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March 17, 2020

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) – 2019 Pacific Lamprey Management Plan
Annual Report**

Dear Secretary Bose,

Please find enclosed Public Utility District No. 2 of Grant County, Washington (Grant PUD) 2019 Pacific Lamprey Management Plan (PLMP) Annual Report consistent with the requirements of Article 401(a)(12) of the Priest Rapids Project License¹ and the Washington State Department of Ecology (Ecology) 401 Water Quality Water Quality Certification Condition of 6.2(5)(b) and Appendix C for the Priest Rapids Project (Project).

The 2019 PLMP Comprehensive Annual Report summarizes the on-going activities undertaken at the Project in 2019, 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 21, 2020, Grant PUD prepared and disseminated the draft 2019 PLMP Annual Report to members of the Priest Rapids Fish Forum, which includes the Ecology, U.S. Fish & Wildlife Service (USFWS), Washington Department of Fish & Wildlife, Colville Confederated Tribes, Yakama Nation (YN), 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 from the USFWS and YN (Appendix B) and they are provided in the response table (Appendix C). On March 6, 2020, Ecology approved the 2019 PLMP Annual Report (Appendix D).

¹ 123 FERC ¶ 61,049 (2008)

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

Sincerely,



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CC: Breean Zimmerman – Ecology
Priest Rapids Fish Forum

2019
Pacific Lamprey Management Plan
Comprehensive Annual Report

Priest Rapids Hydroelectric Project (FERC No. 2114)

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March 2020

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 2019, 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 eleventh year of implementation of the PLMP, Grant PUD continued, for a tenth 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 2019 migrations, Grant PUD monitored a total of 652 and 647 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 19% at Priest Rapids Dam over the 2010-2018 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, 2015-2018 period (2014 intentionally omitted due to anomalous conditions associated with the Wanapum spillway fracture). The fishway passage efficiency for the entire 2010-2018 comprehensive dataset is 94.6% and 100.0% at Priest Rapids and Wanapum dams, respectively. This dataset includes years with lower than average detection efficiency, due to select poor antenna performance, which may artificially inflate passage efficiency. The long-term average fishway passage efficiency for 2010-2018 is 87.4% and 89.4% at Priest Rapids and Wanapum dams, respectively, when factoring in passage efficiency cannot be greater than 100%. Low passage efficiency estimates were associated with small sample sizes in some ladders in certain years. Fishway passage efficiency for 2019 is not yet available and will be included in the 2020 annual report.

During the 2019 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 23.5 hours and 85.9 hours, respectively. Median passage times were based off small sample sizes due to poor antenna performance. Although the entrance and exit antennas were refurbished during the 2018/2019 winter dewatering and maintenance period at both dams, troubleshooting the low detection efficiency remaining at a few of the antennas is ongoing.

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) (Appendix A of Le et al. 2019). For the second year of the agreement, Grant PUD operated the mechanical lamprey traps at Priest Rapids Dam from August 5 to September 17, 2019. A total of 152 lamprey were trapped from August 6 to August 23 to provide lamprey for Public Utility District No. 1 of Douglas County's (Douglas PUD) translocation program. Grant PUD continued to operate the traps from August 27 to September 17, 2019. One hundred and eleven lampreys were trapped during that time period, transported and released upstream of Rock Island Dam at Kirby Billingsley Hydro Park. In 2019, total of 263 lamprey were trapped and transported during the entire effort.

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. The CRBLTWG has since expanded its geographic scope to include California and Alaska, and is now known as the Lamprey Technical Work Group (LTWG) under the Pacific Lamprey Conservation Agreement (PLCA). 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 Modifying and Approving Pacific Lamprey Management Plan¹ and Water Quality Certificate Condition 6.2(5)(b)), 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 (see below) 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

¹ 127 FERC ¶ 62,091 (2009)

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 and 2019 adult Pacific lamprey migration periods, 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 times were 49.1 hours and 49.2 hours in 2018, and 23.5 hours and 85.9 hours in 2019 at the Priest Rapids and Wanapum fishways, respectively. Median passage times were based off small sample sizes due to poor antenna performance. Although the entrance and exit antennas were refurbished during the 2018/2019 winter dewatering and maintenance period at both dams, troubleshooting the low detection efficiency remaining at a few of the antennas is ongoing.

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 (Le et al. 2019). For the second year of the agreement, Grant PUD operated the mechanical lamprey traps at Priest Rapids Dam from August 5 to September 17, 2019. A total of 152 lamprey were trapped from August 6 to August 23, 2019 to provide lamprey for Public Utility District No. 1 of Douglas County's (Douglas PUD) translocation program (see Appendix A, Table A-1). Grant PUD continued to operate the traps from August 27 to September 17, 2019. One hundred and eleven lamprey trapped during that time period were transported and released upstream of Rock Island Dam at Kirby Billingsley Hydro Park. A total of 263 lamprey were trapped and transported during the entire effort (Appendix A, Table A-1).

For the 2010 through 2019 migrations, Grant PUD monitored a total of 652 and 647 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 19% at Priest Rapids Dam over the 2010-2018 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, 2015-2018 period (2014 intentionally omitted due to anomalous conditions associated with the Wanapum spillway fracture). The fishway passage efficiency for the entire 2010-2018 comprehensive dataset is 94.6% and 100.0% at Priest Rapids and Wanapum dams, respectively. This dataset includes years with lower than average detection efficiency, due to select poor antenna performance, which may artificially inflate passage efficiency. The long-term average fishway passage efficiency for 2010-2018 is 87.4% and 89.4% at Priest Rapids and Wanapum dams, respectively, when factoring in passage efficiency cannot be greater than 100%. 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 76 tags were detected that year. In 2019, 36 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 6.5 days during the 2010-2019 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 were detected in 2017 and 2018, 5% of tags detected in 2019 were tagged and released at Bonneville Dam in 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 2010-2019.

Year	Number Detected		Median fishway passage time (h)			
	PR	WA	PR Left	PR Right	WA Left ¹	WA Right ¹
2010-2019	652	647	49.5	5.3	22.1	19.1

Notes:

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

Year	Number NetFallback		Median PR Reservoir passage time (d) ¹	Number of tags from previous year (overwintering fish)
	PR	WA		
2010-2019	1	8	4.8	31

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 before all tag batteries expired. 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.

