSU	Personal Communication with Patrick Carilli (10/23/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				goal of this study is to establish the thermal and oxygen thresholds for the larvae of this species and to determine the chronic effects of temperature and oxygen on larval physiology. Juveniles will be collected from Mary's River in central Oregon and exposed to 90 days of heat, oxygen, or the two stressors simultaneously to observe how larval lamprey respond. Along with growth and development data, a subset from each treatment will be placed in respirometers to measure metabolic rate. At the conclusion of the experiment, the animals will be euthanized and have tissue samples taken to quantify common molecular indicator of stress including elevated levels lactate and glucose. Depending on the results, this study may point towards optimizing habitat parameters to facilitate the recovery of Pacific Lamprey populations. Research is ongoing and has yet to be published		
12.	Lamprey monitoring	No associated hydro project	Hood	Density surveys for ammocoetes were conducted within Hood River during the fall months of 2017. Ammocoetes were present at 9 of the 14 survey sites. Ammocoetes were only found in the main-stem Hood River and its east fork. None were found in the west and middle forks. Hood River densities averaged 10.7/m^2. A salvage effort was conducted in the East Fork Irrigation District canal near its intake in October of 2017 and ammocoetes were present in large numbers. This indicates the furthest upstream known distribution of lamprey within Hood River and its main forks. PIT antennas were in operation at two locations in Hood River during 2017. Three lamprey were detected entering Hood River between April and August. No detections occurred at the east fork antenna. Density surveys are currently being conducted in Hood	CTWS	Personal communication with Andy Johnsen,, CTWS (10/10/18) Evaluate Status and Limiting Factors of Pacific Lamprey in the Lower Deschutes River, Fifteenmile Creek and Hood River (Johnsen and Baker 2017)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				River, its three forks, and in Indian Creek. Survey efforts during the spring months discovered the presence of ammocoetes in Indian Creek. Adult lamprey were also observed within the west fork and surveys will be conducted in west fork this fall as conditions allow. PIT antennas are currently installed within Hood River. To date, seven lamprey have been detected entering Hood River. No detections have been recorded at the east fork antenna to date in 2018.		
13.	Nest surveys for Pacific Lamprey	No associated hydro project	Entiat	USFWS conducted Pacific Lamprey nest surveys to define spawning period and locations. Nests were enumerated and marked using GPS. Report in progress.	USFWS	Personal communication RD Nelle (10/25/18)
14.	Lamprey artificial propagation	N/A	N/A	Since 2012, the Yakama Nation Fisheries in partnership with Confederated Tribes of the Umatilla Indian Reservation (CTUIR), NOAA Fisheries, and USFWS, have been refining best management practices for rearing newly hatched larval lamprey (1-3 months post fertilization), which appears to be the "bottleneck" life stage in the hatchery settings. In 2018, the Yakama Nation Fisheries focused on answering questions related to 1) sexual maturation of adult lamprey held in various ratios of well and river water, 2) effects of transportation on early life stage lamprey, and 3) the effects of feed frequency, sediment depth, and supplemental feed types on survival and growth of larval lamprey. Feeding experiments using 24 aquarium tanks started in July 2018, and lasted for 2 months. A 2017 Report is currently available and a 2018 Report will be available in 2019.	Yakama Nation, CTUIR, NOAA Fisheries, USFWS, Chelan County PUD	Personal communication with Ralph Lampman, Yakama Nation (11/07/18) Development of Artificial Propagation Methods for Production of Juvenile Pacific Lamprey (*Entosphenus tridentatus*) for the Use in Research Associated with Section 4.2.3 of the Rocky Reach Pacific Lamprey Management Plan. (Lampman 2018a)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
15.	Lamprey translocation project including juvenile surveys and radio-telemetry studies.	No associated hydro project	Willamette	In 2018, the Confederated Tribes of Grand Ronde (CTGR) collected 131 adult Pacific Lamprey from Willamette Falls and translocated them to Fall Creek above the Fall Creek Dam. Due to time conflicts and water temperature the goal of 240 translocated fish was not reached, nor were 40 individuals able to be radio tagged. Electrofishing was conducted to determine the presence and distribution of juvenile lamprey above the Fall Creek Dam. This resulted in the identification of 101 Pacific Lamprey and 13 Brook Lamprey ammocoete being identified. Electrofishing occurred on two days, and 8 location throughout the system were surveyed. Prior to the translocation efforts the area was surveyed for ammocoete resulting in 578 Brook Lamprey being identified and zero Pacific. The presence of Pacific Lamprey ammocoete above the dam shows there is suitable spawning and rearing habitat. The study is ongoing with no 2018 reports available at this time.	CTGR	Personal communication with Torey Wakeland, CTGR (10/19/18)
16.	Collection of adult lamprey for translocation, artificial propagation and radio-telemetry studies	No associated hydro project	Umatilla	In 2018, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) collected adult lamprey from lower Columbia River mainstem dams. Approx. 1,700 adults were captured and transported to the South Fork Walla Walla lamprey holding facility throughout the fall and then moved to Minthorn Springs to over-winter. These fish will be used for translocation programs in the Umatilla and Grande Ronde basins; to support radio-telemetry assessments (releases in the lower Umatilla River); and to support artificial propagation research occurring at the Walla Walla Community College, Water Environmental Center lab. Genetic samples were collected for all translocated fish.	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/2/18)
17.	Collection of adult lamprey for translocation, artificial propagation and radio-telemetry studies	No associated hydro project	Yakima, Wenatchee, Methow	In 2018, the Yakama Nation collected adult lamprey from Lower Columbia River mainstem dams. In total, 1,619 adults were captured and transported to the Prosser Fish Hatchery (Prosser, WA). These fish will be used for translocation programs in the Yakima, Wenatchee, and Methow subbasins; to support	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/08/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				supplementation; PIT tag assessments; and to support artificial propagation research. A 2017 Report is currently available and a 2018 Report will be available in 2019.		Yakama Nation Adult Pacific Lamprey Collection in the Columbia River Basin, 2017. BPA 2017 Annual Report Appendix K1 (Lampman 2018b)
18.	Trap and transportation of adult Pacific Lamprey	Priest Rapids Dam	Columbia	From July 31 to September 7, 2018, Grant PUD successfully collected a total of 851 adult Pacific Lamprey from the fish ladders at Priest Rapids Dam and transported them upstream of Rock Island Dam to meet and fulfill its' No Net Impact Statement of Agreement (SOA) with the Priest Rapids Fish Forum (PRFF).	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/02/18)
19.	Adult Pacific Lamprey translocation	Wells	Methow, Okanogan	In 2018, Public Utility District No. 1 of Douglas County (Douglas PUD) began a 4-year lamprey translocation program to bolster the number of adult lamprey in spawning areas upstream of Wells Dam. The goal of the program is to increase adult and juvenile lamprey abundance upstream of Wells Dam which is hypothesized to increase concentrations of lamprey migratory pheromone cues and result in increased numbers of adult lamprey approaching and passing the dam in the future. Between August 10 and September 7, 2018, 669 adult lamprey were translocated from Priest Rapids Dam to locations in the Methow and Okanogan rivers. All lamprey were implanted with full duplex PIT tags and tag data were uploaded to PIT Tag Information System (PTAGIS) to allow for the tracking of fish following release.	Douglas PUD	Personal communication with Chas Kyger (10/24/18)
20.	Occupancy and distribution of larval lamprey.	No associated hydro project	Multiple watersheds	Determining occupancy and distribution of Pacific Lamprey using eDNA techniques.	USFWS	Personal Communication with Tim Whitesel (10/19/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
21.	Habitat restoration and effectiveness monitoring	No associated hydro project	Methow (Chewuch River)	A salmonid-based habitat restoration action on the Chewuch River at river mile (RM) 10 is being assessed to determine its effects on 1) the distribution of larval lamprey rearing habitat, 2) the distribution and relative abundance of ammocoetes. The restoration project was initiated by the Yakama Nation and the monitoring component is being coordinated by John Crandall. Pre-treatment data was collected in 2010 and post-treatment data has been collected in subsequent years including 2013-2016. Methow Salmon Recovery Foundation (MSRF) continues with larval status and trend monitoring at six sites (3 in Methow and 3 in Chewuch) with field assistance from Yakama Nation. Significant changes to larval habitat monitoring sites following spring runoff in 2016 will lead to changes in status and trend sites for 2017 sampling. First young of the year larvae (since lamprey sampling began in the Methow watershed in 2008) were observed in 2016 samples Yakama Nation released several hundred adult lamprey into Methow River in fall 2015, 2016, and 2017. DNA samples from 2016 revealed Western Brook Lamprey which is the first detection of this species in the Methow watershed. Additional monitoring revealed larval use of several instream habitat restoration areas on the Methow River. 2018 activities included eDNA sampling as a component of the larger Basin-wide Lamprey Inventory and Monitoring Project (eBLIMP) project. Final report will be completed in 2020. Initial results to be presented at Lamprey Information Exchange in December 2018.	MSRF, and Yakama Nation	Personal communication with John Crandall, Methow Salmon Recovery Foundation (11/1/18)
22.	eDNA marker for Pacific Lamprey and occurrence probability maps	No associated hydro project	Multiple watersheds	The eDNA Basinwide Lamprey Inventory and Monitoring Project (eBLIMP) has developed an eDNA marker for Pacific lamprey and a preliminary set of rangewide occurrence probability maps to assist with future surveys. 2018 eBLIMP Objectives:	U.S. Forest Service (USFS), National Genomics Center for Wildlife and	eDNA for Pacific Lamprey Conservation. Webinar Presentation for Pacific Lamprey Conservation

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				1) Where do Pacific Lamprey currently exist on the landscape? Model lamprey occurrence within the interior Columbia River basin and validate with eDNA. 2) What is the best sampling protocol for detecting ammocoetes? Pair eDNA with density information to understand detection probabilities and fine scale sampling protocols.	Fish Conservation	Group. USFS (Carim et al. 2018)
23.	Larval lamprey surveys for status and trend, distribution, relative abundance, and habitat availability (including eDNA sampling)	No associated hydro project	Yakima, Wenatchee, Entiat, Methow, White Salmon, Klickitat	Sampling in 2018 for all subbasins within the Yakama Nation Ceded Lands focused more heavily on the collection of eDNA samples (in collaboration with USFS and USFWS) and as a result less time was dedicated to electrofishing surveys. However, electrofishing surveys were conducted in each subbasin in key locations for direct comparison with eDNA data. The eDNA sampling had two focuses: 1) coarse scale study in which eDNA samples were collected every 30-35 km from mouth to upper distribution as well as at tributary mouths and key water inlets that may contain Pacific Lamprey; 2) fine scale study in which eDNA samples were collected every 1 km in a 15-25 km reach within three Lower Yakima River tributaries (Satus, Toppenish, and Ahtanum). Electrofishing surveys and habitat mapping were also part of the fine scale study. In Wenatchee Subbasin, USFWS collected the eDNA samples (see Activity #25), In the Methow Subbasin, we assisted the electrofishing sampling led by John Crandall (see Activity #21), and also collected additional eDNA samples from additional sites. Reports from 2017 are currently available and 2018 Reports will be available in 2019.	Yakama Nation, USFS, USFWS	Personal communication with Ralph Lampman, Yakama Nation (11/07/18) BPA 2017 Annual Report Appendices C1-C6 covering the following subbasins: Lower Yakima, Upper Yakima, Naches, Wenatchee, Methow, Klickitat. (Beals and Lampman 2018a-f) Distribution and Occupancy of Pacific Lamprey in Six Major Columbia River Subbasins within the Yakama Nation Ceded Lands: Summary from

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						2009-2017 Surveys. BPA 2017 Annual Report Appendix C7 (Beals and Lampman 2018g) Yakama Nation Ceded Lands Larval Lamprey Synthesis Report, 2017. BPA 2017 Annual Report Appendix C8. (Beals and Lampman 2018h)
24.	Occupancy and distribution of Pacific Lamprey and comparison of electrofishing and eDNA sampling techniques	No associated hydro project	Chehalis	Pacific Lamprey distribution and occupancy was inferred using eDNA and electrofishing methods in 9-10 sites of three tributaries of the Chehalis River, Washington. Both methods produced similar detection rates in the Black, Skookumchuck, and Newaukum rivers. Our findings suggest eDNA surveys may be at least comparable to electrofishing for informing lamprey occupancy and distributions. Additionally, Pacific Lamprey were detected in the Wynoochee and Wishkah basins using traditional electrofishing techniques.	USFWS and U.S. Geological Survey (USGS)	Personal communication with Judith Barkstedt, USFWS (10/19/18) Evaluation of eDNA-based surveys for identifying occupancy and spatial distribution of Pacific Lamprey and *Lampetra* spp in a Washington coast watershed. (Ostberg et al. *in prep.*)
25.	Larval Pacific Lamprey distribution	No associated hydro project	Wenatchee and Okanogan	In 2018, the Mid-Columbia Fish and Wildlife Conservation Office conducted combined electrofishing and eDNA sampling for Pacific Lamprey in Mid-	USFWS	Personal communication

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Columbia River tributaries. Analysis and reporting for this work is ongoing.		with RD Nelle, USFWS (10/25/18)
26.	eDNA methods for lamprey: validating and refining an emerging tool	No associated hydro project	Columbia and Snake	eDNA is an emerging tool that can be used to detect a species based on DNA (feces, gametes, skin cells, etc.) shed into the environment. Interpretation of an eDNA presence for a species is difficult because information on its relation to biomass, distance, and persistence in the environment is lacking. This study is working to test and refine field sampling approaches to detect lamprey eDNA in water and sediment samples. Tests use ammocoetes in controlled lab settings to evaluate sampling approaches (water vs. sediment), eDNA relationships to lamprey biomass, detection capability relative to distance, and eDNA persistence in water and sediment. October 2017 update: the lab tests have been completed and a draft manuscript is currently in progress. Preliminary summary of findings shows that monitoring eDNA in sediment appears to be a fruitful approach for ammocoetes. There is a relation between biomass and eDNA in sediment and estimates of how long eDNA persists following animal removal and how far away from a known location eDNA can be detected. These findings will aid in design of field sampling procedures to detect ammocoetes in sediments. A final manuscript is not complete, but is still planned for this work.	USGS	Personal communication with Lisa Weiland, USGS (10/2/18)
27.	Environmental (eDNA) sampling	Tumwater Dam	Wenatchee, Icicle Creek	In 2018, the Mid-Columbia River U.S. Fish and Wildlife Conservation Office continued eDNA sampling in the Wenatchee River Basin, building on a pilot study conducted in 2016 and followed up with additional sampling in 2017. A report on the pilot study was also completed and released, indicating that positive eDNA detections in the Wenatchee River matched the known distribution below Tumwater Dam,	USFWS	Personal communication with RD Nelle, USFWS (10/25/18) Using eDNA Sampling to Detect Pacific Lamprey in

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				and suggesting that recolonization of the Upper River by translocated fish was occurring, but that additional sampling, (by both eDNA and other methods) was needed to fully describe the current distribution.		a Large River: 2016 Wenatchee River Pilot Study (Grote and Carim 2017)
28.	Lamprey marine ecology	No associated hydro project	NE Pacific ocean	Pacific Lamprey during their marine phase were collected in 2017 and 2018 by fishery observers on the commercial hake fishery and the commercial shrimp fishery, and by NOAA surveys for hake off the WA/OR coasts and groundfish in Alaska. These fish are being used to estimate marine size and condition, ocean growth rates, feeding success, origins (from genetics [Jon Hess and Laurie Porter] and statoliths [Jessica Miller, OSU]), and latitudinal and depth distributions. Two individuals (1 each in 2017 and 2018) caught by the Northwest Fisheries Science Center (NWFSC) hake survey were PIT tagged, and released.	NOAA Fisheries NWFSC, Columbia River Inter-Tribal Fish Commission (CRITFC), OSU	Personal communication with Laurie Weitkamp, NOAA Fisheries (9/20/18)
29.	Traditional ecological knowledge on Pacific Lamprey	No associated hydro project	Yakima	Within the past several years, the Yakama Nation Pacific Lamprey Project (YNPLP) has interviewed many tribal members, most of whom are tribal elders, to inquire about Pacific Lamprey. Some of the young and middle aged tribal members who have strong connections to lamprey related customs, traditional culture, and tribal elder family members were interviewed. For many of the tribal elders, lamprey have been not only a key food source and medicine but also an integral piece of their culture and tradition, without which there is an indubitable "void" in their very existence. Between March 2013 and March 2014, an oral interview was conducted with sixteen tribal members (all but two were recorded in full length videos), and 15 key questions were asked related to lamprey status, biology, ecology, culture, as well as human impact. Through this interview process, many insights and revelations were attained related to historical distribution, abundance, run timing, potential threats and impacts, and tradition associated with	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/07/18) Yakama Nation Cultural Oral Interviews on Asum (Lamprey Eels): Summary and Review Part III (2017). BPA 2017 Annual Report Appendix M1 (Gaudy et al. 2018)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				harvest, preparation, and consumption by Yakama Nation tribal members across the wide-ranging Ceded Lands. The two interviewees (Johnson Meninick and Tony Washines) for which a summary and review was completed in this report, provided unique and intriguing information related to lamprey customs and tradition within the Yakama Nation Ceded Lands. A 2017 Report is currently available and a 2018 Report will be available in 2019.		
30.	Lamprey identification guide	No associated hydro project	N/A	The purpose of this 2 page document is to help provide a field lamprey ID guide for researchers on the ground conducting surveys or finding lamprey. Through several years of conducting lamprey identification in the lower, mid, and upper Columbia watersheds, and confirmation through genetic methods, separate categories of Lampetra species, Class A and Class B (which are genetically distinct) were found. Most lamprey biologists are able to distinguish Class A as Entosphenus as there is a difference in both the caudal fin and caudal ridge. But Class B Lampetra have speckles on the caudal fin and can be very confusing (many will actually ID them as Entosphenus, including us in our earlier years). The relationship of Class A and Class B to Western Brook Lamprey and Western River Lamprey is still trying to be understood. More work is in progress on this issue. This field lamprey ID guide was included in the BPA 2017 Annual Report as Appendix L1.	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/07/18) Columbia Basin Lamprey Identification Guide; Adults/Juveniles (Lampman 2017)
	<u>Lamprey Migration in Rivers</u>					
31.	Juvenile lamprey outmigration monitoring	No associated hydro project	Umatilla	In 2017-2018 the CTUIR continued to operate a rotary screw trap at RM 2.5 of the Umatilla River to document juvenile lamprey outmigration timing. The trap is run from November to May of each year. Status and trend	CTUIR, and NOAA Fisheries	Personal communication with Aaron Jackson, CTUIR (11/2/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				monitoring shows continued increases since initiating translocation. No juvenile lamprey were PIT tagged in 2017-18 from screw trap operations. In the fall 2018, CTUIR is PIT tagging larval lamprey from electrofishing surveys in the Umatilla River. Additionally, genetic samples are collected for future analysis. CTUIR plans to tag juvenile lamprey from screw trap operations during the 2018-19 winter operation to evaluate irrigation diversion entrainment rates.		
32.	Larval / juvenile lamprey surveys in irrigation diversions	No associated hydro project	Yakima, Wenatchee	The Yakama Nation Pacific Lamprey Project (YNPLP) has been active annually in October/November surveying dewatered irrigation canals within the Yakima and Wenatchee subbasins for larval / juvenile lamprey within these diversions. There is a strong correlation between the amount of new fine sediment collected in diversions and the number of larvae found at these facilities. Lamprey of various sizes (sometimes in the thousands) were found behind screens. A new report summarizing this sampling from 2017 was made available in 2018. Reports from 2017 are currently available and 2018 Reports will be available in 2019. Additional relevant sources include: - Intensive Monitoring of Larval/Juvenile Lamprey Entrainment in the Yakima Subbasin, 2017. BOR 2017 Annual Report: Appendix 3.2. (Beals and Lampman 2018i) - Summary Assessment of Larval/Juvenile Lamprey Entrainment in Irrigation Diversions within the Yakima Subbasin, 2017. BPA 2017 Annual Report: Appendix D1. (Beals and Lampman 2018j)	Yakama Nation / Pacific Northwest National Laboratory (PNNL)	Personal communication with Ralph Lampman, Yakama Nation (11/07/18) Larval Lamprey Assessment at the Sunnyside Fish Screening Facility. 2018. Prepared for DC Consulting LLC under an Interagency Agreement with the U.S. Department of Energy. PNNL-27787 (R.P. Mueller 2018)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				- Summary of Larval Lamprey Hook-and-Line Predator Fish Removal in Chandler Irrigation Diversion (Yakima River, Prosser, WA), 2017. BOR 2017 Annual Report: Appendix 3.5 (Beals 2018a) - Intensive Monitoring of Larval/Juvenile Lamprey Entrainment within Dryden Diversion, Wenatchee River, 2017. BPA Annual Report 2017 Appendix D2. (Lampman 2018c) - Summary of a Pilot Project to Improve Lamprey Salvage Efficiency: Venturi Pump Sluice Box Design (Designed and Operated with the Assistance of Natural Solutions, Inc.). BOR 2017 Annual Report: Appendix 3.3 (Beals 2018b)		
33.	Juvenile lamprey outmigration monitoring	Sunnyside, Wapato, Chandler diversion dams	Yakima	In 2018, juvenile/larval lamprey collected from Yakima River tributary screw traps, Chandler Juvenile Fish Monitoring Facility (Lower Yakima R.), and Columbia River hydro dams (John Day and McNary dams) were PIT-tagged using 8.4 mm Pico FDX tags and released for outmigration studies. As a result of multiple years of surveys in dewatered irrigation diversions within the Yakima Basin, Yakama Nation Pacific Lamprey Project (YNPLP) has discovered that Wapato and Sunnyside diversions entrain the largest number of larval/juvenile lampreys each year. For larval lamprey, these diversions act as a migration corridor as well as an intermittent temporary rearing habitat (due to the slow water and fine sediment habitat). PIT tagged juvenile/larval lampreys were released in various locations between mid-Yakima River to lower Yakima River in 2018. The detection analysis is ongoing. A final report will be available in 2019. In addition, in spring of 2018 a pilot acoustic telemetry project was conducted for juvenile lamprey collected	Yakama Nation, USGS, and BOR	Personal communication with Ralph Lampman, Yakama Nation (11/07/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				from Yakima Subbasin and Columbia River hydro dams (McNary and John Day dams) within Yakima River (mid to lower reaches) and mainstem Columbia River using the newly developed eel/lamprey tags developed by PNNL. USGS and BOR were partners for this project. A report will be available in 2019.		
34.	Effects of dewatering on movements and survival of cultured larval lamprey vs. recently captured	No associated hydro project	Columbia and Snake	The original study evaluated the effects of dewatering on larval lamprey movement and survival. The objective of this controlled laboratory study was to document the response of larval lamprey to dewatering of their habitat, specifically – 1) their movement relative to fish size and ramping rates, and 2) their survival relative to fish size and duration of exposure. This work is an expansion of the Liedtke et al. 2015 work. The same approach was used, controlled laboratory tests of ammocoete movement and survival following dewatering, but it compares the responses of cultured lamprey to those of ammocoetes recently captured from the field. As of October 2017, lab testing has been completed and data are being summarized and integrated with Liedtke et al. 2015 to report findings in a combined report. A final manuscript is not complete, but is still planned for this work.	USGS and USFWS	Vulnerability of Larval Lamprey to Columbia River Hydropower System Operations – Effects of Dewatering on Larval Lamprey Movements and Survival (Liedtke et al. 2015) Personal communication with Lisa Weiland, USGS (10/23/18)
35.	Migration data from translocated adults	No associated hydro project	Yakima, Wenatchee, Methow	This project is composed of two parts: 1) summary of all 2017-2018 broodstock adult Pacific Lamprey releases within the Yakima, Wenatchee, and Methow subbasins and 2) analysis of migration data from those adults that were PIT tagged. From the 2017-2018 broodstock (adults collected in summer 2017 that primarily matured in 2018), adult Pacific Lamprey were released in the fall of 2017 and spring of 2018 in the aforementioned three subbasins. From the 2018-2019 broodstock (adults collected in summer 2018 that	Yakama Nation, USFWS, and Colville Tribe	Personal communication with Ralph Lampman, Yakama Nation (11/07/18) Translocation of Adult Pacific Lamprey within

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				primarily mature in 2019), adult Pacific Lamprey were released in the fall of 2018 and another release is scheduled in spring of 2019 in the aforementioned three subbasins. Reports from 2017 are currently available and 2018 Reports will be available in 2019.		the Yakima Subbasin, 2016-2017 Broodstock. BPA 2017 Annual Report Appendix G1. (Lampman 2018d) Translocation of Adult Pacific Lamprey within the Wenatchee Subbasin, 2016-2017 Broodstock. BPA 2017 Annual Report Appendix G2. (Lampman 2018e) Translocation of Adult Pacific Lamprey within the Methow Subbasin, 2016-2017 Broodstock. BPA 2017 Annual Report Appendix G3. (Lampman 2018f))
36.	LPS operation at Warm Springs National Fish Hatchery	No associated hydro project	Warm Springs	A Lamprey Passage Structure (LPS) was installed in the fish ladder at Warm Springs National Fish Hatchery in 2017. Prior to the LPS installation, an evaluation of adult Pacific Lamprey movements at the barrier dam showed that they are able to pass upstream using the fish ladder. The LPS became fully operational in Summer 2018 and monitoring using PIT detections of lamprey	USFWS, and CTWS	Personal communication with Judith Barkstedt, USFWS (10/19/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				tagged at Sherars Falls showed 13 adult lamprey using the LPS.		
37.	Determination of optimal dewatering rates to protect larval Pacific Lamprey	No associated hydro project	Columbia and Snake	Planning took place in 2018 to develop a study to determine optimal dewatering rates to protect larval Pacific Lamprey. Testing will begin in early 2019 for a project that will use an existing laboratory test system to evaluate the risk of stranding for larval lamprey exposed to different dewatering rates under both day and night conditions. The test system is a tank with a false bottom and a 10-percent (5.7 degree) slope, filled with river sediment, with water inflow and drains that can be manipulated to control the rate of dewatering. The tank was used for previous evaluations of dewatering, when several dewatering levels and two dewatering rates were compared. This project will use a single dewatering level, with variable dewatering rates and light conditions. We will evaluate "stranding", defined as the number of lamprey either in or on the substrate outside of the watered area. Lamprey that traverse the dewatered section of the tank and enter the water at the lower end of the slope will be classified as "safe". We will test 5 dewatering rates under both day and night conditions. The five rates to be tested will be determined through consultation with USFWS staff and other interested parties to ensure that the project will generate real-world, usable information to guide future dewatering applications. The goal is to test a range of rates so that a statistical relationship can be developed and outcomes from rates not tested directly can be inferred.	USGS	Personal communication with Lisa Weiland, USGS (10/23/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	Adult Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
38.	Conduct ladder tours	All Army Corps of Engineers (ACOE) projects	Columbia and Snake	Completed a tour of fish ladders with regional fish managers and researchers to identify potential minor fishway modification opportunities. No tours (for this purpose) were given at Portland District dams in 2018, though ACOE staff did hold several project-specific site visits. No tours were given at Walla Walla District dams in 2018.	ACOE	Personal communication with Sean Tackley, ACOE (9/26/18) and Steve Juhnke, ACOE (9/26/18)
39.	Inspect fishway at Priest Rapids and Wanapum dams and identify areas that could represent passage problems for adult Pacific Lamprey	Priest Rapids, Wanapum	Columbia	In February 2018, Grant PUD conducted a tour during scheduled maintenance outages with the PRFF members to evaluate the modifications to the fish ladders to improve adult lamprey passage (i.e., plating installation, adult lamprey collection facilities, count stations, and ramps downstream of perched orifices) and to identify any potential passage problem areas.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/02/18)
40.	Design LPS for Prosser Dam	Prosser, Sunnyside, Wapato, Horn Rapids dams	Yakima	In November 2017, two new vertical wetted wall (VWW) lamprey structures were successfully deployed at the left fish ladder of Prosser Dam to help improve passage. During spring 2018, from a total of three VWW structures (including the existing right ladder VWW structure), 224 adults were successfully trapped and counted for passage (7 total were counted from the fish ladder, totaling 231, which equates to 97% passage through VWW structures). A variety of modifications were implemented to improve passage and retention within the trap box and video monitoring.	Yakama Nation, USFWS, and BOR	Personal communication with Ralph Lampman, YN (11/07/18)
41.	Passage improvement design	McNary	Columbia	A prototype adult lamprey passage structure was installed in Oregon shore ladder (SFE2) in February	ACOE	Evaluation of Adult Fish Ladder

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				2014. Structure usage and passage success were monitored using dual-frequency identification sonar (DIDSON), optical video and half-duplex (HDX)-PIT tags, during a two year evaluation. The two years (2014 and 2015) results are available in the cited annual reports. To make the lamprey passage structure permanent at SFE2 will require some re-design effort. Physical modeling of alternate face designs are underway in 2017. Designs for modifying the ported hood box (i.e., entrance) section were completed in 2018. Modifications will reduce the length of this structure to clear the bulk head slot. Additional modifications include removing the knife gate and lifting mechanism and installing inspection ports in baffle box section. Construction will occur in January 2019.		Modifications to Improve Pacific Lamprey Passage at McNary and Ice Harbor Dams, 2014 (Thompson et al. 2015) Evaluation of Adult Fish Ladder Modifications to Improve Pacific Lamprey Passage at McNary Dam, 2015 (Thompson et al. 2016) Personal communication with Steve Juhnke, ACOE (9/26/18)
42.	Install and/or utilize slotted "keyhole" fishway entrance at Project	Priest Rapids, Wanapum	Columbia	Grant PUD currently utilizes the "keyhole" fishway entrance at Priest Rapids and Wanapum dams.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/02/18)
43.	Modify dewatering procedures	All ACOE projects	Columbia and Snake	Modifications to dewatering procedures to reduce stranding and mortalities have occurred over the past several years. These include: managing dewatering to better flush fish down to the tailrace; to keep fish remaining in the ladder in standing water while dewatering to reduce the efforts by lamprey to move through gratings when stranded; and adequate personnel and equipment to ensure timely salvage. This is an ongoing action.	ACOE	Personal communication with Sean Tackley, ACOE (9/26/18)
44.	Modify dewatering procedures	Wells	Columbia	Pursuant to the Wells Habitat Conservation Plan (HCP; Douglas PUD 2002), a dewatering protocol is in place.	Douglas PUD	Personal communication