Grant PUD has continued to coordinate with the PRFF, other PUDs, and tribes by providing adult lamprey for ongoing regional studies for the past five years. In 2018 and 2019, a total of 674 fish and 152 fish, respectively, 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 also provided fish to support other adult lamprey studies for six 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 to address a requirement in 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. Existing Grant PUD bathymetry data were used to identify areas affected by the Project's operations, and aerial photographs were used to segregate the Project operational zone into habitat types with high (Type 1), medium (Type 2), and low potential (Type 3) for use by juvenile lamprey (Close and Aronsuu 2003; Hansen et al 2003). Sample sites were chosen favoring Type 1 habitat, but including Type 2 and Type 3 habitat, and water less than 1 meter in depth. In the Wanapum Reservoir, 36 shoreline habit locations were sampled. In the Priest Rapids Reservoir, 12 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 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 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) suggests that juvenile lamprey are present, but rare in the operational zone of the Priest Rapids Project (Grant PUD 2017).

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 LTWG 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 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:

License Order: 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.

401 Water Quality Certification, Appendix C: 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, 2019) 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, 2018 through October 31, 2019) 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 21, 2020. Comments were received from the Yakama Nation on February 19, 2020 and USFWS on February 21, 2020. Washington Department of Ecology approved the 2019 PLMP Annual Report on March 6, 2020.

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 LTWG 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 lampreys are cartilaginous, jawless, anadromous fish that develop morphologically and physiologically in three primary stages. First, Pacific lampreys 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 lampreys 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												
Metamorphosis/Transition ^{2,3}												
Young adult downstream migration ⁴												
Parasitic feeding initiated and entry into saltwater ⁵												

¹ Beamish and Levings (1991)
² Hammond (1979)
³ Close et al. (2002)
⁴ Dawson et al. (2015)
⁵ Lampman p. communication.
 Peak period = dark shade

Pacific lampreys 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 lampreys are also termed macrophtalmia following major morphological changes, but prior to parasitic feeding (Hardisty and Potter 1971 as cited in Beamish 1980). Pacific lampreys transform from ammocoetes to macrophtalmia from July to November (Hammond 1979 and Close et al. 2002). During transformation, the shape and angle of the head and mouth change, 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 lampreys 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. Physiological experiments showed that Pacific lamprey in the Fraser River begin entering saltwater in December and continue through June (Beamish 1980), and in the Columbia River anecdotal evidence suggests young adults enter salt water starting in November and continue through June (R. Lampman Yakama Nation, personal communication). 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, 2018 and 2019. 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, ocean collection efforts from 2017-2019 included the release of four PIT tagged individuals (one in 2017, one in 2018, and two in 2019) 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 (1980-1981 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 eight 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; review of and a call for standard terminology to describe lamprey life stages; 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.). For example, upstream migration in the upper Columbia reaches tends to end around mid-October (R. Lampman Yakama Nation, personal communication).

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 winter or 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; R. Lampman, Yakama Nation, personal communication).

Historically, 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. Since 2009, the Yakama Nation Pacific Lamprey Project (YNPLP) has conducted larval lamprey electrofishing surveys in White Salmon, Klickitat, Yakima, Wenatchee, Entiat, and Methow subbasins. Survey results indicate Pacific lamprey occupy all subbasins with the exception of the White Salmon (Beals and Lampman, 2018). 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 macrophthalmia) and larval (ammocoetes) Pacific lamprey 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. Recently, advances in tag implementation techniques (Moser et al. 2017) and micro tag technology (Deng et al. 2018, Mueller et al. 2019) are becoming available to help fill key information gaps for juvenile lamprey downstream movements 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 the size of the mesh is a critical factor and that wire cloth screens should be replaced with perforated plate and vertical bar, or interlocking bar screens to reduce lamprey entrainment at water diversions (R. Lampman, Yakama Nation, personal communication). 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 as well as the impact of de-watering rates (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). In the Lower Columbia River, collections and historic observations of Pacific lamprey are common

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 (C. Peery, USFWS, personal communication). Historic observations were common all the way to Kettle Falls (R. Lampman, Yakama Nation, 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 impassable barriers. These barriers include the Willamette sub basin 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). Counts in 2018 equaled 43,419 fish, and current 2019 year to date² counts equal 19,374. 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,

² December 2, 2019

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 overwintering 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	1,566	11,758	175	1,019	207
2019 ³	1,005	3,276	14	271	94

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 October 31, 2019.

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) provides 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 et al. (2008) found that trapping and translocating adult lamprey from McNary Dam and releasing at Ice Harbor Dam did not significantly affect passage efficiency indicating no negative affects due to transportation. The continued migration indicates that Pacific lamprey do not hone to specific natal sites and instead potentially rely on environmental or other cues for locating spawning reaches (Cummings et al. 2008). 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 LTWG 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 LTWG members, the LTWG 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. Keefer et al. 2009c indicated significantly lower passage success from release to passage of John Day Dam for radio-tagged lamprey compared to HDX-PIT-tagged lamprey (4.5% for radio-tagged versus 17.9 for HDX-PIT-tagged%), 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	2018	100.0% (SE 13-22%)	HDX-PIT	Section 1.2 of this report
		2017	100.0% (SE 5-9%)	HDX-PIT	Le et al. (2019)
		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	2018	100% (SE 7-19%)	HDX-PIT	Section 1.2 of this report
		2017	96.2-100.0% (SE 0%)	HDX-PIT	Le et al. (2019)
		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 2010-2018 comprehensive dataset is 94.6% and 100.0% 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 that was used to evaluate 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 with fish moving up the ramp more slowly at the high ramp flow treatment. 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 or sidewall 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 et al. 2008). In 2006, additional

detectors were installed at the tops of ladders at The Dalles and John Day dams. Daigle et al. (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 for both years of study (n=7), 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, lifting picket leads at count stations, and resting boxes. 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 (e.g., reduced flows, etc.). 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 and tested (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 (e.g., continued bypass operations to support fish protection). (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 (Colotelio 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 Status of Active Tag Technology

A significant challenge in addressing juvenile lamprey at hydroelectric facilities has been the 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 has been 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 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 most recent prototype tag lasts 30 days at 3-s ping rate interval (R. Lampman, Yakama Nation, personal communication). 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, resulting in a detection efficiency of nearly 100% (R. Lampman, Yakama Nation, personal communication). 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, 2018 through October 31, 2019. 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
	<u>General Biology, Ecology, Behavior, and Population Status</u>					
1.	Monitoring entrance timing, escapement, and movement patterns	No associated hydro project	Fifteenmile Creek	<p>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.</p> <p>In 2017 eighteen adult Pacific lamprey were tagged and several were detected upstream of Cushing Falls. Approximately 150 were tagged at Bonneville Dam. 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.</p> <p>In 2018 approximately 500 lamprey were tagged at Cushing Falls. Antennas were in operation from 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.</p> <p>In 2019, fieldwork for a mark-recapture escapement estimate at Cushing Falls on Fifteenmile Creek was completed but results are unavailable. There were 285 Pacific lamprey PIT tagged and 39 recaptured. The pool of marked fish is adjusted by PIT tag antenna detections that indicate fish that fall back below the study site. Creel surveys were done but harvest has yet to be estimated. Ammocoete surveys were completed for</p>	Confederated Tribes of the Warm Springs (CTWS)	<p>Personal communication with Cyndi Baker, CTWS (10/28/19)</p> <p>Evaluate Status and Limiting Factors of Pacific lamprey in the Lower Deschutes River, Fifteenmile Creek and Hood River (Johnsen and Baker 2018)</p>

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				distribution and densities but data have not been entered for densities to be calculated.		
2.	Adult lamprey monitoring and juvenile lamprey density and distribution surveys	No associated hydro project	Deschutes and tributaries	<p>Since 2016, CTWS has engaged in ongoing adult lamprey monitoring and juvenile lamprey density and distribution surveys.</p> <p>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/m²) and averaged 17/m² in Warm Springs River, Beaver Creek, and Badger Creek. Total counts of ammocoetes collected were lowest in Badger Creek (71) and were 136, 139, and 151 in Warm Springs River, Beaver Creek, and Shitike Creek respectively.</p> <p>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. 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 Sherars 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.</p> <p>In 2019, fieldwork for a mark-recapture escapement estimate at Sherars Falls on the Deschutes River was completed but results are unavailable. Creel surveys were done but harvest has yet to be estimated. Ammocoete surveys were completed for distribution and densities but data have not been entered for densities to be calculated.</p>	CTWS	<p>Personal communication with Cyndi Baker, CTWS (10/15/19)</p> <p>Evaluate Status and Limiting Factors of Pacific lamprey in the Lower Deschutes River, Fifteen Mile Creek, and Hood River (Johnsen and Baker 2017)</p>
3.	Conduct adult lamprey movement study using radio telemetry	Bureau of Reclamation (BOR)	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	USFWS	Personal communication with Ann Grote,

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
		projects in Yakima		<p>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).</p> <p>Work is ongoing on a manuscript summarizing three years of adult Pacific lamprey mark-recapture data, and developing dam-specific passage efficiencies, inter-dam survival estimates and detection and uncertainty estimates.</p>		USFWS (10/28/19) Passage of Radio-tagged Adult Pacific lamprey at Yakima River Diversion Dams 2014 Annual Report Phase 3: Roza and Cowiche Dams (Grote et al. 2016)
4.	Determining adult escapement and adult harvest monitoring	Willamette Falls	Willamette	<p>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.</p> <p>In 2019, there were 1,229 Pacific lamprey PIT tagged at Willamette Falls for a mark-recapture escapement estimate. Of these, 11 were recaptured from the 1,432 inspected. During late fall, PIT tag detections from antenna array will be appended into a database and stray rate will be determined so that escapement can be calculated. The pool of marked fish is adjusted using the stray rate. During June and July, six tribal groups and one non-tribal person harvested about 3,150 lamprey.</p>	CTWS	Personal communication with Cyndi Baker, CTWS (10/28/19) 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)
5.	Techniques for estimating Pacific	Willamette Falls	Willamette	Since 2010, adult Pacific lamprey abundance and escapement has been monitored at Willamette Falls using capture-recapture techniques and a relatively	CTWS and Oregon State	Personal communication