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						with Chas Kyger, Douglas PUD (10/24/18)
45.	Modify dewatering procedures	Rocky Reach, Rock Island	Columbia	Pursuant to the Rocky Reach Unwatering/Water up Job Plan 1402 and Rock Island Standard Operating Procedures (SOP), fishway, dewatering protocols and fish recovery operations for all species are followed during annual winter fishway maintenance and dewatering activities. This is an ongoing activity.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/30/18)
46.	Modify dewatering procedures	Priest Rapids, Wanapum	Columbia	Pursuant to the Project Fishway Operation Plan, dewatering protocols are followed annually during winter maintenance and dewatering activities.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/02/18)
47.	Operate old fishway for lamprey passage	Willamette Falls	Willamette	Based upon past lamprey evaluations conducted at Willamette Falls, activities to restore portions of the existing "old fishway" to operability for lamprey passage were completed in 2011 with the completion of a 52m linear curb and an adjustable headgate. The facility began operation in early spring 2012 when flows decrease below a river elevation (upstream of the falls) of 54 ft. Current information indicated that lamprey congregate in an area of this fishway early in the migration season. Annual operations of this fishway allow lamprey volitional passage to the forebay of the project. Additionally, 3 lamprey ramp structures are installed along the concrete cap to provide passage for lamprey over the Falls after flashboard construction is complete. These structures provide a smooth attachment surface over the 3.5 ft flashboards. Ramps are generally installed in early summer and removed mid-September. In 2018, Portland General Electric (PGE) continued to operate the "old fishway" and install lamprey ramps to	PGE	Personal communication with Nick Ackerman, PGE (10/01/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				facilitate adult lamprey passage at Willamette Falls Dam.		
48.	Passage design elements for new fishway construction	Carmen-Smith (Trail Bridge Dam)	McKenzie	As part of the implementation of the Carmen-Smith Project Federal Energy Regulatory Commission (FERC) license (currently awaiting issuance), the Eugene Water & Electric Board (EWEB) has included several design elements in the Trail Bridge Dam trap and haul that will assist in the upstream passage of Pacific Lamprey. A lamprey ramp or other passage system for Pacific Lamprey that 1) integrates with the trap and haul, 2) which could be installed at a future date if necessary, and 3) will exclude lamprey from the trap pool.	EWEB	Personal communication with Andy Talabere, EWEB (9/21/18)
49.	Reduce water velocities at fishway entrances	Bonneville and The Dalles	Columbia	Continued reduced nighttime flow operations at the Washington Shore Fish Ladder during the lamprey passage season to improve lamprey passage efficiency. In 2018, as part of a ACOE-funded radio-telemetry study, reduced nighttime flow operations were conducted at Bonneville's Powerhouse 1 (Bradford Island Fish Ladder, A-Branch) and at The Dalles East Fish Ladder. This study is expected to continue in 2019.	ACOE	Personal communication with Sean Tackley, ACOE (9/26/18)
50.	Reduce water velocities at fishway entrances	McNary	Columbia	In 2013, continued reduced nighttime flow operations were implemented at the Oregon Shore Fish Ladder entrances, to improve lamprey passage efficiency. In 2014, with the installation of the lamprey passage entrance structure (LPES) in SFE2, nighttime flow operations were discontinued.	ACOE	Personal communication with Steve Juhnke, ACOE (9/26/18)
51.	Lift picket leads at count station	Bonneville	Columbia	In 2011, lifted picket leads by 1 inch at Bradford Island Fish Ladder count station to improve access to auxiliary water supply (AWS) channel LPS. The 1 inch spacers were removed mid-passage season (June 29) due to an incident in which dozens of sockeye salmon were found milling behind picket leads. During an emergency dewatering on June 30, it appeared that the sockeye	ACOE	Personal communication with Sean Tackley, ACOE (9/26/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				were able to get behind the picket leads via inconsistencies in the floor surface at the base of the picket leads (some gaps were up to 3 inches). ACOE modified picket leads at Bradford Island during winter 2011-12 to allow lifting picket leads by 1 inch while ensuring a contiguous floor surface. University of Idaho monitored these picket leads in summer 2012. Results suggest that adult salmonids, including relatively small-bodied sockeye salmon, jack Chinook salmon, and steelhead, did not attempt to or successfully enter the AWS channel at Bradford Island during the viewing period. Observations from project biologists at Bonneville Dam also did not see sockeye milling behind picket leads, despite the record-sized run. Accordingly, ACOE modified the Washington Shore Fish Ladder count station picket leads in winter 2012-13 to improve access to the AWS channel LPS in that fishway. This is now the standard configuration.		
52.	Lift picket leads at count station	The Dalles	Columbia	Lifted picket leads at East and North Fish Ladder count stations by 1.5 inches to provide alternative passage routes for Pacific Lamprey. This is now the standard configuration.	ACOE	Personal communication with Sean Tackley, ACOE (9/26/18)
53.	Lift picket leads at count station	John Day	Columbia	Lifted picket leads at South Fish Ladder (already lifted at North) count station by 1.5 inches to provide alternative passage routes for Pacific Lamprey. This is now the standard configuration.	ACOE	Personal communication with Sean Tackley, ACOE (9/26/18)
54.	Lift picket leads at count station	McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite	Columbia and Snake	Lifted picket leads at fish ladder count stations by 1.5 inches to provide alternative passage routes for Pacific Lamprey. This is an ongoing ladder operation, and now the standard configuration.	ACOE	Personal communication with Steve Juhnke, ACOE (9/26/18)
55.	Maintain fishway operations criteria	Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island Fish Passage Plan (Chelan PUD 2012), fishway operations criteria are in place.	Chelan PUD	Personal communication with Steve

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						Hemstrom, Chelan PUD (10/30/18)
56.	Maintain fishway operations criteria	Priest Rapids, Wanapum	Columbia	Pursuant to the Project Fishway Operation Plan (Grant PUD 2009), fishway operations criteria are routinely maintained.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/02/18)
57.	Design, construct and test lamprey vertical climbing structure (wetted wall) for passage	Bonneville	Columbia	An experimental vertical climbing structure intended as a mechanism of passing lamprey out of a serpentine weir section of a fish ladder into a make-up water supply (MUWS) channel that features an LPS was tested in the Fish Ecology Research Lab facility at Bonneville Dam in 2014. Lamprey climbing success was measured against three flow levels and three ways of supplying water to the structure. Lamprey passage was 100% under all experimental conditions for fish that interacted with the structure. A manuscript detailing this research has been published. The ACOE field tested this climbing structure in the Bonneville Dam Bradford Island fishway in 2018. Post-construction monitoring results from NOAA researchers are pending.	NOAA Fisheries	Climbing Success of Adult Pacific Lamprey on a Vertical Wetted Wall (Frick et al. 2017) Personal communication with Mary Moser, NOAA (10/23/17) and Sean Tackley, ACOE (9/26/18)
58.	Design and construct rounded caps and plating for fishway entrance weirs	Bonneville, The Dalles, John Day	Columbia	Modulating weirs located at fishway entrances are used to maintain consistent attraction flows under a variety of tailrace elevations. Radio-telemetry data have consistently shown delays and passage efficiency issues for Pacific Lamprey at fishway entrances throughout the Columbia River Basin, presumably due to the high velocities (> 8 ft/sec) and turbulence associated with these features, and entrance weir geometry that makes attachment and entry challenging. As part of a broader minor fishway modifications project, in 2014 the ACOE designed novel, radiused weir caps to be installed on the flat crests of existing entrance weirs at the Bonneville Washington Shore	ACOE	Personal communication with Sean Tackley, ACOE (9/26/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Ladder. In addition to the rounded crests (to facilitate attachment) cap design included short plates on the ends of the weir crests to cover weir guide slots, along with approximately 2 ft of plating on the downstream faces of weirs to provide attachment surface for lamprey that are approaching the top of the weir. Caps were fabricated and installed by ACOE staff at the following locations: - Bonneville Washington Shore Fish Ladder South Upstream Entrance (SUE) and South Downstream Entrance (SDE) (Winter 2014-15); - The Dalles North and East entrance weirs, except E1, E2 and E3 entrances at East Fish Ladder (Winter 2017-18). The ACOE intends to install similar structures at the following locations: - Bonneville Washington Shore Fish Ladder North Downstream Entrance (NDE) and North Upstream Entrance (NUE) (Winter 2018-19); - The Dalles East Fish Ladder – Entrances E1, E2 and E3 (Winter 2018-19). Entrance weir submergence criteria and existing configurations preclude installation of similar weir caps at Bonneville Bradford Island Ladder and the John Day South Ladder.		
59.	Design and construct fishway modifications to improve lamprey passage conditions in serpentine weir (control) section of fishways	Bonneville	Columbia	The serpentine weir (control) sections of the Bradford Island and Washington Shore ladders at Bonneville Dam are known to be problematic for adult Pacific Lamprey. This is probably due to a combination of high velocities, turbulence, confusing directional changes, cumulative effects of the passage experience, and lack of suitable cover/resting areas within the fishways.	ACOE	Personal communication with Sean Tackley, ACOE (9/26/18) Underwater video monitoring of slot orifices installed to

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				As part of a broader minor fishway modifications project, in 2015 the ACOE designed 1.5-in x 18-in weir orifices and prototype refuge boxes for testing in the serpentine weir sections of Bonneville Dam fishways. These structures were installed for initial evaluation at the Bonneville Washington Shore Ladder in Winter 2016-17 and the Bonneville Bradford Island Ladder in Winter 2017-18. Results from post-construction monitoring at the Washington Shore Ladder are summarized in Gallion et al. (2018):		improve Pacific Lamprey passage at Bonneville Dam's Washington Shore Fish Ladder. U. S. Army Corps of Engineers, Portland District Fisheries Field Unit. Cascade Locks, OR (Gallion et al. 2018)
60.	Development and improvements to LPS	Bonneville and John Day	Columbia	To (a) improve functionality and reliability of existing LPS ("lamprey ramps") and (b) expand the network of LPSs available to lamprey, the ACOE is modifying LPSs and installing new structures at Bonneville and John Dams through 2019. Current scope includes: 1. Modify Bonneville Washington Shore –NDE Lamprey Flume System to address known entrained air problem and possible velocity barrier issue within the structure. Completed in Winter 2016-17. 2. Bonneville Washington Shore Ladder AWS LPS – Install two new LPS ramps in channel between Upstream Migration Tunnel (UMT) junction and count station to divert lamprey away from problematic serpentine weir section of ladder; counting system improvements; exit chute improvements; integrate full-duplex (FDX-PIT) detection capability (in addition to HDX-PIT); other mods as needed. Completed in Winter 2016-17. 3. Bonneville Bradford Island Ladder LPS – Extend exit chute into forebay to reduce fallback risk; counting system improvements; integrate HDX-PIT and FDX-	ACOE	Personal communication Sean Tackley, ACOE (9/26/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				PIT detection capability; other mods as needed. Completed in Winter 2017-18. 4. Bonneville Cascades Island Ladder Entrance LPS – Various small-scale improvements. Completed in Winter 2017-18. 5. John Day North Ladder Entrance LPS – Various small-scale improvements. Planned for Winter 2018-19 construction. A post-construction radio-telemetry study by the University of Idaho is being conducted in 2018 and 2019 (see line items #68, #69 and #70 in this Table 5 for preliminary results).		
61.	Install low-level fishway entrance	Wells	Columbia	The low-level side fishway entrances on both Wells Dam fishways were re-opened and equipped with prototype lamprey entrances. The lamprey entrances consist of a fiberglass box with an opening to the tailrace one inch tall by eight feet wide. The interior of the box houses six rows of pipe bollards that serve to reduce water velocity and head differential. The designed water discharge and velocity of the lamprey entrances are approximately 1 cfs and 2 ft/s. Each lamprey entrance is equipped with a PIT antenna capable of reading HDX- and FDX-PIT tags.	Douglas PUD	Personal communication Chas Kyger, Douglas PUD (10/24/18)
	Project Passage Effectiveness					
62.	Evaluate fishway modifications	Priest Rapids, Wanapum	Columbia	Grant PUD implemented a comprehensive adult passage evaluation study plan, titled "Assessment of Pacific Lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams" (Nass et al. 2009). The goal was to collect data in support of determining whether proposed modifications (plating, ramps at perched orifices, and lamprey-specific crowders at fish count stations) improved adult passage. HDX-PIT system were used to collect data from fish tagged	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/02/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				downstream of Priest Rapids Dam. Pacific Lamprey tagged at lower river facilities were passively monitored at the Priest Rapids Project facilities as directed by the PRFF. In 2018, Grant PUD, in consultation with the PRFF, continued to monitor adult Pacific Lamprey with HDX-PIT-tags and evaluate both fish passage efficiency and fish ladder entrance efficiency. Cumulative data analysis will be completed as part of 2018 activities and are included in this annual report. Final fish ladder entrance efficiency results were presented to the PRFF in early 2018 for review.		
63.	Assess lamprey passage success post fishway modifications, raw conversion rates via fishway window counts	Rocky Reach	Columbia	Window Count Conversions Rates and Fishway Passage Studies, Rocky Reach Dam- Final 2016 Rocky Reach Dam Fishway FDX-PIT-Tag adult lamprey passage success measured at 98.8%; 162 of 164 adults detected within the fishway passed the exit pool to forebay. 2017 replicated Rocky Reach PIT-Tag study, second year, released 300 tagged adult lampreys collected/transported from Priest Rapids Dam. All fish PIT-tagged and released 10 miles below Rocky Reach Dam. In-progress results show 274 fish detected at some location. 257 study fish detected within Rocky Reach fishway; 249 successfully passed being last detected at fishway exit for still-in-progress passage success rate of 96.9%. Most all fish passed Rocky Reach within two-week period following release. Combined 2016 and 2017 FDX-PIT-Tag lamprey passage study results for Rocky Reach show a 97.6% passage rate; 411 of 421 lampreys detected in Rocky Reach fishway during back to back annual studies exited the fishway. No fall back documented. 2017 study still in progress.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/30/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				October 31, 2017 fishway count of adult lampreys at Rocky Reach = 23,984 adults; Rock Island fishways = 20,137 adults. Chelan PUD evaluated Rocky Reach Reservoir Operations over six years which showed Rocky Reach Reservoir does not affect migration of adult lampreys to Wells Dam, or ability of adult lampreys to reach Wells Dam. October, 2018 - Chelan PUD's adult Pacific Lamprey FDX PIT-tag study results for 2016-2018 are finalized. Rocky Reach Fishway passage rate for 511 tagged lampreys is 98.1% for fish detected inside the fishway. Passage rate is highest measured on mainstem Columbia River; adult passage studies are complete for Rocky Reach Dam.		
64.	Examine adult lamprey approach and passage	Wells	Columbia	In 2016 Douglas PUD conducted an acoustic telemetry tracking study to evaluate the behavior of Pacific Lamprey (*Entosphenus tridentatus*) through the Rocky Reach Reservoir and determine the proportion that approach and interact with Wells Dam. Acoustic and PIT tags were surgically implanted, and the 51 tagged fish were released into the lower reaches of Rocky Reach Reservoir. In addition, there were 211 Pacific Lamprey that were PIT-tagged as part of another unrelated study by Chelan County PUD, which were released downstream of Rocky Reach Dam, some of which entered the study area. In general, fish in the Rocky Reach Reservoir moved quickly in the upstream direction after release. Travel speeds varied among reaches and among individuals. In general, the fastest reach-specific travel speeds were in the lowest parts of the Reservoir. In each reach, there was a bimodal distribution of travel speeds, with some individuals moving very slowly, and a second group	Douglas PUD	Adult Lamprey Approach and Passage Study. Wells Dam. 2016-17. (Robichaud and Kyger 2018)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				moving more quickly. At least 79% (65 of 82) of the fish appeared to pause at the end of the summer, and then resume their upstream progression after the winter. Of the 83 acoustic-tagged lamprey that were tracked in the Reservoir, 21 (25%) moved far enough upstream to be detected at or upstream of the Wells Dam tailrace. In all, 14 fish (17% of the 83 tracked fish) interacted with Wells Dam fishways (i.e., were detected at receivers deployed at or inside the fishway entrances), making 23 approach events of which three (13%) were followed by detections on the inside of the fishways. Only three study fish were detected beyond the entrances of the Wells Dam fishways. One was a double-tagged (PIT and acoustic) lamprey whose PIT tag was detected in Pool 19 of the east ladder before it returned to the tailrace. The other two were PIT-tagged fish (one passed Wells Dam via the west ladder, and the other was last detected in Pool 19 of the west ladder).		
65.	Evaluate passage at LPS structures	Threemile Falls Dam, Maxwell and Feed diversions	Umatilla	In the Umatilla River watershed, LPS have been completed and are operational at Threemile Falls Dam (July 2009), Feed Diversion (October 2010), and Dillon Diversion (2011-since removed). A flat plate was installed to aid upstream lamprey movement at Maxwell Diversion (August 2010). Refinement of LPSs continued in 2018. Approximately 3000 adult lamprey returned to the Umatilla River from spring to fall 2018. Several hundred of the adults were trap and hauled upstream to suitable habitat during low flow conditions. Genetic samples were collected for all trap and hauled adults and provided to CRITFC for further analysis. Zero adult lamprey used the LPS at Feed Diversion.	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/01/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Dillon diversion was removed in summer 2017, and the Brownell Diversion was removed in summer 2018.		
66.	Project passage evaluation	Clackamas	Clackamas	To compensate for poor passage performance through the North Fork ladder, PGE initiated a trap-and-haul program beginning in 2017. In each year, through 2025, approximately 250 adult Pacific Lamprey will be trapped at River Mill Dam and hauled upstream to North Fork Reservoir. In each of the first two years 25 of those fish will be radio tagged and tracked. In 2017, 22 radio-tagged lamprey actively migrated upstream. Maximum upstream migration ranged from 2.7 to 23.4 miles above North Fork Reservoir with a median distance of 19.5 miles. Median arrival date to over winter-holding was August 11, 2017. Prior to over winter holding, fish migrated at a median rate of 0.57 mi/day. Fish remained in the mainstem Clackamas River below the confluence of the Collawash River. In addition, passage through the North Fork ladder will continued to be evaluated by PIT tagging 100 adult lamprey each year at River Mill Dam and releasing them into the River Mill forebay. Results from the summer of 2017 suggest that passage rates throughout the North Fork ladder were the highest in the three years of assessment.	PGE	Pacific Lamprey Upstream Passage Evaluation, 2017-2018 Annual Report [draft] (Ackerman 2018)
67.	Evaluate migration characteristics of adult lamprey in the Priest Rapids Project	Priest Rapids, Wanapum	Columbia	In 2017, Grant PUD continued to evaluate passage behavior and travel times through various reaches of the Priest Rapids Project, including both reservoirs, using the adults previously tagged in 2016. One hundred adult lamprey collected at Priest Rapids Dam were tagged with Vemco acoustic and FDX-PIT tags and released at one of three locations; above Priest Rapids Dam (n=30 Desert Aire RM 400.3), or above Wanapum Dam at either the left bank boat launch (n=35 RM 416.0) or at Vantage (n=35 RM 419.9). Fixed receiver arrays were used to monitor lamprey that migrated within the Priest Rapids and Wanapum reservoirs. Detections of FDX-	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/02/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				PIT tags were queried using PTAGIS. Final results of the study are summarized in section 1.2 of this 2018 annual report.		
68.	Adult lamprey radiotelemetry study	Bonneville, The Dalles, John Day, McNary	Columbia	In 2018, 599 adult lamprey were collected at Bonneville Dam, tagged with radio transmitters and HDX-PIT tags, and released downstream from the dam. The primary study objectives were to: 1) evaluate performance of new LPS structures and the NDE lamprey flume system at the Bonneville WA-shore ladder; 2) evaluate the response of lamprey to reduced nighttime fishway entrance velocities at the Bonneville Bradford Island fishway and The Dalles east fishway; and 3) evaluate overall upstream passage by lamprey in the Federal Columbia River Power System (FCRPS). Radiotelemetry monitoring was limited to the four lower Columbia River dams, but additional monitoring data were collected from HD-PIT and dual readers at FCRPS dams and in some tributaries, with cooperation from collaborating agencies.	University of Idaho	Personal communication with Chris Caudill, University of Idaho (11/06/18) Evaluation of Adult Pacific Lamprey Passage Behavior in Relation to Lower Columbia River Dam Modifications (Caudill *in prep.*)
69.	Adult lamprey HD-PIT study	Federal Columbia River Power System	Columbia and Snake	In 2018, 578 adult lamprey were collected at Bonneville Dam, tagged with HDX-PIT tags (only), and released downstream from the dam. The primary study objectives were to: 1) evaluate performance of new LPS structures and the NDE lamprey flume system at the Bonneville WA-shore ladder; and 2) evaluate overall upstream passage by lamprey in the FCRPS. Monitoring data were collected from HDX-PIT and dual readers at FCRPS dams and in some tributaries, with cooperation from collaborating agencies.	University of Idaho	Personal communication with Chris Caudill, University of Idaho (11/06/18) Evaluation of Adult Pacific Lamprey Passage Behavior in Relation to Lower Columbia River Dam Modifications (Caudill *in prep.*)
70.	Adult lamprey flume study	No associated hydro project	N/A	In 2018, 200 adult lamprey were collected at Bonneville Dam, tagged with HDX-PIT tags (only), and then used for experimental fishway tests. The primary objective was to: 1) investigate the effects of exercise history (i.e.,	University of Idaho	Personal communication with Chris Caudill,

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				fatigue) on lamprey passage through an experimental flume located at Bonneville Dam. An additional 100 adult lamprey tagged with HD-PIT tags (only) were used to: 2) evaluate swimming performance of a prototype flume to test the feasibility of the design for installation at USACE fishways. Further, 9 fish were tagged with HD-PIT tags and accelerometer tags for: 3) the use of biolotelemetry accelerometers for improving passage at fishways at Bonneville Dam. Tagged fish for objectives 1 and 2 were released upstream from Bonneville Dam post-experiments and then monitored using HDX-PIT and dual readers at FCRPS dams and in some tributaries, with cooperation from collaborating agencies. Tagged fish for objective 3 were released at the WA-shore fish ladder and monitored using above methods at the FCRPS dams and tributaries.		University of Idaho (11/06/18) Evaluation of Adult Pacific Lamprey Passage Behavior in Relation to Lower Columbia River Dam Modifications (Caudill and Hanchett *in prep.*)
	Lamprey Counts at Dams					
71.	Conduct 24-hour lamprey counts	Bonneville, The Dalles, John Day, McNary, Lower Granite	Columbia and Snake	Counts include nighttime video window counts. Nighttime counting was expanded in 2012 to include The Dalles and John Day dams. This is an ongoing operation. Nighttime counts at Bonneville Dam, are problematic due to extensive up/down movement at the fish count windows (probably largely due to poor passage conditions in the control sections of the Washington Shore and Bradford Island fish ladders). The ACOE is discussing options for how to address this problem and communicate count uncertainties to regional fish managers in future years. Validated LPS counts from Bonneville Dam are reported in tabular format to interested parties via email, but are not posted directly to the ACOE or Fish Passage Center (FPC) fish count websites. The ACOE is considering options for incorporating LPS counts	ACOE	Personal communication with Sean Tackley, ACOE (9/26/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				(which constitute a substantial portion of passage at the dam) into counts reported online. The ACOE intends to integrate LPS counts into broader fish count data posted online in the future.		
72.	Conduct 24-hour lamprey counts	Wells	Columbia	On-going 24-hour fishway monitoring since the 1990's.	Douglas PUD	Personal communication with Chas Kyger Douglas PUD (10/24/18)
73.	Conduct 24-hour lamprey counts	Rocky Reach, Rock Island	Columbia	On-going 24-hour fishway monitoring since the late 1980's.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/30/18)
74.	On-going 24-hour fishway monitoring since the mid 1990's.	Priest Rapids, Wanapum	Columbia	On-going 24-hour fishway monitoring since the mid 1990's.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/02/18)
75.	Conduct 24-hour lamprey counts	Prosser and Roza	Yakima	On-going 24-hour fishway monitoring since 1996 at Prosser Dam and since 1997 at Roza Dam. New vertical wetted wall structures were constructed and installed at Prosser Dam.	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/07/18)
	Predation					
76.	Establish predation control measures (sea lions)	Bonneville	Columbia	Ongoing implementation of predation control measures, such as sea lion removal efforts - although planned for salmon, are also expected to benefit adult Pacific Lamprey. Efforts are being made to be sure to include concerns for lamprey and adequate monitoring of lamprey predation in future efforts.	ACOE	ACOE Pacific Lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	Juvenile Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
77.	Delayed deployment of extended length screen during outmigration	McNary	Columbia	Installation of extended screens has been delayed each year since 2013 to reduce impacts to juvenile lamprey migrating out early. This is an ongoing action.	ACOE	Personal communication with Steve Juhnke, ACOE (9/26/18)
78.	Continue salvage activities during ladder maintenance de-watering	All ACOE projects	Columbia and Snake	Modifications to dewatering procedures to reduce stranding and mortalities have occurred over the past several years. These include: managing dewatering to better flush fish down to the tailrace; to keep fish remaining in the ladder in standing water while dewatering to reduce the efforts by lamprey to move through gratings when stranded; and adequate personnel and equipment to ensure timely salvage. This is an ongoing action.	ACOE	Personal communication with Sean Tackley, ACOE (9/26/18) and Steve Juhnke, ACOE (9/26/18)
79.	Continue salvage activities during ladder maintenance de-watering	Wells	Columbia	Pursuant to the Wells Habitat Conservation Plan (HCP; Douglas PUD 2002), a dewatering protocol is in place. Any adult lamprey captured during salvage activities are released upstream of Wells Dam, juveniles downstream per the Wells PLMP.	Douglas PUD	Personal communication with Chas Kyger Douglas PUD (10/24/18)
80.	Continue recovery activities during ladder maintenance de-watering	Rocky Reach, Rock Island	Columbia	Pursuant to the Rocky Reach Unwatering/Waterup Job Plan 1402 and Rock Island SOP, fishway dewatering protocols and fish recovery operations for all species are followed during annual winter fishway maintenance and dewatering activities.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/30/18)
81.	Continue salvage activities during ladder maintenance de-watering	Priest Rapids, Wanapum	Columbia	Consistent with its Fishery Operations Plan (Grant PUD 2010), Grant PUD conducts collection operations for all fish species during annual ladder maintenance activities.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/02/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
82.	Maintain bypass operations criteria	Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island Fish Passage Plan (Chelan PUD 2012), bypass operations criteria are in place.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/30/18)
83.	Maintain bypass operations criteria	Priest Rapids, Wanapum	Columbia	Grant PUD has existing bypass systems, which includes gatewells, spillways, the Wanapum Future Unit Fish Bypass (WFUFB), and Priest Rapids Top-Spill Bypass.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/02/18)
84.	Planning and permit acquisition for reservoir drawdown to remove silt	Leaburg-Walterville	McKenzie	Silt removal is required from around the Leaburg Dam left-bank fish ladder to maintain sufficient depth at the ladder exit and the auxiliary water supply intake. The silt deposit is documented to contain a high density of ammocoetes that are observed to exit from the silt surface if the reservoir is drawn down slowly. Because silt removal requires reservoir drawdown, EWEB has worked on a new programmed drawdown routine of 1.8 inches per hour to facilitate ammocete escape. Additionally, the proposed action is to allow silt to remain in the river and immediately flushed downstream through rollgate #3. Testing of the programmed drawdown occurred on March 19-25, 201.. Two objectives were accomplished during the drawdown: 1) Assess the abundance and spatial distribution before and after the drawdown to identify any changes in distribution that occurred because of the drawdown and re-watering. 2) Evaluate four sampling techniques for collecting larvae lamprey during drawdown or similar dewatering event. The results of the study will likely be published/made available in 2019.	EWEB	Personal communication with Andy Talabere and Andrew Janos, EWEB (10/26/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	Project Passage Effectiveness					
85.	Monitor passage timing, number, and mortalities of juvenile lamprey collected at projects with juvenile fish bypass facilities	Bonneville, McNary, Lower Monumental, Little Goose, Lower Granite	Columbia and Snake	Monitoring is occurring at all of the identified projects. This is an ongoing action.	ACOE	Personal communication with Sean Tackley, ACOE (09/26/18) and Steve Juhnke, ACOE (9/26/18)
86.	Effectiveness of fish screens to protect lamprey ammocoetes: pilot testing of variable screen angles	No associated hydro project	Columbia and Snake	This project, via a series of laboratory-based experiments, specifically addresses the question of how the angle of a screen influences the safe and effective passage of juvenile lampreys. We compared entrainment rate, impingement rate, release location, and fate of juvenile lampreys exposed to two different screen angles (12 and 20 degrees) in a series of laboratory tests in a recirculating flume tank with a simulated bypass channel. The flume tank has been used during previous screen material testing. Testing was completed in spring of 2018 and we are currently summarizing the findings and working on a draft manuscript.	USGS, WDFW and Yakama Nation	Personal communication with Lisa Weiland, USGS (10/23/18)
87.	Juvenile Pacific Lamprey acoustic telemetry studies	No associated hydro project	Columbia	In the spring of 2017, PNNL conducted a pilot field study using the new lamprey/eel acoustic tag in the John Day Pool of the Columbia River. Autonomous receiver arrays were deployed in April and June and recorded tagged fish movements of 100 tagged juvenile lamprey released near RM 456. Fish were collected from the juvenile fish facilities at John Day Dam and McNary Dam. The lamprey ranged in length from 140 to 176 mm. Only two of the 100 tagged fish were not detected at any of the arrays and possibly moved upstream, experienced tag loss, or were lost to predation. At the first two detection arrays the same 98 tagged fish were detected, resulting in a detection probability of 100% at each of these arrays. Of the 98 fish detected at the first two	PNNL	Personal communication with Bob Mueller, PNNL (10/05/18) Pilot Field Trial of the Juvenile Lamprey/Eel Tag and RME Plan to Guide Future Juvenile Pacific Lamprey Acoustic Telemetry Studies. PNNL-27295 (Deng et al. 2018)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				arrays, 96 were detected at the last array. The two fish not detected at the last array were observed to move between the first and second array multiple times, which may indicate that they were preyed upon. Combining all detections from each of the arrays, the median number of total detections per tag was over 300. In addition the work included developing a Research, Monitoring, and Evaluation (RME) Plan to inform planning and prioritization for future juvenile Pacific Lamprey passage investigations in the Columbia River.		
	Predation					
88.	Establish predation control measures (pike minnows and birds)	All ACOE projects	Columbia	Ongoing implementation of predation control measures such as harassment, avian lines, avian colony management, and the pikeminnow bounty program, although planned for salmon, are also expected to benefit juvenile Pacific Lamprey. Efforts are being made to be sure to include concerns for lamprey and adequate monitoring of lamprey predation in future efforts.	BPA and ACOE	ACOE Pacific Lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009)
89.	Predation control measures and gut sampling	Rocky Reach, Rock Island	Columbia	As part of its HCP obligations, Chelan PUD implements predation control activities. Controlling predators of juvenile salmonids, both fish and birds, is a tool Chelan PUD has used to achieve HCP survival standards for juvenile fish. This is an ongoing activity.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/30/18)
90.	Predation control measures	Priest Rapids, Wanapum	Columbia	Grant PUD implements predation control measures (avian and aquatic) to protect outmigrating, anadromous salmonids as a requirement of Grant PUD's NOAA Biological Opinion (NOAA Fisheries 2004). These measures include use of lethal and non-lethal control and monitoring presence and absence of juvenile lamprey through dietary sub sampling. It would be expected that these predation control activities will indirectly benefit outmigrating juvenile lamprey throughout the project.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/02/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
91.	Predation potential of various native and non-native species to larval lamprey	No associated hydro project	Yakima	During the summer months (July-September) in 2016 and 2017, conventional hook and line methodology (earthworms, larval Western Brook Lamprey, and artificial baits) was used to assess the diversity of predator fishes in the Chandler Canal (Lower Yakima River). A total of 338 predator fishes were removed from Chandler Canal in 59.8 hours of angling. In total, five invasive species were captured during this study (number removed shown in parenthesis); 1) Smallmouth Bass (235 total), 2) Brown Bullhead (12 total), 3) Channel Catfish (9 total), 4) Common Carp (2 total) and 5) Bluegill Sunfish (1 total). One native species was captured during this study (number removed shown in parenthesis); Northern Pikeminnow (79 total). During the day time, the most commonly captured species was Smallmouth Bass, followed by Northern Pikeminnow. During a short period of night time fishing with earthworms in 2016, the most commonly caught species was Brown Bullhead, followed by Smallmouth Bass and Northern Pikeminnow. Live larval Western Brook Lamprey (90-100 mm) were attached to a hook, and captured predator fish were measured and enumerated by species. In 2016, Total Catch Per Unit Effort (CPUE, # of fish/hour) was highest for earthworms at 7.4 fish/hour, although larval lamprey was close behind (6.4 fish/hour) and artificial baits had the lowest CPUE (4.5 fish/hour). A Report from 2017 is currently available and a 2018 Report will be available in 2019.	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/07/18) Summary of Larval Lamprey Hook-and-Line Predator Fish Removal in Chandler Irrigation Diversion (Yakima River, Prosser, WA), 2017. BOR 2017 Annual Report: Appendix 3.5 (Beals 2018a)
	Policy/Recovery Activities					
92.	Develop/implement implementation plan for Pacific Lamprey restoration	All ACOE projects	Columbia and Snake	In May 2009, the Nez Perce, Umatilla, Yakama and Warm Springs tribes ("tribes") developed a Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin. A final draft of the Plan was completed in December 2011.	Nez Perce, Umatilla, Yakama and Warm Springs tribes	Tribal Pacific Lamprey Restoration plan for the Columbia River Basin (Nez Perce, Umatilla,