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	lamprey escapement and abundance			<p>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.</p> <p>Existing information was used 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 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</p> <p>In March, 2019, Steve Whitlock, Jeff Deweber, and Jim Peterson, OSU Fish and Wildlife Dept., released a final report for the alternative method of estimating lamprey abundance at Willamette Falls. Because of this work CTWS was able to present an escapement estimate for Pacific lamprey in 2018, using the refined integrated daily escapement estimate (IDEM) developed by Whitlock et, al. Because CTWS failed to recapture</p>	University (OSU)	with Cyndi Baker, CTWS (10/28/19) Assessment of Pacific lamprey Monitoring Techniques at Willamette Falls, OR. (Whitlock et al 2019) 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
				enough marked lamprey, use of the Lincoln-Petersen estimator was impossible. The IDEM escapement estimate for 2018 was 43.2% below the model's 2011 to 2017 average of 65,009 (range 24,258 in 2016 to 125,579 in 2014). Catch in 2018 was the lowest since the project began in 2010 with only 589 lamprey tagged; previously the range had been 868 in 2016 to 4,670 in 2014. Recapture rates have declined since the beginning of the project but more severely since 2015. The relationship between lamprey escapement at Willamette Falls and counts at Bonneville Dam became decoupled after 2015. This alternative method for estimating lamprey is a significant improvement for this project.		
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 (11/5/19) Evaluation of Larval Pacific Lamprey Occupancy in Portland Harbor Superfund Area Restoration Sites, 2018 Annual Report (Skalicky et al. 2018)
7.	Abundance of larval lamprey in the mainstem Columbia River	No associated hydro project	Columbia	In 2019, the second year of seasonal sampling at three tributary mouths each above and below Bonneville Dam using a deepwater electrofisher was conducted. 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,	USFWS	Personal Communication with Joe Skalicky, USFWS (11/5/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Spring, and Summer. Preliminary results indicate a significant seasonal difference in larval lamprey densities in some 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 rewetting. 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. Results indicate that about 50% of the lampreys remain in sediments and 50% emerged from the burrows during dewatering. Dry electrofishing proved to be an effective method to induce lamprey out of dewatered sediments.	USFWS	Personal Communication with Joe Skalicky and Julie Harris, USFWS (11/5/19) Evaluation of changes in abundance and methods for salvage of larval lamprey during a “slow” water drawdown and dewatering in Leaburg Reservoir, OR. Final Report (Skalicky et al. 2019)
9.	Pacific lamprey passage assessments at manmade barriers	No associated hydro project	N/A	In June 2019, fishway and barrier assessments were conducted at 11 Washington Department of Fish and Wildlife (WDFW) hatcheries in the Lower Columbia Regional Management Unit (RMU) for adult Pacific lamprey. To date, the facilities evaluated thus far were found to have significant passage issues for lamprey.	USFWS	Personal Communication with Joe Skalicky (11/5/19)
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 and continued in 2019 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 (11/5/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
11.	Physiological response of larval Pacific lamprey to chronic temperature stress	No associated hydro project	N/A	<p>Freshwater habitats in the Pacific Northwest of the United States are becoming warmer due to climate change. The Pacific lamprey (<i>Entosphenus tridentatus</i>) 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 goal of this study is to establish the thermal thresholds for the larvae of this species and to determine the chronic effects of temperature on larval physiology. Juveniles collected from Mary's River in central Oregon were exposed to 90 days of heat stress to observe how larval lamprey respond. Along with growth and development data, a subset from each treatment was placed in respirometers to measure metabolic rate. Preliminary data indicates that these larvae are sensitive to thermal stress resulting in a loss of mass and length. Additionally, OSU is exploring the use of next generation RNAseq to identify genes responding to chronic thermal stress. Depending on the results, this study may point towards optimizing habitat parameters to facilitate the recovery of Pacific lamprey populations.</p> <p>Research is ongoing and has yet to be published</p>	OSU	Personal Communication with Patrick Carilli (10/25/19)
12.	Lamprey monitoring	No associated hydro project	Hood	<p>Density surveys for ammocoetes were conducted within Hood River during the fall months since 2017. In 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/m².</p> <p>In 2018, density surveys were conducted in Hood River, its three forks, and in Indian Creek. Survey efforts during the spring months discovered the presence of ammocoetes in Indian Creek.</p> <p>In 2019, ammocoete surveys for distribution and densities in Hood River were completed. The</p>	CTWS	<p>Personal communication with Cyndi Baker, CTWS (10/28/19)</p> <p>Evaluate Status and Limiting Factors of Pacific Lamprey in the Lower Deschutes River, Fifteenmile Creek and Hood River (Johnsen and Baker 2017)</p>

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				distribution of Pacific lamprey in East Fork Hood River has remained the same since 2018. Data have not been entered for densities to be calculated. During October, lamprey salvage was done at two sites on East Fork Hood River and one on Odell Creek.		
13.	Nest surveys for Pacific lamprey	No associated hydro project	Entiat	USFWS conducted a second year of Pacific lamprey nest surveys to define spawning period and locations. Nests were enumerated and marked using GPS. Report in progress.	USFWS	Personal communication Ann Grote (10/28/19)
14.	Lamprey artificial propagation	No associated hydro project	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 2019, the Yakama Nation focused on rearing larvae to grow larger in lower densities. A feeding experiment was conducted starting in October 2019 using 20 aquarium tanks using artificially propagated larvae from 2018 and this is ongoing. A summary of the 2018-2019 overwintering adult maturation study is provided in Appendix 4.2 of the 2018 BOR Annual Report (see the Source column). A study on the stable isotope ratios of artificially propagated larval lampreys and their feed and water was conducted in partnership with Thomas Evans from Cornell University and was published 2019. Abernathy Fish Technology Center was able to produce a few dozen metamorphosed (eyed) lamprey from Yakama Nation artificially propagated larvae in late summer 2019, so plans are underway to test and compare these juveniles with wild juveniles collected from the field.	Yakama Nation, CTUIR, NOAA Fisheries, USFWS, Chelan County PUD	Personal communication with Ralph Lampman, Yakama Nation (11/12/19) An overview of adult Pacific lamprey translocation, artificial propagation, and a sexual maturation study. 2018 BOR Annual Report, Appendix 4.2 (Lumley and Lampman 2019a) Comparison of stable isotope ratios in larval Pacific lamprey tissues and their nutritional sources when reared on a