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				The tribes propose the plan for restoration of the species to numbers adequate for tribal use and ecological health of the region. Activities to support the objectives identified in the plan are ongoing.		Yakama, and Warm Springs Tribes 2011)
93.	Develop/implement Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research	No associated hydro project	Columbia (Mid and Upper)	This Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research is a phased approach, emphasizing adaptive management, with the goal of making progress towards the supplementation, artificial propagation, and aquaculture research goals and biological objectives identified in the Tribal Pacific Lamprey Restoration Plan (TPLRP) (CRITFC 2011), Lamprey Conservation Agreement (USFWS 2012), the Framework for Pacific Lamprey Supplementation research in the Columbia River Basin (CRITFC 2014), subbasin plans, and the Columbia Basin Fish Accords within a feasible, cost effective, and biological conservative manner. The Master Plan intends to continue utilizing adult translocation as well as the structured, strategic, and phased release of artificially reared Pacific Lamprey to reintroduce, augment, and/or supplement Pacific Lamprey within select Columbia River Basin subbasins to achieve the stated, long-term goals identified in various lamprey planning documents and restoration efforts. A draft plan was shared with co-managing agencies and partners and the final draft was submitted in spring of 2018.	HDR Engineering, Inc. (HDR), CRITFC, Yakama Nation, and CTUIR	Personal communication with Ralph Lampman, Yakama Nation (11/07/18) Master Plan: Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research (CRITFC, Umatilla, Yakama, and Nez Perce Tribes 2018)
94.	Implement Pacific Lamprey restoration plan	All ACOE projects	Columbia and Snake	In May 2009, the Nez Perce, Umatilla, Yakama and Warm Springs tribes ("tribes") developed a Tribal Pacific Lamprey Restoration Plan (TPLRP) for the Columbia River Basin. A final draft of the Plan was completed in December 2011. The tribes propose the plan for restoration of the species to numbers adequate for tribal use and ecological health of the region. Activities to support the objectives identified in the plan were implemented in 2013 (see other categories in Table 5).	ACOE	ACOE Pacific Lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009; revised 2014)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				ACOE and the partnering Tribes agreed in 2013 that it would be useful to draft this revised implementation plan based on actions completed and lessons learned from 2008-2013. The revised plan was issued in December 2014. Implementation of actions identified in the plan are ongoing.		
95.	Develop/implement management plan for Pacific Lamprey restoration	Wells	Columbia	In 2010, a Pacific Lamprey Management Plan (PLMP) was filed as part of the Wells Hydroelectric Project FERC License Application. In addition to fishway evaluations and activities to improve adult lamprey passage and juvenile passage and survival (when technology exists), management plan activities also include implementation of adult fishway and juvenile bypass operations criteria at the Project, regional data sharing, protocol development, and participation in regional conservation and recovery activities. Implementation of some management plan activities is ongoing.	Douglas PUD	Wells Pacific Lamprey Management Plan (Douglas PUD 2009)
96.	Develop/implement management plan for Pacific Lamprey passage monitoring and improvement	Rocky Reach	Columbia	On-going implementation of the PLMP that was developed and finalized in 2005. In addition to fishway evaluations and activities to improve adult lamprey passage and juvenile passage and survival (when technology exists), management plan activities also include implementation of adult fishway and juvenile bypass operations criteria at the Project, regional data sharing and protocol development, and participation in regional conservation and recovery activities.	Chelan PUD	Rocky Reach Pacific Lamprey Management Plan (Chelan PUD 2005)
97.	Develop/implement management plan for Pacific Lamprey restoration	Priest Rapids, Wanapum	Columbia	On-going implementation of the PLMP that was developed, finalized, and approved by the PRFF, Ecology, and FERC in 2009.	Grant PUD	Priest Rapids PLMP (Grant PUD 2009)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				In addition to fishway evaluations and activities to improve adult lamprey passage and juvenile passage and survival (when technology exists), management plan activities also include, regional data sharing, protocol development, and participation in regional conservation and recovery activities.		
98.	Lamprey Technical Work Group • Passage Engineering Subgroup • Juvenile Entrainment and Dredging Investigations Subgroup • Restoration Subgroup • Genetics/eDNA Subgroup • Tagging Subgroup • Critical Uncertainties Subgroup	All ACOE projects, Wells, Rocky Reach, Rock Island, Priest Rapids	Columbia and Snake	The Columbia River Basin Lamprey Technical Work Group (CRBLTWG) is a committee of the Pacific Lamprey Conservation Agreement. The purpose of the CRBLTWG is to provide technical review, guidance, and recommendations for activities related to lamprey conservation and restoration. The CRBLTWG accomplishes this by: 1) identifying and prioritizing critical uncertainties regarding lamprey conservation; 2) providing a forum for discussion regarding lamprey-related concerns; and 3) developing best management practices regarding issues affecting lamprey; and 4) disseminating technical information. The Passage Engineering subgroup published the following paper in 2017. Pacific Lamprey Technical Workgroup. 2017. Practical guidelines for incorporating adult Pacific lamprey passage at fishways. June 2017. White Paper. 47 pp + Appendix. Available online: https://www.fws.gov/pacificlamprey/mainpage.cfm The CRBLTWG met on 12-6 and 4-24 in 2018. The CRBLTWG hosted the 1st Annual Lamprey Information Exchange Workshop in Portland on Dec 6-7. There were four focal sessions covering eDNA, alternative passage fixes, artificial propagation and translocation/genetics. Planning is underway for the 2nd Annual Workshop Dec 12-13 in Portland. Topics for this year's focal sessions are temperature/climate change, dredging, life history/behavior, and the ocean.	USFWS	Personal communication with Christina Wang, USFWS (11/13/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				The newly formed Restoration subgroup successfully applied to have a lamprey session at the River Restoration Northwest Annual Symposium in Feb 2019.		
99.	Pacific Lamprey Conservation Initiative	All ACOE projects	Columbia and Snake	Pacific Lamprey Conservation Agreement partners hosted the Policy Committee 5-Year Review on Dec 5th in Portland. At the Review, signatories re-committed to the Conservation Agreement for 5 more years. Regional Management Unit (RMU) leads revised the Pacific Lamprey Assessment in 2018. Findings were presented at the 5-Year Review in December. RMUs continued to work on Regional Implementation Plans (RIPs) for all RMUs in the Columbia and Snake rivers including the mainstem Columbia and Snake. The Pacific Lamprey Conservation Initiative Columbia Basin Projects umbrella project was developed and approved by the Northwest Power and Conservation Council (NPCC) in 2018. Funds from BPA's Cost Savings Program funded $250K in high priority lamprey projects from the RIPs. The Initiative/Pacific Lamprey Fish Habitat Partnership received National Fish Habitat Partnership coordination funds in fiscal year (FY) 18. Those funds will be put towards on the ground restoration projects to be implemented in FY19. FY19 RIPs were presented to the Conservation Team on August 22, 2018. Projects were prioritized for FY19 BPA Cost Savings and National Fish Habitat Partnership (NFHP) funding.	USFWS	Personal communication with Christina Wang, USFWS (11/13/18)
100.	Pacific Lamprey outreach	No associated hydro project	Yakama Nation	The Yakama Nation Fisheries Resource Management Program Pacific Lamprey Project (YN PLP) has a duty	Yakama Nation	Personal communication

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				to educate the public about Pacific Lamprey. The team members give presentations about the life cycle, history, cultural significance, medicinal uses of lamprey, and the problems they face. At release events, the visitor is able to hold a lamprey and release it into the river. Numerous outreach events were held through community events and hatchery tours throughout the year. Fishery events, the Treaty Day Parade, the Backpack Give Away, adult release events (such as the World Fish Migration Day), news media, and social media were opportunities to expose large numbers of people to the importance of Pacific Lamprey. Over 2,300 students, 233 teachers, 1,544 agency workers, and 102,575 people from the general public, totaling 106,652 people have been introduced to the Pacific Lamprey through these collection of events, newspapers, e-magazines, and social media. A Report from 2017 is currently available and a 2018 Report will be available in 2019.		with Ralph Lampman, Yakama Nation (11/07/18) Yakama Nation Pacific Lamprey Project Outreach and Education, 2017. BPA 2017 Annual Report Appendix E1. (Lampman 2018g)
101.	Review of legal protections and recovery actions	No associated hydro projects	Columbia	An article was published in the Idaho Law Review, titled "An ecological, cultural and legal review of Pacific Lamprey in the Columbia River Basin." Pacific Lamprey (*Entosphenus tridentatus*) is an anadromous species in an ancient lineage of jawless fishes. The species is native to the North Pacific and its marine-accessible freshwater rivers and streams. Pacific Lamprey are understudied relative to other anadromous fishes and has severely declined in abundance throughout the Columbia River Basin. Indigenous people of the Snake and Columbia River Basins have long recognized the ecological role and value of lamprey through their spiritual and cultural practices connected to Pacific Lamprey. The combined effects of poor passage at dams, historic and continued habitat degradation, and altered marine host conditions have contributed to the observed decline in abundance and distribution. The unique characteristics and	University of Idaho	An Ecological, Cultural, and Legal Review of Pacific Lamprey in the Columbia River Basin (Wicks-Arshack et al. 2018)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				management history have placed Pacific Lamprey in a legal and cultural grey area and provide a useful foil to Pacific salmon in considering protections for migratory fish. Here we provide a review of legal protections and recovery actions throughout the Columbia River Basin, including an analysis of the Fish and Wildlife Service's 2004 denial of a petition to list Pacific Lamprey under the Endangered Species Act. The current patchwork of measures fails to provide integrated protections across the life history of the species. This stems from a complex lifecycle spanning dozens of local, state, tribal, federal, and international jurisdictions as well as a cultural legacy of lamprey being considered "trash fish" by western society and early fishery managers. However, recent shifts in perceptions about the ecological value of the species and increased co-management of anadromous species within the Columbia River Basin have elevated the species as a management priority. Continued efforts to conserve and recover Pacific Lamprey pose a complex and honorable challenge for fisheries managers within the Columbia River Basin.		

ACOE = Army Corps of Engineers
AWS = auxiliary water supply
BOR = U.S. Bureau of Reclamation
BPA = Bonneville Power Administration
CI = Confidence interval
CPUE = Catch per unit effort
CRBLTWG = Columbia River Basin Lamprey Technical Work Group
CRITFC = Columbia River Inter-Tribal Fish Commission
CTGR= Confederated Tribes of Grand Ronde
CTUIR = Confederated Tribes of the Umatilla Indian Reservation
CTWS = Confederated Tribes of the Warm Springs
DIDSON = Dual-frequency Identification Sonar
eBLIMP = eDNA Basin-wide Lamprey Inventory and Monitoring
EWEB = Eugene Water and Electric Board
FCRPS = Federal Columbia River Power System
FDX = full-duplex
FERC = Federal Energy Regulatory Commission
FPC = Fish Passage Center
FY = Fiscal year
GRTS = Generalized Random Tesselation Stratified
HCP = Habitat Conservation Plan
HDX = half-duplex
LPES = Lamprey Passage Entrance Structure
LPS = lamprey passage system/structure
MCMC = Markov Chain Monte Carlo
MSRF = Methow Salmon Recovery Foundation
MUWS = make-up water supply
N/A = not applicable
NDE = North Downstream Entrance
NFHP = National Fish Habitat Program

NOAA = National Oceanic and Atmospheric Administration
NPCC = Northwest Power and Conservation Council
NUE = North upstream entrance
NWFSC = Northwest Fisheries Science Center
OSU = Oregon State University
PGE = Portland General Electric
PIT = passive integrated transponder
PTAGIS = PIT Tag Information System
PLMP = Pacific Lamprey Management Plan
PNNL = Pacific Northwest National Laboratory, Battelle
PRFF = Priest Rapids Fish Forum
PUD = Public Utility District
RIP = Regional Implementation Plan
RM = river mile
RME = Research, monitoring, evaluation
SDE = South Downstream Entrance
SOA = Statement of Agreement
SOP = Standard Operating Procedure
SUE = South Upstream Entrance
TPLRP = Tribal Pacific Lamprey Restoration Plan
UMT = Upstream Migration Tunnel
USFS = U.S. Forest Service
USFWS = U.S. Fish and Wildlife Service
USGS = U.S. Geological Survey
VWW = vertical wetted wall
WFUFP = Wanapum Future Unit Fish Bypass
WSLS = West-side Lamprey Structure
YNPLP = Yakama Nation Pacific Lamprey Project

3.0 Status of Pacific Lamprey Activities at the Priest Rapids Project

Pursuant to the requirements of Grant PUD's PLMP (Grant PUD 2009) and specifically for this comprehensive annual report (as described in Section 1.2 above), activities at the Project related to Pacific Lamprey are described in Table 6. The information is organized by the protection, mitigation and enhancement (PM&E) measures for each of the four objectives set forth in the Project's PLMP. Included for each PM&E is the timeframe for implementation/completion of the measure, the action taken by Grant PUD in 2018, and any variations in schedule. In general, measures are currently on or ahead of schedule.

Table 6 Schedule and status of Pacific Lamprey Management Plan implementation measures at the Priest Rapids Project.

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2018	Variation from Schedule (if applicable)
Objective 1: Identify, address, and fully mitigate Project effects to the extent reasonable and feasible to achieve No Net Impact (NNI)					
1.	Provide an annual report summarizing activities undertaken to identify and address Project impacts.	Annually (by March 31), starting 2010	Yes	Yes, report will be filed on or before March 31, 2019.	No
Objective 2: Provide safe, effective, and timely volitional passage for adult upstream and downstream migration					
2.	Maintain adult fishways.	Annually for the period 2009-2018	Yes	Grant PUD continues to maintain fishways at the Project in accordance with the National Oceanic and Atmospheric Administration (NOAA) Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for dewatering and the collection of all fish.	No
3.	Develop adult Pacific Lamprey passage criteria.	To be determined by the Priest Rapids Fish Forum (PRFF) Annual passage detection monitoring initiated in July 2010 – 2018	Yes	Grant PUD installed half-duplex passive integrated transponder (HDX-PIT) tag arrays in the fish ladders at Wanapum and Priest Rapids dams to measure adult Pacific Lamprey passage. Passage metrics will be determined when a sufficient sample size has been achieved. Presently, Grant PUD has tracked a total of 615 unique PIT tags at Priest Rapids and 620 at Wanapum since 2010. Fish passage efficiency (FPE) and passage times were calculated and are included in Section 1.2.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2018	Variation from Schedule (if applicable)
4.	Continue to operate and maintain fish count systems at the Project (upgrade count systems as new technology becomes available).	Annually for the period 2009-2018	Yes	Grant PUD maintains video stations at the Project to count fish in accordance with the Pacific Lamprey Management Plan (PLMP), NOAA Fisheries Biological Opinion and agreements included in the Federal Energy Regulatory Commission (FERC) License. Newly designed and fabricated fish crowder facilities were installed and operated at both Priest Rapids and Wanapum dams prior to April 2010. Fish counts are for all species including adult lamprey are expected to be extremely accurate and are available at www.gcpud.org for review.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2018	Variation from Schedule (if applicable)
5.	Develop and implement a comprehensive evaluation of adult lamprey passage at the Project.	Develop / implement: Within one year of license issuance (2009)	Yes	This annual report includes a comprehensive evaluation on adult lamprey passage in the Project area by addressing each measure in the PLMP. PRFF members conducted an on-site inspection of the Priest Rapids and Wanapum left bank fishway facilities during the 2015-2016 winter fish ladder maintenance outage.	No
		Determination of whether proposed modifications improve adult passage: Within four years of license issuance (2012)	Yes	Grant PUD implemented components of a comprehensive adult passage evaluation study plan, titled "Assessment of Pacific Lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams" (Nass et al. 2009). The goal of the evaluation was to collect data in support of determining whether the modifications improved adult passage. The assessment of plating and count station use in 2010 documented the effective use of these structures by migrating lamprey. FPE and passage times are being calculated for statistical comparisons. Data analyses have been conducted annually since 2010 and are ongoing.	No
6.	Implement improvements to the junction pool and the diffusion gratings at the Priest Rapids Dam as identified in the FLA.	Within two years of license issuance (2010)	No	None. Grant PUD completed improvements proposed in the Final License Application (FLA) and included in the FERC License in 2010.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2018	Variation from Schedule (if applicable)
7.	Implement an evaluation program to assess the effectiveness of fishway modifications on adult lamprey.	Within one year of completion of fishway modifications at Priest Rapids Dam (2011)	Yes	Grant PUD implemented an evaluation program in coordination with the PRFF to determine and assess the effectiveness of fish ladder modifications. HDX-PIT system were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific Lamprey tagged at lower river facilities were passively monitored at Priest Rapids Project facilities as directed by the PRFF. The assessment of plating and count station use in 2010 documented the effective use of these structures by migrating lamprey. FPE and passage times are being calculated for statistical comparisons. Fishway passage efficiency ranged from 62.3 to 100.0% with a standard error range of 2 to 12% at Priest Rapids Dam over the 2010-2017 period and ranged from 44.4 to 100.0% with a standard error range of 2 to 35% at Wanapum Dam over the 2010-2013, and 2015-2017 periods (2014 intentionally omitted).	Yes, ahead of schedule. An evaluation program was implemented in 2010 and was continued in 2018.
8.	Implement all modifications identified for adult fishways at the Project as identified in the FLA or as amended by the PRFF.	Within seven years of license issuance (2015)	Yes	Grant PUD has implemented improvements proposed in the FLA and included in the FERC License (see #6 above). Grant PUD will consider additional modifications based on the evaluation of the effectiveness of fishway modifications.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2018	Variation from Schedule (if applicable)
9.	Begin investigation of the efficacy and advisability of reducing fishway flows at night during peak lamprey migration periods.	Following implementation and evaluation of identified fishway modifications	No	Grant PUD began to investigate the efficacy and advisability of reducing fishway flows at night and had incorporated this objective into the 2010 study plan. However, after consideration by the PRFF and NOAA Fisheries, this objective of the study plan was determined to be considered following evaluations of existing fishway modifications (see PRFF meeting minutes for May 5, 2010) if needed in the future.	No
10.	Complete a biological objectives status report for Washington Department of Ecology (WDOE) 401 water quality certification.	Every 5th year of the license term (Aug. 2013, 2018, 2023, etc.)	Yes	Biological objectives status report update for 2017 was included in the 2017 report filed in March 2018.	No
11.	Conduct a monitoring and evaluation study of adult Pacific Lamprey passage at Project; if based on the 10-year status report, WDOE concludes that a Pacific Lamprey Biological Objective has not been met; Grant PUD shall continue to implement the Adaptive Management process.	Every 10th year of the license term (2018, 2028, 2038, 2048, 2058) or as recommended by the PRFF	No	Grant PUD and the PRFF have been conducting monitoring and evaluation studies for the past ten years through HDX PIT detection at both Priest Rapids and Wanapum dams. These results were summarized in the Biological Objectives Status Report Update for 2017 and was included in the 2017 report filed in March 2018.	Yes
12.	Participate in regional studies, forums and measures and cooperate with other entities performing those activities when useful information may be obtained about Project impacts on adult Pacific Lamprey. Forums will include (but not limited to) the Columbia River Basin Lamprey Technical Work Group (CRBLTWG).	Annually for the life of the license	Yes	Grant PUD currently participates in regional forums such as the Columbia River Basin Pacific Lamprey Technical Workgroup, the Lamprey Conservation Initiative (USFWS), and the Tribal Restoration Plan activities (CRITFC). Refer to Section 2.2 for specific activities.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2018	Variation from Schedule (if applicable)
13.	Continue to operate and maintain the adult PIT-tag detection system [full-duplex (FDX)] at the Priest Rapids Dam fishway.	Annually for the life of the license	Yes	Grant PUD continues to maintain the adult PIT-tag detection system (FDX) at Priest Rapids Dam.	No
Objective 3: Provide safe, effective and timely volitional passage for juvenile migration					
14.	Identify and mitigate for Project effects on juvenile Pacific Lamprey	No later than 10 years following license issuance (2018)	Yes	Currently, options for measuring Project effects on juvenile Pacific Lamprey are under consideration by the PRFF. At this time, the tested methodology is not available to measure juvenile Pacific Lamprey passage.	No
15.	Develop juvenile Pacific Lamprey passage criteria	No later than 10 years following license issuance (2018)	Yes	None. At this time, the tested methodology is not available to measure juvenile Pacific Lamprey passage.	No
16.	Participate in regional studies, forums and measures and cooperate with other entities performing those activities when useful information may be obtained about Project impacts on juvenile Pacific Lamprey. Forums will include (but not limited to) the CRBLTWG.	Annually for the life of the license	Yes	Grant PUD currently participates in regional forums such as the Columbia River Basin Pacific Lamprey Technical Workgroup, the Lamprey Conservation Initiative (USFWS), and the Tribal Restoration Plan activities (CRITFC). Refer to Section 2.2 for specific activities.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2018	Variation from Schedule (if applicable)
Objective 4: Avoid and mitigate Project impacts on rearing habitat					
17.	Determine juvenile lamprey presence / absence, habitat use, and relative abundance in the Project area. If significant ongoing effects are identified, Grant PUD shall develop a plan and implement reasonable and feasible measures to address such effects.	No later than 10 years following license issuance (2018)	Yes	Grant PUD implemented a PRFF approved study plan to determine juvenile lamprey presence / absence, habitat use, and relative abundance in the Project area in 2012 and 2013. Additional sampling was completed in the Wanapum Reservoir in 2014, although the reservoir elevations were well below normal operations due to the fracture in the Wanapum Dam spillway. Only a few lamprey were captured or observed during these surveys. Given three years of sampling at varying reservoir elevations (2012-2014) have indicated that juvenile lamprey do not commonly occur within the Project operational zone, no additional assessments were conducted in 2015. A report addressing results from 2012-2013 was included as Appendix B in the 2016 annual report (Le et al. 2017).	No

Notes:

CRBLTWG = Columbia River Basin Lamprey Technical Work Group
CRITFC = Columbia River Inter-Tribal Fish Commission
FDX = Full Duplex
FERC = Federal Energy Regulatory Commission
FLA = Final License Application
FPE = Fish Passage Efficiency
NNI = No Net Impact
NOAA = National Oceanic and Atmospheric Administration
HDX-PIT = Half-Duplex Passive Integrated Transponder
PLMP = Pacific Lamprey Management Plan
PRFF = Priest Rapids Fish Forum
PUD = Public Utility District
USFWS = U.S. Fish and Wildlife Services
WDOE = Washington Department of Ecology

4.0 Evaluation of Activities in the Columbia River Basin Relative to the Priest Rapids Project

This section provides a comprehensive assessment of activities occurring in the Columbia River Basin and their applicability to the Project. Table 7 is designed to meet the requirement of the comprehensive annual report (described in Section 1.2 above) to determine whether measures being investigated and/or implemented in the Columbia River Basin are: (i) consistent with similar measures taken at other projects; (ii) appropriate to implement at the Project; and (iii) cost effective to implement at the Project.

For purposes of this evaluation, the definitions used for the three stated elements above are as follows:

1). "Consistent with similar measures taken at other projects" is "Yes" for an activity that has been implemented by a hydroelectric facility operator in a hydroelectric project area other than Grant PUD's Priest Rapids Project.
2). "Appropriate to implement at the Priest Rapids Project" is "Yes" for an activity that is a requirement of Grant PUD's PLMP (Grant PUD 2009) or is an activity subsequently agreed to by Grant PUD as a result of implementation of the PLMP.
3). "Cost-effective to implement at the Priest Rapids Project" is "Yes" for an activity where resource benefits are commensurate with the level of effort and cost to implement, and in a manner not inconsistent with anadromous fish passage criteria and habitat requirements. If a measure is "appropriate to implement", then it is also considered cost effective and the specific action being taken by Grant PUD is described. If a measure is not "appropriate to implement," then cost effectiveness is considered not applicable.

The activities identified in the table include both those that have been implemented (as identified and described in Table 5 of Section 2.2: Updated Information above), or planned or proposed pursuant to an existing and approved implementation, restoration, or management plan of another utility, the ACOE, or tribal entities. As such, for each activity, details include the project(s) where the activity has been implemented, planned or proposed, river of each project, and in the case of implemented items, a cross reference to Table 5. For planned or proposed efforts (which are not identified as current activities in Table 5) the source of the information is noted at the end of Table 7.

Table 7 Pacific Lamprey activities in the Columbia River basin and applicability to the Priest Rapids Project.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
General Biology, Ecology, and Population Status							
1.	Identify spawning areas or determine the extent of adult spawning	Bureau of Reclamation (BOR) projects in Yakima (I) No associated hydro projects (I)	Yakima Entiat	#3 #13	No	No. This activity is not required by Grant PUD's Pacific Lamprey Management Plan (PLMP). Radio-telemetry studies conducted in 2001-2002 did not show use of any tributaries in the Priest Rapids Project Area (PRPA) (Nass et al. 2003)	N/A
2.	Develop measures to protect spawning habitat	Wells (P) Rocky Reach (P)	Columbia Columbia	N/A[2] N/A[3]	No	No. This activity is not required by Grant PUD's PLMP.	N/A
3.	Monitor adult population status and trends (unrelated to counting at hydroelectric projects)	BOR projects in Yakima (I) Willamette Falls (I) No associated hydro projects (I)	Yakima Willamette Fifteenmile Creek Deschutes, and tributaries Hood Umatilla N/A (NE Pacific ocean)	#3 #4 #1 #2 #12 #16 #28	No	No. This activity is not required by Grant PUD's PLMP.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
4.	Determine the extent of juvenile rearing habitat	No associated hydro projects (I)	Fifteenmile Creek Deschutes and tributaries Willamette	#1 #2 #15	Yes	Yes. PLMP Objective 4 requires quantification of lamprey habitat in the Project area.	Yes. Stratified sampling habitat surveys were implemented in 2012, 2013, and again in 2014 (under abnormally low reservoir elevations) to detect presence/absence of juvenile lamprey within the Project operational zone. Required to be conducted within the PRPA within 10 years of license issuance. This activity has been completed.
5.	Develop measures to protect juvenile rearing habitat	Leaburg-Walterville (I) No associated hydro project (I) Wells (P) Rocky Reach (P)	McKenzie Fifteenmile Creek Columbia, Snake Columbia Columbia	#8 #1 #34 N/A[2] N/A[3]	No	No. This activity is not required by Grant PUD's PLMP.	N/A
6.	Monitor juvenile population status and trends (unrelated to counting at hydroelectric projects)	No associated hydro projects (I)	Deschutes and other tributaries Willamette Columbia Hood	#2 #6 #7 #12	No	Yes. PLMP Objective 4 requires the assessment of juvenile presence / absence and relative abundance.	Yes. Stratified sampling habitat surveys were implemented in 2012 to detect presence/absence in the Project operational zone. Required to be conducted within the PRPA within 10 years of license issuance.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
			Methow (Chewuch) Yakima, Wenatchee, Entiat, Methow, White Salmon, and Klickitat Chehalis Wenatchee, Okanogan Columbia, Snake Wenatchee, Icicle Creek Yakima, Wenatchee	#21 #23 #24 #25 #26 #27 #32			
7.	Evaluate lamprey physiology, energy use, swimming performance, and behavior	No associated hydro project (I) No associated hydro project (P)	Umatilla N/A	#10 #11	No	No. This activity is not required by the PLMP. Evaluating lamprey physiology, energy use, and swimming performance are not objectives, goals, or measures outlined in the PLMP.	N/A
8.	Evaluate, implement and/or monitor	Priest Rapids Dam (I)	Columbia	#18	Yes	No. This activity is not required by Grant PUD's	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
	translocation, supplementation, and artificial propagation programs	No associated hydro projects (I)	N/A Willamette Umatilla Yakima Wenatchee Methow Okanogan Columbia (Mid and Upper)	#14 #15 #16 #17, 35 #17, 35 #17, 35 #19 #93		PLMP. However, trap and transport is being implemented by the PRFF as a measure in fulfillment of an ongoing conceptual No Net Impact (NNI) agreement. Grant PUD successfully trapped and transported 851 adult Pacific Lamprey above Rock Island Dam during 2018 as a result of fish trapping and translocation for Grant PUD, Douglas PUD, and the Confederated Colville Tribe.	
9.	Evaluate the need for a lamprey aquaculture facility based upon a limiting factor analysis	No associated hydro project (I)	Columbia (Mid and Upper)	#93	No	No. This activity is not required by the PLMP. However, lamprey aquaculture is being evaluated by the PRFF as a potential implementation measure in fulfillment of an ongoing conceptual NNI agreement.	N/A
10.	Develop and test new technologies / methodologies / protocols for lamprey	Willamette Falls (I) No associated hydro projects (I) N/A (I)	Willamette Willamette N/A	#5 #6 #14	No	No. This activity is not required by the PLMP. Developing technologies for sampling juvenile lamprey in deep water are not objectives, goals, or measures outlined in the PLMP. However, Grant	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
						PUD will determine juvenile lamprey presence / absence, habitat use, and relative abundance in the Project area, in coordination with the PRFF no later than 10 years following license issuance.	
11.	Use of eDNA to monitor lamprey population status	No associated hydro project (I)	Multiple watersheds Methow (Chewuch River) Yakima, Wenatchee, Entiat, Methow, White Salmon, Klickitat Chehalis Wenatchee and Okanogan Columbia and Snake	#20, #22 #21 #23 #24 #25 #26	No	No. This activity is not required by the PLMP. Monitoring lamprey population numbers through use of eDNA are not objectives, goals, or measures outlined in the PLMP. However, Grant PUD does provide accurate 24/7 adult Pacific lamprey fish count numbers at www.grantpud.org for interested parties to review.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
			Wenatchee, Icicle Creek	#27			
12.	Determine genetic structure and maintain genetic integrity	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No	No. This activity is not required by the PLMP. Determining genetic structure and maintaining genetic integrity are not objectives, goals, or measures outlined in the PLMP.	N/A
13.	Determine water quality impacts of hydropower projects on lamprey and implement actions to mitigate these impacts	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No	No. This activity is not required by the PLMP. Grant PUD monitors and maintains water quality in compliance with freshwater designated uses and criteria for the Project as required by the WDOE 401 Certification; therefore, no further actions are required.	N/A
14.	Restore tributary habitat and passage	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No	No. This activity is not required by the PLMP. Radio-telemetry studies conducted in 2001-2002 did not show use of any tributaries in the PRPA (Nass et al. 2003).	N/A
Lamprey Migration in Rivers							
15.	Evaluate adult migration in rivers and reservoirs	Priest Rapids and Wanapum (I) No associated hydro project (I)	Columbia N/A	#67 #9	Yes	Yes. The PLMP does not include a specific protection, mitigation and enhancement (PM&E) measure related to this	Yes. Monitoring of lamprey through the Project reservoirs was conducted using HDX-PIT tags in 2010 through

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
			Warm Springs	#36		activity; however, Grant PUD has committed to collect and evaluate data on the passage of adult lamprey through the Project reservoirs as part of a telemetry evaluation (Objective 2). Grant PUD conducted this activity as part of its 2001-2002 radio-telemetry studies on adult lamprey (Nass et al. 2003).	2018 for fish detected at both Priest Rapids and Wanapum dams. Where detection systems are present at upstream projects, the additional data will be evaluated during future adult Pacific Lamprey fishway evaluations. Also in 2016, Grant PUD tagged and released 100 adult lamprey with both acoustic tags (Vemco V7) and full-duplex (FDX)-PIT tags. An array of fixed acoustic receivers deployed throughout the Project area was used to monitor the tagged fish after release. This evaluation will help determine and inform trends in reservoir and upstream tributary passage.
16.	Assess impacts of irrigation water withdrawal structures on juvenile passage/habitat	No associated hydro project (I)	Yakima, Wenatchee	#32	No	No. This activity is not required by the PLMP. Assessing the impacts of irrigation water withdrawal are not objectives, goals, or measures outlined in the PLMP.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
17.	Assess juvenile lamprey outmigration	Sunnyside, Wapato, Chandler diversion dams (I) No associated hydro project (I)	Yakima Umatilla Yakima, Wenatchee	#33 #31 #32	No	No. This activity is not required by the PLMP. Assessing the impacts of irrigation water withdrawal are not objectives, goals, or measures outlined in the PLMP.	N/A
Adult Passage at Hydroelectric Facilities							
Structural and Operational Fishway Modifications							
18.	Inspect / inventory / document / assess structural improvements for fishway	All ACOE projects (I) Priest Rapids and Wanapum (I) Prosser, Sunnyside, Wapato, Horn Rapids dams (I) Bonneville (I) Wells (P)	Columbia and Snake Columbia Yakima Columbia Columbia	#38 #39 #40 #59 N/A[2]	Yes	Yes. PLMP Objectives 1 and 2 specifically identify methods and reporting requirements for assessing and improving passage conditions for adult lamprey. These activities are a continuation of efforts started in 2001.	Yes. Grant PUD implemented an evaluation program in coordination with the PRFF to determine and assess the effectiveness of fish ladder modifications. HDX-PIT system were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific Lamprey tagged at lower river facilities were passively monitored at Project facilities as directed by the PRFF. The assessment of plating and count station use in 2010 documented the effective use of these structures by migrating lamprey. Fish passage efficiency (FPE)