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						mixed diet (Evans and Lampman 2019)
15.	Lamprey artificial propagation	No associated hydro project	N/A	A review paper manuscript was submitted recently to Journal of Great Lakes Research describing a blue print for the production of 1,000 macrophthalmia (eyed juvenile) through artificial propagation and is currently in review.	Yakama Nation, CTUIR, NOAA Fisheries, USFWS	Personal communication with Ralph Lampman, Yakama Nation (11/12/19) Lamprey aquaculture successes and failures: A path to production for control and conservation (Lampman et al. in press)
16.	Lamprey artificial propagation	No associated hydro project	N/A	Artificial propagation of lampreys was first developed to produce specimens for the study of evolutionary development in vertebrates. In recent years, artificially propagated larvae have been used to improve identification methods for native lamprey species, to study invasive sea lamprey <i>Petromyzon marinus</i> in the Laurentian Great Lakes and to provide animals for genomic studies, and for restoration and conservation research. In the course of developing methods for lamprey cultivation, insights into lamprey behavior, biology, genetics, and early life history have been gained. Broodstock holding has indicated that adult lampreys can be kept at extremely high densities when provided with cold, oxygenated water. Sexual maturation is controlled primarily by temperature, but may be affected by photoperiod, the presence of other lampreys, and suitable substrate. Fertilization and incubation experiments have revealed that gamete	NOAA Fisheries, CTUIR, USFWS, Yakama Nation	Lamprey Reproduction and Early Life History: Insights from Artificial Propagation (Moser et. al 2019)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				contact times are very short and that embryos are resilient to low flow, poor water quality, or variable substrates. Early larvae are also resilient to these factors and can tolerate abrupt changes in temperature and extended periods of starvation. However, they cannot survive sudden changes in water quality, excessive disturbance, and lack of adequate burrowing media. These observations have resulted in more efficient and effective lamprey propagation and have yielded important information about the early life stage requirements of lampreys in the wild. Further study is needed on a broader array of species to allow inter-specific comparisons of early life history. However, information from lampreys receiving the most attention to date (European river lamprey <i>Lampetra fluviatilis</i> , sea lamprey, and Pacific lamprey <i>Entosphenus tridentatus</i>) indicates that culture and environmental requirements of the early life stages are remarkably similar, allowing generalization across species.		
17.	Pathogen prevalence in Lamprey	No associated hydro project	N/A	Pacific lamprey (<i>Entosphenus tridentatus</i>) is a First Food of Native Americans. Declines in lamprey abundance due to dam construction and habitat loss have curtailed traditional harvest opportunities. Artificial propagation is an emerging recovery tool for this imperiled species, and other lamprey species in Finland and Japan. To manage disease risk at prospective lamprey hatcheries, it is critical to understand the pathogens and parasites most likely to affect lamprey and other fish, both in culture and in the wild. Data from regional fish health laboratories was assembled to assess pathogen prevalence in Pacific lamprey sampled from various sources (518 adults, 275 larvae, and one juvenile). In adults, <i>Aeromonas salmonicida</i> was identified using standard health screening methods in 0–69% of dead lamprey samples submitted, but no other pathogens were typically observed. All larvae were negative for bacterial and	CTUIR, NOAA Fisheries, USFWS, Yakama Nation	Occurrence of pathogens in Pacific lamprey (<i>Entosphenus tridentatus</i>) (Jackson et al. 2019)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				viral infections, and larvae experimentally exposed to <i>A. salmonicida</i> showed no infection or mortality. Conspicuously absent were detailed health assessments for metamorphosed larvae (juveniles). However, external examinations of over 20,000 juveniles captured at dams on the lower Columbia River indicated that they are susceptible to fungal infection in warm water conditions (12 C), which can lead to mortality. To fully evaluate the disease risk associated with lamprey culture, directed research is needed along with standardized health screenings of lamprey at all life stages. Control of <i>A. salmonicida</i> , the etiological agent for furunculosis, will be a top priority for Pacific lamprey use, as this was the only pathogen regularly identified in this species.		
18.	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. Updated information was not available at time of reporting.	CTGR	Personal communication with Torey Wakeland, CTGR (10/19/18)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
19.	Collection of adult lamprey for translocation, artificial propagation and radio-telemetry studies	No associated hydro project	Umatilla	<p>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.</p> <p>Updated information was not available at time of reporting.</p>	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/2/18)
20.	Collection of adult lamprey for translocation, artificial propagation and radio-telemetry studies	No associated hydro project	Yakima, Wenatchee, Methow, Klickitat	<p>In 2019, the Yakama Nation collected adult lamprey from Lower Columbia River mainstem dams. In total, 1,042 adults were captured and transported to the Prosser Fish Hatchery (Prosser, WA). These fish will be used for translocation programs in the Yakima, Wenatchee, Methow, and Klickitat subbasins; to support supplementation; PIT tag assessments; and to support artificial propagation research. A 2018 Report is currently available and a 2019 Report will be available in 2020.</p>	<p>Yakama Nation</p> <p>Yakama Nation Adult Pacific Lamprey Collection in the Columbia River Basin, 2018. BOR/BPA 2018 Annual Report Appendix 1.1/K1 (Lampman 2019a)</p>	Personal communication with Ralph Lampman, Yakama Nation (11/12/19)
21.	Trap and transportation of adult Pacific lamprey	Priest Rapids Dam	Columbia	From August 6 to September 17, 2019, Grant PUD successfully collected a total of 263 adult Pacific lamprey from the fish ladders at Priest Rapids Dam and transported them upstream of Rock Island Dam to meet	Grant PUD	Personal communication with Mike

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				and fulfill its' No Net Impact Statement of Agreement (SOA) with the Priest Rapids Fish Forum (PRFF).		Clement, Grant PUD (10/8/19)
22.	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 9 and August 23, 2019, 150 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 (09/23/19)
23.	Habitat restoration and effectiveness monitoring	No associated hydro project	Methow, Chewuch, and Twisp Rivers	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 2013-2019. Several of the sites included in this monitoring effort have undergone shifts in habitat presence, including the loss of Type 1 larval rearing habitat, so specific sampling sites have changed to account for this shift to ensure habitat sampled includes Type 1 habitat. Methow Salmon Recovery Foundation (MSRF) continues with larval status and trend monitoring at six sites (3 in Methow and 3 in Chewuch) with field	MSRF, and Yakama Nation	Personal communication with John Crandall, Methow Salmon Recovery Foundation (10/29/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				assistance from Yakama Nation. Additional sites monitored for larval presence in 2019 included several sites in both the upper Methow and Twisp Rivers. These sites were sampled, in part, to assist in the determination of the effectiveness of the adult translocation efforts conducted by the Yakama Nation. Larval presence has been documented in both areas which is a shift from pre-translocation where no larvae were observed in these areas. Final report will be completed in 2020 and will include all relevant data for Methow Pacific lamprey including Wells Dam counts and screw trap catch.		
24.	eDNA marker for Pacific lamprey and occurrence probability maps	No associated hydro project	Multiple watersheds	<p>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:</p> <ol style="list-style-type: none"> 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. 	U.S. Forest Service (USFS), National Genomics Center for Wildlife and Fish Conservation, and multiple partners	eDNA for Pacific Lamprey Conservation. Webinar Presentation for Pacific Lamprey Conservation Group. USFS (Carim et al. 2018)
25.	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	<p>A total of 26 electrofishing sites were surveyed for larval Pacific lamprey within the Klickitat (1 site), Yakima (20 sites), Wenatchee (5 sites) and Entiat (1 site) subbasins.</p> <ul style="list-style-type: none"> • In the Klickitat River, the estimated density of Pacific lamprey are present upstream of the hatchery weir. However, seasonal passage efficiency over the weir is unclear. • In the Yakima Subbasin, larval lampreys were found at 14 of 16 (60%) of surveyed sites. Pacific lamprey were found at all 14 sites where lampreys were present. 	Yakama Nation, USFWS	<p>Personal communication with Ralph Lampman, Yakama Nation (11/12/19)</p> <p>Yakama Nation Ceded Lands larval lamprey monitoring report, 2018. BPA 2018 Annual Report</p>