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
							and passage times are being calculated. Following the 2016 migration period, the 2010-2016 cumulative passage dataset have been empirically and statistically evaluated. Results were presented to the PRFF for review in spring 2017 and included in the following annual report.
19.	Conduct a literature review of upstream passage improvements	Rocky Reach (I) Priest Rapids and Wanapum (I) Wells (P)	Columbia Columbia Columbia	#96 #97 N/A[2]	Yes	Yes. PLMP Objective 1 requires compilation of measures taken in the Columbia River basin and an assessment of their applicability to the Project.	Yes. This activity is documented in this PLMP Comprehensive Annual Report (see Section 2.2: Updated Information).
20.	Design / install / evaluate lamprey passage system (LPS) and entrance structures	Prosser, Sunnyside, Wapato, Horn Rapids dams (I) McNary (I) Carmen Smith (Trail Bridge Dam) (I) Bonneville (I) John Day (I)	Yakima Columbia McKenzie Columbia Columbia	#40 #41 #48 #59, 60 #60	Yes	No. The LPS has been evaluated with respect to application in the Project (2001-2002 radio-telemetry study; Nass et al. 2003) and determined that because there are no areas where lamprey concentrate at either facility, this method would not be appropriate to implement.	N/A
21.	Install / evaluate / operate slotted	Priest Rapids and Wanapum (I)	Columbia	#42	Yes	Yes. Keyhole entrances are currently utilized at both	Yes. See adjacent response.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
	"keyhole" fishway entrances	John Day (P)	Columbia	N/A[5]		Wanapum and Priest Rapids dams.	
22.	Develop / implement / evaluate ladder dewatering procedures	No associated hydro project (I) All ACOE projects[6] (I) Wells (I) Rocky Reach (I) Priest Rapids and Wanapum (I)	Yakima, Wenatchee Columbia, and Snake Columbia Columbia Columbia	#32 #43 #44 #45 #46	Yes	Yes. Dewatering procedures exist at the Project and were identified in the PLMP.	Yes. Grant PUD operates its fishways according to the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for dewatering and the recovery of all fish.
23.	Rehabilitate and/or operate old or existing fishway for lamprey passage	Willamette Falls (I)	Willamette	#47	No	Yes. Subsequent to fishway modifications completed in 2009-2010 outage at Priest Rapids and Wanapum dams, Grant PUD and the PRFF will continue to assess the applicability, feasibility, and appropriateness of other potential modifications.	Yes, as determined appropriate by Grant PUD and the PRFF.
24.	Reduce/evaluate ladder entrance flow velocities at night	Bonneville and The Dalles (I) McNary (I) Priest Rapids (P)	Columbia Columbia Columbia	#49 #50 N/A[7]	Yes	Yes. PLMP Objective 2 requires that Grant PUD and the PRFF evaluate the efficacy of reducing fishway flows at night.	Yes. Grant PUD developed a PRFF-approved comprehensive study plan to evaluate improvements and modifications to the fish ladders at Priest Rapids and Wanapum dams in 2010.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
							Grant PUD began to investigate the efficacy and advisability of reducing fishway flows at night and had incorporated this objective into the 2010 study plan. However, after consideration by the PRFF and NOAA Fisheries, this objective of the study plan was considered to be unnecessary (see PRFF meeting minutes for May 5, 2010).
25.	Lift picket leads at count station	Bonneville (I) The Dalles (I) John Day (I) McNary (I) Ice Harbor (I) Lower Monumental (I) Little Goose (I) Lower Granite (I)	Columbia Columbia Columbia Columbia Snake Snake Snake Snake	#51 #52 #53 #54 #54 #54 #54 #54	No	Picketed leads at count stations at Priest Rapids and Wanapum dams were specifically designed (11/16" gap size) to preclude passage through the leads and force fish through the count station resulting in 100% count accuracy.	N/A
26.	Develop and/or maintain fishway operations criteria	Rock Island (I) Priest Rapids and Wanapum (I)	Columbia Columbia	#55 #56	Yes	Yes. PLMP Objective 2 requires Grant PUD to maintain its fishways in a manner that is consistent with the NOAA Fisheries	Yes. Specific operations criteria are presented in Grant PUD's Project Adult Fishways Operational Plan (Grant PUD 2008).

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
		Wells (I) Rocky Reach (I)	Columbia Columbia	#95 #96		Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). In 2011, Grant PUD implemented a Standard Operating Procedure (SOP) for operation of the Off-ladder Adult Fish Trap (OLAFT) vertical orifice gate to remain open when the OLAFT is not operating.	
27.	Address issues with diffuser gratings and picket leads, e.g., replace gratings with material of ¾-inch spacing (and replace other related structures: e.g., trash rack cleaning system and grating support system)	Other ACOE projects (exact one unspecified) (P) Wells (P)	Columbia, Snake Columbia	N/A[5] N/A[2]	No	No. These issues have not been identified in the Project fishways. Members of the PRFF toured the fish ladders at Priest Rapids and Wanapum dams and did not identify that these issues existed at either dam. However, Grant PUD replaced the fish count stations at both dams in 2010 with picket-lead gratings that is 11/16-inch gap to ensure accurate adult counts.	N/A
28.	Install/evaluate plates over diffuser along the bases of walls and weir	Bonneville (I) The Dalles (P)	Columbia Columbia	#57, 58 #58	Yes	Yes. PLMP Objective 2 requires installation of plating along the edges and through the orifices in the pools with diffusion chambers at Priest Rapids Dam.	Yes. Grant PUD installed permanent aluminum plating on diffuser grates at Priest Rapids during the 2009-2010 winter fish ladder maintenance outage. The effectiveness of the plating was evaluated

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
							through the use of underwater video as part of the 2010 assessment of Pacific Lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams (Nass et al. 2009). This study showed that lamprey effectively used the plating to move through a weir orifice or past the counting station.
29.	Modify/evaluate weir head differentials	Bonneville (I) Wells (I) The Dalles (P)	Columbia Columbia Columbia	#59 #61 #59	No	No. Fishway operational procedures were identified as existing at the Project in the PLMP.	N/A. Grant PUD operates its fishways according to the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for weir head differentials.
30.	Manage flows to a peaking hydrograph	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No	No. Grant PUD operates its facilities as part of a seven dam coordination schedule of flows. The proposed activity is not consistent with operations for power generation, flood control and recreational activities.	N/A
31.	Establish protocol for formal inspection of passage facilities	Priest Rapids and Wanapum (I)	Columbia	#97	No	Yes. PLMP Objective 2 requires inspection of passage facilities by PRFF members.	Yes. Inspection by the PRFF is coordinated with annual winter fish ladder maintenance outages.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
32.	Fishway guidelines for adult Pacific Lamprey passage	All ACOE projects, Wells, Rocky Reach, Rock Island, Priest Rapids (I)	Columbia and Snake	#98	No	No. Fishway operational procedures exist at the Project and were identified in the PLMP.	N/A. Grant PUD operates its fishways according to the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008).
Project Passage Effectiveness							
33.	Develop adult lamprey passage criteria	Rocky Reach (P) Priest Rapids and Wanapum (P)	Columbia Columbia	N/A[3] N/A[4]	No	Yes. PLMP Objective 2 requires the development of adult lamprey passage criteria that are not inconsistent with the Fishery Operations Plan (Grant PUD 2010).	Yes. Grant PUD and the PRFF will consider success achieved at other Columbia River basin projects and site specific conditions related to Priest Rapids and Wanapum dams.
34.	Evaluate effectiveness of dam passage	Priest Rapids and Wanapum (I) Rocky Reach (I) Wells (I) Threemile Falls Dam, Maxwell and Feed diversions (I) Clackamas (I) Bonneville, The Dalles, John Day, McNary (I)	Columbia Columbia Columbia Umatilla Clackamas Columbia	#62, #67 #63 #64 #65 #66 #68 #69	Yes	Yes. PLMP Objective 2 requires a comprehensive passage evaluation.	Yes. Grant PUD implemented an evaluation program in coordination with the PRFF to determine and assess the effectiveness of fish ladder modifications. HDX-PIT systems were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific Lamprey tagged at lower river facilities were passively monitored at Priest Rapids Project facilities as directed by the PRFF. The assessment of plating and count station use in 2010 documented

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
		Federal Columbia River Power System (I)	Columbia and Snake				the effective use of these structures by migrating lamprey. Analysis of the data available from 2010 – 2017 was completed and is presented in Section 1.2 of this report. During this time period, fishway passage efficiency of the comprehensive dataset was 85.9% and 91.0% at Priest Rapids and Wanapum dams, respectively.
35.	Evaluate upstream passage modifications	Priest Rapids and Wanapum (I) Rocky Reach (I) Wells (I) Bonneville, The Dalles, John Day, McNary (I) Federal Columbia River Power System (I) No associated hydro project (I)? [Note: evaluations performed on existing structural /	Columbia Columbia Columbia Columbia Columbia N/A	#62, #67 #63 #64 #68 #69 #70	No	Yes. PLMP Objective 2 requires a comprehensive passage evaluation of modifications to fishways as required per the Federal Energy Regulatory Commission (FERC) License Order and PLMP.	Yes. Grant PUD conducted an adult passage evaluation to determine the effectiveness of fish ladder modifications made during the 2009-2010 winter fish ladder maintenance outage (Nass et al. 2009). Specific modifications included diffusion grate plating and new fish crowder structures. HDX-PIT systems were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific Lamprey tagged at lower river facilities were passively monitored at Priest Rapids Project facilities as directed by the

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
		operational improvements at ACOE dams are identified earlier in this table, under the heading, Structural and Operational Fishway Modifications.]					PRFF. The assessment of plating and count station use in 2010 documented the effective use of these structures by migrating lamprey. Analysis of the data available from 2010 – 2017 was completed and is presented in Section 1.2 of this report. During this time period, fishway passage efficiency of the comprehensive dataset was 85.9% and 91.0% at Priest Rapids and Wanapum dams, respectively.
Lamprey Counts At Dams							
36.	Develop feasibility, techniques, and protocols to improve 24-hour counting / conduct counts	Bonneville, The Dalles, John Day, McNary, Lower Granite (I) Wells (I) Rocky Reach, Rock Island (I) Priest Rapids, Wanapum (I) Prosser and Roza (I)	Columbia and Snake Columbia Columbia Columbia Yakima	#71 #72 #73 #74 #75	Yes	Yes. PLMP Objective 2 requires maintenance and feasible improvements to adult fish counting systems.	Yes. Grant PUD currently provides counts of all fishes 24 hours per day, 7 days per week for the period April 15 – November 15, annually.
Predation							

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
37.	Establish predation control measures (sea lions)	Bonneville (I)	Columbia	#76	Yes	No. Sea lions are not present in the PRPA.	N/A
Juvenile Passage at Hydroelectric Facilities							
Structural and Operational Fishway Modifications							
38.	Conduct a literature review of juvenile Pacific Lamprey passage and survival	Priest Rapids and Wanapum (I) Wells (P)	Columbia Columbia	#97 N/A[2]	No	Yes. PLMP Objective 1 requires compilation of measures taken in the Columbia River basin and an assessment of their applicability to the Project.	Yes. This activity is documented in this PLMP Comprehensive Annual Report.
39.	Lift/remove extended length screens during outmigration	McNary (I)	Columbia	#77	Yes	No. Grant PUD has existing turbines bypass systems, gatewells and spill, but does not have a system into which a separator could be installed.	N/A
40.	Manage flows to a peaking hydrograph	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No	No. Grant PUD operates its facilities as part of the seven dam coordinated system. The proposed activity is not consistent with operations for power generation, fish protection, flood control and recreational activities.	N/A
41.	Implement JBS modifications	McNary (I)	Columbia	#77	Yes	No. Grant PUD has existing bypass systems, which includes gatewells, spillways, the Wanapum Future Unit Fish Bypass	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
						(WFUFB), and Priest Rapids Top-Spill Bypass. The WFUFB and experimental Priest Rapids Top-Spill Bypass are operated to achieve safe passage of out-migrating salmonids. It would be expected that juvenile lamprey would also benefit as a result of these operations.	
42.	Establish/continue salvage activities during ladder maintenance de-watering	All ACOE projects (I) Wells (I) Rocky Reach, Rock Island (I) Priest Rapids and Wanapum (I)	Columbia, Snake Columbia Columbia Columbia	#78 #79 #80 #81	Yes	Yes. Dewatering procedures were identified as existing at the Project in the PLMP.	Yes. Grant PUD operates its fishways according to the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for dewatering and the recovery of all fish during all maintenance activities.
43.	Develop and/or maintain bypass operations criteria	Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia Columbia Columbia Columbia	#79 #80 #80, 82 #81, 83	Yes	Yes. Grant PUD has existing bypass systems, which includes gatewells, spillways, the WFUFB, and Priest Rapids Top-Spill Bypass.	Yes. The WFUFB and experimental Priest Rapids Top-Spill Bypass are operated to achieve safe passage of out- migrating salmonids. It would be expected that juvenile lamprey would also benefit as a result of these structural modifications and spill operations.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
44.	Planning / permit acquisition for reservoir drawdown for silt removal	Leaburg and Walterville (I)	McKenzie	#84	No	No. This activity is not required by the PLMP.	N/A
Project Passage Effectiveness							
45.	Monitor passage timing, number, and mortalities of juvenile lamprey collected at projects with juvenile fish bypass facilities	Bonneville, McNary (I) Lower Monumental, Little Goose, Lower Granite (I)	Columbia Snake	#85 #85	Yes	No. Grant PUD does not have juvenile collection facilities at either Priest Rapids or Wanapum dams that could be used for this purpose.	N/A
46.	Evaluate tagging and development of miniature tags	No associated hydro project (I) No associated hydro project (I)	N/A Columbia	#86 #87	No	No. This activity is not required by the PLMP. Evaluation and development of tags are not objectives, goals, or measures outlined in the PLMP.	N/A
47.	Develop juvenile lamprey passage criteria	Priest Rapids and Wanapum (P)	Columbia	N/A[4]	No	Yes. PLMP Objective 3 requires the development of juvenile lamprey passage criteria.	Yes. Grant PUD and the PRFF will include consideration of success achieved at other Columbia River basin projects and site specific conditions when the tested methodology exists to measure juvenile lamprey passage.
48.	Evaluate downstream passage and survival when technology available	Wells (P) Rocky Reach (P)	Columbia Columbia Columbia	N/A[2] N/A[3] N/A[4]	No	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD has committed to providing	Yes

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
		Priest Rapids and Wanapum (P)				safe, effective and timely passage which could be evaluated when adequately tested methodology exists.	
Predation							
49.	Continue predation control measures (Northern pikeminnow and birds)	Pikeminnow only. All ACOE projects (I) Pikeminnow and birds Rocky Reach (I) Pikeminnow and birds Rock Island (I) Pikeminnow and birds Priest Rapids and Wanapum (I)	Columbia, Snake Columbia Columbia Columbia	#88 #89 #89 #90	Yes	Yes. The PLMP does not include a specific PM&E related to this activity. However, Grant PUD maintains predator control programs for piscivorous birds and Northern pikeminnow in the PRPA.	Yes. Grant PUD maintains both avian and Northern pikeminnow control programs to minimize the effects of predation to salmonids which would also be expected to provide a benefit to lamprey.
50.	Evaluate predation potential of various native and non-native species to larval lamprey	No associated hydro project (I)	Yakima	#91	Yes	Yes. The PLMP does not include a specific PM&E related to this activity. However, Grant PUD maintains predator control programs for piscivorous birds and Northern pikeminnow in the PRPA. Monitoring of Northern pikeminnow diet contents (i.e., larval lamprey) is included as part of this on-going program.	Yes. Grant PUD maintains both avian and Northern pikeminnow control programs to minimize the effects of predation to salmonids which would also be expected to provide a benefit to larval lamprey.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
Policy and Recovery Activities							
51.	Develop/implement Pacific Lamprey Management Plans	All ACOE projects (I) Wells (I) Rocky Reach (I) Priest Rapids and Wanapum (I)	Columbia, Snake Columbia Columbia Columbia	#92, 94, 98, 99 #95 #96 #97	Yes	Yes. Grant PUD is required by FERC to develop and implement a PLMP.	Yes. Grant PUD has a FERC- approved PLMP (Grant PUD 2009). Implementation of that plan is in progress.
52.	Establish regional data protocols for collection, storage and analysis; develop means to widely access and share information	All ACOE projects (I) Wells (I) Rocky Reach (I) Priest Rapids and Wanapum (I)	Columbia, Snake Columbia Columbia Columbia	#92, 94, 95, 98, 99 #95 #96 #97	Yes	Yes. PLMP Objectives 2 and 3 require "Regional Studies" which includes participation and cooperation in studies where useful information may be obtained about project impacts to lamprey.	Yes. Grant PUD participates in regional forums such as the Columbia River Basin Lamprey Technical Work Group (CRBLTWG) the USFWS Lamprey Conservation Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.
53.	Collect traditional ecological knowledge and establish coordinated public education and other outreach programs	No associated hydro project (I) Priest Rapids and Wanapum (I)	Yakima N/A Columbia	#29, 100 #30 #97	No	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD participates in education programs regarding lamprey.	Yes. Grant PUD participates in the annual Wanapum Indian Archeological Days program and provides technical support and displays regarding the importance of lampreys.
54.	Participate in regional lamprey activities	All ACOE projects (I) Wells (I)	Columbia, Snake Columbia	#92, 94, 98, 99 #95	Yes	Yes. PLMP Objectives 2 and 3 require "Regional Studies" which includes participation and cooperation in studies	Yes. Grant PUD participates in regional forums such as the CRBLTWG the USFWS Lamprey Conservation

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 5 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
		Rocky Reach (I) Priest Rapids and Wanapum (I)	Columbia Columbia	#96 #97		where useful information may be obtained about Project impacts to lamprey.	Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.
55.	Environmental analysis and feasibility investigations	All ACOE projects (I)	Columbia, Snake	#98, 99	No	No. This activity is not required by the PLMP. Environmental analysis and feasibility investigations related to public transportation and lamprey propagation are not objectives, goals, or measures outlined in the PLMP.	N/A

Notes:

1. Defined as a measure identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River (Nez Perce, Umatilla, Yakama, and Warm Springs Tribes 2009), that has not already been implemented or planned by the ACOE or mid-Columbia PUDs.
2. Per requirement in Wells Project PLMP (Douglas PUD 2009).
3. Per requirement in Rocky Reach PLMP (Chelan PUD 2005).
4. Per requirement in Priest Rapids PLMP (Grant PUD 2009); see Table 5 for status.
5. Per commitment in ACOE's 10-year implementation plan (ACOE 2009).
6. "All ACOE projects" includes Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite.
7. An evaluation of reducing fishway flows at night was planned for the 2009-2010 winter work period; however, the evaluation was not done (as agreed to by the PRFF) as returning numbers were insufficient.

ACOE = Army Corps of Engineers
BOR = Bureau of Reclamation
CRBLTWG = Columbia River Basin Lamprey Technical Work Group
CRITFC = Columbia River Inter-Tribal Fish Commission
FDX = full-duplex
FPE = Fish Passage Efficiency
HDX = half-duplex
LPS = lamprey passage system
N/A = Not applicable
NNI = No Net Impact
NOAA = National Oceanic and Atmospheric Administration
OLAFT = Off-ladder Adult Fish Trap
PLMP = Pacific Lamprey Management Plan
PM&E = protection, mitigation and enhancement
PRFF = Priest Rapids Fish Forum
PRPA = Priest Rapids Project area
PUD = Public Utility District
SOP = Standard Operating Procedure
USFWS = U.S. Fish and Wildlife Service
WFUFB = Wanapum Future Unit Fish Bypass

5.0 Summary

One of the goals of Grant PUD's PLMP is to improve Pacific Lamprey passage efficiency through the implementation of structural and, potentially, operational modifications to the Project fishways. In the tenth year of PLMP implementation, several planned activities were conducted on schedule. Grant PUD continued to conduct components of a PRFF-approved study plan titled, "Assessment of Pacific Lamprey Behavior and Passage Efficiency at Priest Rapids and Wanapum Dams" (Nass et al. 2009). This ongoing study is being conducted to evaluate the effectiveness of structural modifications to Priest Rapids Project fishways that are intended to facilitate lamprey passage.

The study plan objectives were to:

1. Determine the fishway passage efficiency for adult lamprey at Priest Rapids and Wanapum dams; and
2. Evaluate the passage of adult lamprey through sections of the Priest Rapids fishways where new structures have been installed to facilitate upstream movement.

In 2018, Grant PUD, in consultation with the PRFF, continued monitoring adult Pacific Lamprey tagged at downstream facilities and added valuable information to the cumulative Project data set. The intent of the PIT data collection program is to provide sufficient sample size over time to calculate relevant passage metrics. Analysis of the data available from 2010 – 2017 was completed and is presented in Section 1.2 of this report. During this time period, fishway passage efficiency of the comprehensive dataset was 85.9% and 91.0% at Priest Rapids and Wanapum dams, respectively. Note that 2014 data for Wanapum Dam was intentionally omitted due to anomalous conditions associated with the Wanapum fracture. Passage efficiencies for 2018 were not available at the time of reporting and will be included in the 2019 annual report. Interpretation of fishway passage efficiency should include consideration of fish that overwintered during migration (fish tagged in the previous study year). Overwintering fish typically made up ~ 6.0% of detected tags during the 2010-2016 period. These detections indicate the complexity of adult lamprey migration behavior. No overwintering fish were detected in 2017 and 2018.

In addition to the monitoring effort in 2018, the PRFF agreed by consensus to the Grant PUD Adult Pacific Lamprey No Net Impact Trap and Transportation SOA (Appendix A). As a result of the first year of the agreement, Grant PUD operated the mechanical lamprey traps at Priest Rapids Dam from July 31 to August 17. A total of 177 lamprey were trapped, transported, and released upstream of Rock Island Dam, at Kirby Billingsley Hydro Park. Grant PUD continued to operate the traps from August 20 to September 7 to provide lamprey for Douglas PUD's translocation program. A total of 674 lamprey were transferred to Douglas PUD and released upstream of Wells Dam.

Table 8 **Number of adult Pacific Lamprey trapped in four mechanical traps at Priest Rapids Dam. Lamprey were transported to Kirby Billingsley Hydro Park (KBHP) or transferred to Douglas PUD (DPUD) for their translocation program. Trap efficiency was calculated using the 24-hour window counts from Priest Rapids Dam.**

Date	Right Bank West Trap	Right Bank East Trap	Left Bank West Trap	Left Bank East Trap	Total Trapped	24-Hour Window Count	Trap Efficiency (%)	Destination
7/31/18	1	4	0	1	6	251	2	KBHP
8/1/18	8	8	4	15	35	118	30	KBHP
8/2/18	4	9	13	45	71	114	62	KBHP
8/3/18	5	17	7	36	65	279	23	KBHP
8/7/18	30	2	11	8	51	452	11	DPUD
8/8/18	6	2	6	3	17	162	10	DPUD
8/9/18	6	7	1	4	18	177	10	DPUD
8/10/18	30	30	6	41	107	142	75	DPUD
8/14/18	5	8	4	25	42	113	37	DPUD
8/15/18	9	12	7	21	49	75	65	DPUD
8/16/18	17	6	7	21	51	55	93	DPUD
8/17/18	4	10	3	2	19	69	28	DPUD
8/21/18	7	8	14	41	70	123	60	DPUD
8/22/18	2	1	22	18	43	99	43	DPUD
8/23/18	5	0	0	0	5	88	6	DPUD
8/24/18	1	0	1	9	11	125	9	DPUD
8/28/18	1	2	1	1	5	23	22	DPUD
8/29/18	3	1	9	26	39	72	54	DPUD
8/30/18	5	1	6	23	35	82	43	DPUD
8/31/18	1	2	0	15	18	27	67	DPUD
9/4/18	1	0	9	4	14	57	25	DPUD
9/5/18	0	0	5	34	39	48	81	DPUD
9/6/18	1	1	5	25	32	23	139	DPUD
9/7/18	1	0	6	2	9	58	16	DPUD
Total	**153**	**131**	**147**	**420**	**851**	**2832**	**30**	

In 2018, Grant PUD also continued its regional approach to monitoring lamprey by coordinating among other utilities, participating in forums, and the sharing of PIT data with other researchers.

In 2019, Grant PUD plans to complete PLMP-required activities and study planning/implementation efforts including:

1. PRFF on-site inspection of Priest Rapids and Wanapum fish facilities during the 2018-2019 winter fish ladder maintenance outage. Entrance and exit HDX-PIT antennas will be refurbished during this time.
2. Pre-season testing and calibration of HDX-PIT arrays, and maintenance of arrays during the migration season. Continue to operate HDX-PIT arrays to assess passage metrics (passage efficiency, etc.) and coordinate detection of tagged fish with regional monitoring efforts to evaluate Pacific Lamprey passage; both downstream and upstream of the Priest Rapids Project.
3. Tracking lamprey enumeration statistics for the Priest Rapids Project and lower Columbia River dams.
4. Continue to execute the terms of the Adult Pacific Lamprey No Net Impact SOA. (Appendix A)

Pursuant to the requirements identified in the PLMP, Grant PUD will continue to monitor lamprey-related efforts occurring throughout the Columbia River Basin, will actively participate in regional research and forums, and will assess opportunities for lamprey restoration at the Project.

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Appendix A
Grant PUD Adult Pacific Lamprey No Net Impact Trap and Transportation Statement of Agreement (SOA)

Adult Pacific Lamprey No Net Impact
Statement of Agreement

1. Statement:

The Priest Rapids Fish Forum (PRFF) agrees by consensus to this adult Pacific Lamprey No Net Impact Trap and Transportation Statement of Agreement (SOA).

As a result of this SOA, Grant PUD will deploy, operate, and maintain, four mechanical traps at Priest Rapids Dam, which have been used in previous years in support of adult Pacific lamprey trapping and tagging evaluations (2014-2017).

Grant PUD will fish four traps for a total of 15 days during nighttime hours only to collect a maximum number (as determined by run size and trap efficiency) of adult lamprey annually during the peak migration period and transport collected individuals upstream from Rock Island Dam (Kirby-Billingsly Park, unless otherwise determined by the PRFF), thereby removing the Priest Rapids Project area from their upstream migration or the potential effect of the Project. Grant PUD will include a description of trapping period, total trapping effort, total number of fish collected (by trap) and transported, health and mortality of captured fish, and the proportion of the run captured and transported in their annual Pacific lamprey report. Other entities will coordinate with Grant PUD and the PRFF on the collection of genetic samples, tagging fish, and possible release locations. Grant PUD will coordinate annually with the PRFF on the timing of trapping at Priest Rapids Dam each year. The annual review by the PRFF will include evaluation of compelling evidence for possible changes in the trap-and-haul program.

This SOA maintains Pacific lamprey as a “Non-Covered Species” as defined in Grant PUD’s 401 Certification and achieves specific requirements in Grant PUD’s Pacific Lamprey Management Plan (PLMP, Objective 1: No Net Impact (NNI). Identify, address, and fully mitigate Project effects to the extent reasonable and feasible) for implementation measures associated with adult passage evaluations and goals and objectives associated with No Net Impact. This SOA does not supersede other PLMP requirements related to adult Pacific Lamprey.

2. Terms of the Agreement:

This SOA will remain in effect for a period of 10 years (with a 5-year check-in to evaluate the performance of the trapping program) unless there is compelling[1] evidence that demonstrates that the Priest Rapids Project has an impact on adult Pacific lamprey migration through the Priest Rapids Project. This SOA satisfies adult lamprey NNI for the 10-year term of this agreement.

[1] Compelling evidence should be related to but not limited to information collected as part of the annual HDX Passive Integrated Transponder fishway monitoring program in the fishways of Wanapum and Priest Rapids Dams, through the white sturgeon monitoring and evaluation program (predation impacts), etc.

Appendix B
February 12, 2019 Email with Yakama Nation Comments

From: Mike Clement
To: Debbie Firestone
Subject: FW: Grant County PUD"s draft Pacific Lamprey Management Plan annual report
Date: Wednesday, February 20, 2019 10:44:06 AM
Attachments: 2018_01_10 GCPUD draft PLMP Annual Report.pdf

Deb,
Here are the comments on the lamprey report (for the appendix) from YN

Thanks, Mike

From: Ralph Lampman [mailto:lamr@yakamafish-nsn.gov]
Sent: Tuesday, February 12, 2019 1:11 PM
To: Mike Clement <Mclemen@gcpud.org>; Chris Mott <Cmott@gcpud.org>
Cc: Tracy Hillman <tracy.hillman@bioanalysts.net>
Subject: Fwd: Grant County PUD's draft Pacific Lamprey Management Plan annual report

---

Hi Mike and Chris,
(cc: Tracy)

Attached are my comments for the Grant County PUD's draft 2018 Pacific Lamprey Management Plan annual report.

"5.0 Summary" seem to be the place where all the 2018 activities are listed - just a suggestion, but it may make more sense to bring this at the top rather than at the very end, so the reader sees the most important new items at the beginning? The tables are certainly updated each year, but most of the written info in 1.0-2.0 are recycled each year and not sure if that needs to precede the more relevant new info for this annual report.

I would like to see a little more details about the adult trapping efforts.
See my comment within the pdf (I believe my last comment):
Could we get a little more details on this?
I would like to see a basic table that shows: capture of adults per day, estimate of daily trapping efficiency based on ladder counts (2-3 day average? - whatever deems most appropriate), if there are data for # trapped per specific trap, even better and more informative. Then, a season avaerge for the trapping effectiveness could be calculated (at the bottom). We talked about this during the PRFF meeting. Also, destination for each day would be good info in the daily table (Kirby or Douglas, or if split within a single day, show # for each in the comment).

I've seen the excel table being shared at PRFF - mainly just polishing that table a little to show the key info and adding it to this report.

Many other comments in here, but just wanted to highlight that one in this email.

And as I've said before, the Table 5 is a very good summary of regional lamprey work, so I

recommend saving it as a stand alone document as well so it can be shared with others (very few people outside of the PRFF know of this table, but could certainly benefit from it).

Let me know if you have any questions.

Ralph Lampman
COLUMBIA RIVER| Honor. Protect. Restore
Yakama Nation FRMP, Pacific Lamprey Project
lamr@yakamafish-nsn.gov
509-388-3871

Appendix C
Yakama Nation Comments and Grant PUD Responses

Submitting Entity	Date Received	Paragraph #	Agency Comment	Grant PUD Response
YN	2/12/2019	1	Attached are my comments for the Grant County PUD's draft 2018 Pacific Lamprey Management Plan annual report.	Comment noted.
YN	2/12/2019	2	"5.0 Summary" seem to be the place where all the 2018 activities are listed - just a suggestion, but it may make more sense to bring this at the top rather than at the very end, so the reader sees the most important new items at the beginning? The tables are certainly updated each year, but most of the written info in 1.0-2.0 are recycled each year and not sure if that needs to precede the more relevant new info for this annual report.	Comment noted. Grant PUD has modified the Executive Summary and included 2018 activities to reflect this recommendation.
YN	2/12/2019	3	I would like to see a little more details about the adult trapping efforts. See my comment within the pdf (I believe my last comment): Could we get a little more details on this? I would like to see a basic table that shows: capture of adults per day, estimate of daily trapping efficiency based on ladder counts (2-3 day average? - whatever deems most appropriate), if there are data for # trapped per specific trap, even better and more informative. Then, a season avaerge for the trapping effectiveness could be calculated (at the bottom). We talked about this during the PRFF meeting. Also, destination for each day would be good info in the daily table (Kirby or Douglas, or if split within a single day, show # for each in the comment). I've seen the excel table being shared at PRFF - mainly just polishing that table a little to show the key info and adding it to this report.	Comment noted. Grant PUD has modified and included a comprehensive and detailed summary table, which includes the suggested trapping and release data and is included in the Summary section of this report.
YN	2/12/2019	4	Many other comments in here, but just wanted to highlight that one in this email. And as I've said before, the Table 5 is a very good summary of regional lamprey work, so I recommend saving it as a stand-alone document as well so it can be shared with others (very few people outside of the PRFF know of this table, but could certainly benefit from it).	Comment noted. Grant PUD has modified this report to reflect these recommendations.

Appendix D
Washington Department of Ecology's February 21, 2019 Approval Letter

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
1250 W Alder St • Union Gap, WA 98903-0009 • (509) 575-2490

February 21, 2019

Mr. Tom Dresser
Fish, Wildlife and Water Quality Manager
Grant County PUD
PO Box 878
Ephrata, WA 98823

RE: Request for Ecology Review and Comment –*2018 Pacific Lamprey Management Plan Comprehensive Annual Report.*
Priest Rapids Hydroelectric Project No. 2114

Dear Tom Dresser:

The Department of Ecology (Ecology) has reviewed the *2018 Pacific Lamprey Management Plan Comprehensive Annual* e-mailed to Ecology on January 10, 2019. This report is a requirement of Section 6.2(5)(d) for the *Pacific Lamprey Management Plan* of the 401 certification.

If you have any questions for Ecology, please call me at (509) 575-2808, or e-mail me at breean.zimmerman@ecy.wa.gov.

Sincerely,

Breean Zimmerman

Breean Zimmerman
Hydropower Projects Manager
Water Quality Program

cc: Mike Clement, Senior Biologist, Grant County PUD