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<ul style="list-style-type: none"> • In the Upper Wenatchee Subbasin (upstream of Tumwater Dam, river km 49.6), Pacific lamprey densities were highest in Nason Creek (4.5 #/m2), compared to the mainstem Wenatchee River (up to 4.1 #/m2). No lamprey were found in the Chiwawa River. • In 2018, Entiat River had the highest estimated density of Pacific lamprey (11.5 #/m2). • In the Methow Subbasin, young of the year lampreys were found at five of seven index sites suggesting successful spawning of adult Pacific lamprey translocated into the subbasin in Fall of 2017 and (or) Spring of 2018. <p>In the Methow Subbasin, YN assisted the electrofishing sampling led by John Crandall (see Activity #23), and also conducted surveys at additional sites.</p> <p>A separate report focused on the analysis and trend of past data from 2012-2018 surveys within the Wenatchee Subbasin. Finally, one report was also submitted summarizing the presence of freshwater mussels detected from various larval lamprey monitoring sites. Reports from 2018 are currently available and 2019 Reports will be available in 2020.</p>		Appendix C1 (Beals et al. 2019a) Summary of Yakama Nation Fisheries larval lamprey electrofishing surveys in the Wenatchee Subbasin (2012- 2018). BPA 2018 Annual Report Appendix L1, (Beals and Lampman 2019a) Summary of freshwater mussel sightings within the Yakama Nation Ceded Lands during larval lamprey habitat surveys (2014-2018). BPA 2018 Annual Report Appendix L3 (Beals 2019)
26.	Larval Pacific lamprey distribution	No associated hydro project	Wenatchee and Okanogan	In 2019, the Mid-Columbia Fish and Wildlife Conservation Office conducted combined electrofishing and eDNA sampling for Pacific lamprey in Mid-Columbia River tributaries. Analysis and reporting for this work is ongoing.	USFWS	Personal communication with Ann Grote, USFWS (10/28/19)
27.	Lamprey marine ecology	No associated hydro project	NE Pacific ocean	Pacific lamprey during their marine phase were collected in 2017, 2018, and 2019 by fishery observers	NOAA Fisheries	Personal communication

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				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 and eye lens [Jessica Miller and Keala Pelekai, OSU]), and latitudinal and depth distributions. Two individuals (1 each in 2017 and 2018, 2 in 2019) caught by the Northwest Fisheries Science Center (NWFSC) hake survey were PIT tagged, and released.	NWFSC, Columbia River Inter-Tribal Fish Commission (CRITFC), OSU	with Laurie Weitkamp, NOAA Fisheries (9/20/19)
28.	Traditional ecological knowledge on Pacific lamprey	No associated hydro project	Yakima	Within the past several years, the Yakama Nation (YN) Pacific Lamprey Project 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 harvest, preparation, and consumption by Yakama Nation tribal members across the wide-ranging Ceded Lands. The two interviewees (Russel Jim and Elmer Shuster) 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	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/12/19) Yakama Nation Cultural Oral Interviews on Asum (Lamprey Eels): Summary and Review Part IV (2018). BPA 2018 Annual Report Appendix M1 (Goudy and Lampman 2019)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				2018 Report is currently available and a 2019 Report will be available in 2020.		
29.	Lamprey identification guide	No associated hydro project	N/A	<p>Through several years of conducting lamprey identification in the lower, mid, and upper Columbia watersheds, and confirmation through genetic methods, separate categories of <i>Lampetra</i> species, Class A and Class B (which are genetically distinct) were found.</p> <p>Most lamprey biologists are able to distinguish Class A as <i>Entosphenus</i> as there is a difference in both the caudal fin and caudal ridge. But Class B <i>Lampetra</i> have speckles on the caudal fin and can be very confusing (many biologists will actually ID them as <i>Entosphenus</i>, including the YN team in the earlier years). This field lamprey ID guide was included in the BPA 2017 Annual Report as Appendix L1.</p> <p>Research on the relationship between Class A and Class B <i>Lampetra</i> and between Western Brook Lamprey and Western River Lamprey is ongoing. More work is in progress on this issue. Lamprey ID guides for Alaska State and BC Canada regions are in draft forms and will be available in 2020.</p>	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/12/19)
30.	Review and call for standard terminology	No associated hydro projects	NA	<p>An essay was published in Fisheries Magazine titled “A call for Standard Terminology for Lamprey Life Stages.”</p> <p>The essay published by Benjamin Clemens of the Oregon Department of Fish and Wildlife and Oregon State University, discusses the use of various terminology to describe the life stages of Lamprey, and proposes the consolidation of terms from 11 to seven terms. The seven terms are provided below:</p> <ul style="list-style-type: none"> • Embryo – fertilized egg, • Pro-larva – recently hatched larva that feed endogenously with egg sac, 	Oregon Department of Fish and Wildlife	A call for Standard Terminology for Lamprey Life Stages (Clemens 2019)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<ul style="list-style-type: none"> • Larva – immature, filter-feeding individuals without eyes, • Transformer – stage between larva and juvenile – for parasitic lampreys or between larva and adults for non-parasitic, brook lampreys, • Juvenile – transformed individuals with eyes that are ready to feed, • Adult – non-feeding, pre-spawn individuals that are actively migrating upstream to spawning ground and are in various stages of sexual maturation, • Senescent – post-spawn individual in the process of dying. 		
31.	Review translocation efforts and genetic analysis	No associated hydro projects	Columbia	The CRITFC member tribes have been conducting translocation of Pacific lamprey for nearly twenty years. The CTUIR began translocation in 2000, followed by the Nez Perce Tribe (2006) and the Yakama Nation (2010). Lamprey are collected at the mainstem dams (BON, TDA, JDA) and transported to the member tribes holding facilities where they are held overwinter and released when they are near maturation. Some fish are collected and released the same year as collection. The member tribes conduct parentage-based tagging, and since 2013 have tagged ~100% of all adult lamprey used for translocation. The Tribes also collect samples for analysis of larval lamprey that are collected in fish surveys and at screw traps. The Warm Springs Tribe does not translocate; however, they collect genetic samples from adult, juvenile, and larval lamprey at the Deschutes, Fifteenmile Creek, Willamette River and tributaries. Other locations where we collect tissue samples are the JDA dam smolt monitoring facility, the mortalities from the lower Snake River dams, and as incidental catch in the NOAA fisheries hake surveys. These tissues are analyzed at the CRITFC Hagerman	CRITFC	Tracking the kids: Use of Parentage to Measure Success of Tribal translocation Programs for Pacific lamprey Restoration (Hess and Porter 2019)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Genetics lab in Idaho. From this vast array of tissues, we have been able to monitor the success of the translocation efforts and to compare the contribution of larval abundance from translocated vs volitional returns. Additionally, we have been able to look at population genetic structure, body size correlations to migration distance, dispersal rates of fish of known origin, and ocean distribution of geo stocks. This presentation provides a summary of what we have learned from the genetics analyses up to this point and what we expect to learn in the future.		
	<u>Lamprey Migration in Rivers</u>					
32.	Juvenile lamprey outmigration monitoring	No associated hydro project	Umatilla	<p>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 monitoring shows continued increases since initiating translocation.</p> <p>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.</p> <p>CTUIR plans to tag juvenile lamprey from screw trap operations during the 2018-19 winter operation to evaluate irrigation diversion entrainment rates.</p> <p>Updated information was not available at time of reporting.</p>	CTUIR, and NOAA Fisheries	Personal communication with Aaron Jackson, CTUIR (11/2/18)
33.	Larval / juvenile lamprey surveys in irrigation diversions	No associated hydro project	Yakima, Wenatchee	The Yakama Nation Pacific Lamprey Project (YN) has been active annually in October/November surveying dewatered irrigation canals within the Yakima and Wenatchee subbasins for larval / juvenile lamprey within these diversions. A lab study was also conducted	Yakama Nation / Pacific Northwest National	Personal communication with Ralph Lampman,

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>in partnership with USGS and WDFW. A manuscript regarding the deep water shocking was also submitted in 2019, but is currently in review. Reports from 2018 are currently available and 2019 Reports will be available in 2020.</p> <p>Additional relevant sources include (all appendices from BOR / BPA 2018 Annual Reports):</p> <ul style="list-style-type: none"> - Summary Assessment of Larval/Juvenile Lamprey Entrainment in Irrigation Diversions within the Yakima Subbasin, 2018. Appendix 3.1 / D1 (Beals et al. 2019b) - Intensive Monitoring of Larval/Juvenile Lamprey Entrainment in the Yakima Subbasin, 2018. Appendix 3.2 / D2 (Beals and Lampman 2019b) - Experimental sprinkler system for reducing larval lamprey mortality during irrigation diversion dewatering events - highlights and lessons learned. Appendix 3.5 / D3 (Beals and Lampman 2019c) - Implementation of a simulated perennial side channel flow regime in the Wapatox Diversion (Naches River) to protect high densities of larval/juvenile lampreys. Appendix 3.6 / D4 (Beals and Lampman 2019d) 	Laboratory (PNNL)	<p>Yakama Nation (11/12/19)</p> <p>Effectiveness of fish screens in protecting lamprey (<i>Entosphenus</i> and <i>Lampetra</i> spp.) ammocoetes—pilot testing of variable screen angle (Liedtke et al. 2019a)</p> <p>Also, see the four appendix reports listed in the “Results” section</p>
34.	Juvenile lamprey outmigration monitoring	Sunnyside, Wapato, Chandler diversion dams	Yakima	In 2019, 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. PIT tagged juvenile/larval lampreys were released in various locations between mid-Yakima River to lower Yakima River in 2018. The	Yakama Nation, USGS, and BOR	<p>Personal communication with Ralph Lampman, Yakama Nation (11/12/19)</p> <p>Survival assessment of</p>

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>detection analysis is ongoing. A final report will be available in 2019.</p> <p>In addition, in spring of 2019 a pilot acoustic telemetry project (year 2) was conducted for juvenile lamprey collected 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. The first report summarizing 2018 data is available and a 2019 report will be available in 2020.</p>		juvenile Pacific lamprey implanted with a dummy acoustic tag for a Yakima Basin acoustic telemetry study. Appendix 3.3 / H1 (Beals et al. 2019c) Movements of juvenile Pacific lamprey (<i>Entosphenus tridentatus</i>) in the Yakima and Columbia Rivers, Washington, 2018 - a pilot study using acoustic telemetry (Liedtke et al. 2019b)
35.	Effects of dewatering on movements and survival of cultured larval lamprey vs. recently captured	No associated hydro project	Columbia and Snake	<p>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.</p> <p>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.</p>	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

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				As of October 2017, lab testing has been completed and data are being summarized and integrated with Liedtke et al. 2015 and 2019 activities to report findings in a combined manuscript.		with Lisa Weiland, USGS (10/01/19)
36.	Migration data from translocated adults	No associated hydro project	Yakima, Wenatchee, Methow, Klickitat	This project is composed of two parts: 1) summary of all 2018-2019 broodstock adult Pacific lamprey releases within the Yakima, Wenatchee, Methow, and Klickitat subbasins and 2) analysis of migration data from those adults that were PIT tagged. From the 2018-2019 broodstock (adults collected in summer 2018 that primarily matured in 2019), adult Pacific lamprey were released in the fall of 2018 and spring of 2019 in the aforementioned four subbasins. From the 2019-2020 broodstock (adults collected in summer 2019 that primarily mature in 2020), adult Pacific lamprey were released in the summer of 2019 and another release is scheduled in spring of 2020 in the aforementioned four subbasins. Reports from 2018 are currently available and 2019 Reports will be available in 2020.	Yakama Nation, USFWS, and Colville Tribe	Personal communication with Ralph Lampman, Yakama Nation (11/12/19) Translocation of Adult Pacific lamprey within the Yakima Subbasin, 2017-2018 Broodstock. BOR / BPA 2018 Annual Report Appendix 1.1 / G1. (Lampman 2019b) Translocation of Adult Pacific lamprey within the Wenatchee Subbasin, 2017-2018 Broodstock. BPA 2018 Annual Report Appendix G2 (Lampman 2019c) Translocation of Adult Pacific lamprey within

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						the Methow Subbasin, 2017-2018 Broodstock. BPA 2018 Annual Report Appendix G3 (Lampman 2019d)
37.	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 tagged at Sherars Falls showed adult lamprey continued using the LPS in 2019.	USFWS, and CTWS	Personal communication with Joe Skalicky, USFWS (11/05/19)
38.	Devaluating dewatering approaches to protect larval Pacific Lamprey	No associated hydro project	Columbia and Snake	In 2019, controlled laboratory experiments comparing five dewatering rates (1, 1.8, 4, 8, and 16 in/h) and two light conditions (day vs. night) were conducted to define effective dewatering approaches. Pacific lamprey for testing were collected from a tributary of the Columbia River. A tank with a simulated shoreline was used at a 10-percent (5.7 degree) slope, filled with river sediment. Outflow was manipulated to control the rate of dewatering. Following each dewatering event fish were classified as either stranded (in or on the substrate outside of the watered area) or safe (relocated to the wetted area at the lower end of the tank). Three replicate trials were completed for each rate and light condition. Lamprey responses to a series of dewatering and re-watering events were also investigated. Individual larvae were held in cylinders and exposed to four cycles of dewatering and re-watering using dewatering rates of 1 and 16 in/h. The location of fish, either on the surface of the sediment or burrowed was recorded after each dewatering event. Each dewatering rate was replicated	USGS	Personal communication with Lisa Weiland, USGS (10/01/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>twice under both day and night conditions. Results will help inform best management practices on dewatering rates and light conditions to help protect larval Pacific lamprey.</p> <p>Lab testing has been completed, data are being summarized and a final report is in progress.</p>		
	<u>Adult Passage at Hydroelectric Facilities</u>					
	<i>Structural and Operational Fishway Modifications</i>					
39.	Conduct ladder tours	All Army Corps of Engineers (ACOE) projects	Columbia and Snake	<p>Completed a tour of fish ladders with regional fish managers and researchers to identify potential minor fishway modification opportunities.</p> <p>No tours (for this purpose) were given at Portland District dams in 2019, though ACOE staff did hold several project-specific site visits.</p> <p>No tours were given at Walla Walla District dams in 2019.</p>	ACOE	Personal communication with Sean Tackley, Ricardo Walker, ACOE (10/15/19) and Steve Juhnke, ACOE (9/24/19)
40.	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 2019, 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 (10/08/19)
41.	Design LPS for Prosser Dam	Prosser, Sunnyside, Wapato, Horn Rapids dams	Yakima	New vertical wetted wall (VWW) passage structures were installed at Prosser Dam on the center ladder and the existing passage structures on the left ladder were converted to a volitional passage structure using 4 inch smooth flexible PVC tubes. A new video monitoring station was installed and a variety of tests and	Yakama Nation, USFWS, and BOR	Personal communication with Ralph Lampman, Yakama Nation (11/12/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>modifications were implemented to improve passage and motion detection. A flow rate study and video monitoring are ongoing.</p> <p>Passage structure designs for Sunnyside and Wapato diversions were completed in the summer of 2019. Implementation is scheduled for 2020.</p>		<p>2018 BOR Annual Report: Yakima River Prosser Dam Vertical Wetted Wall Lamprey Passage Structure. Appendix 1.2 (Lampman 2019e)</p> <p>Vertical wetted walls: How to make them work the “dam” best? Appendix 1.3 (Lampman 2019f)</p>
42.	Passage improvement design	McNary	Columbia	<p>A prototype adult lamprey passage structure was installed in Oregon shore ladder (SFE2) in February 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.</p> <p>In 2019, the lamprey passage structure was modified from the existing prototype design. The ported hood box was removed and altered to reduce the size (depth) of the entrance component, then re-installed by divers. Additional modifications included the removal of the knife gate closure mechanism, and inspection ports were installed in the baffle box section. The modifications are not expected to change the flows through the structure or the attraction flume in the tailrace, so no further evaluations are planned.</p>	ACOE	<p>Personal communication with Steve Juhnke, ACOE (9/24/19)</p> <p>Evaluation of Adult Fish Ladder Modifications to Improve Pacific Lamprey Passage at McNary and Ice Harbor Dams, 2014 (Thompson et al. 2015)</p> <p>Evaluation of Adult Fish Ladder Modifications to Improve Pacific</p>

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						Lamprey Passage at McNary Dam, 2015 (Thompson et al. 2016)
43.	Passage improvement design	Ice Harbor	Snake	<p>In January 2019, an adult lamprey passage structure was installed in the Ice Harbor south fish ladder entrance (SFE2). The structure consists of a removable entrance component and a baffle box component. The design allows for the bottom telescoping weir to be raised 12" to provide a low water column entrance into the fish ladder. The entrance component is lowered into the bulkhead slot and can be removed for dewatering purposes. The baffle box component is mounted to the fishway floor and provides slower water velocity (approx. 4 fps) for aiding passage into the ladder.</p> <p>Evaluation of this passage structure began in July 2019 and will continue through October 2019. The purpose of the evaluation is to show adult lamprey are attracted to and enter the structure. Additionally the evaluation is determining if adult salmonids are attracted and attempt to enter the structure, causing harm or delay. Although the results are very preliminary, there has been minimal salmonid attraction as well as light usage by adult lamprey. More information will be available at the conclusion of the evaluation.</p>	ACOE	Personal communication with Steve Juhnke, ACOE (9/24/19)
44.	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 (10/08/19)
45.	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	ACOE	Personal communication with Sean Tackley and Ricardo Walker, ACOE (10/15/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				through gratings when stranded; and adequate personnel and equipment to ensure timely salvage. This is an ongoing action.		
46.	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 with Chas Kyger, Douglas PUD (9/23/19)
47.	M Standardized Fishway 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 (11/4/19)
48.	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 (10/08/19)
49.	Operate old fishway for lamprey passage	Willamette Falls	Willamette	<p>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.</p> <p>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</p>	PGE	Personal communication with Nick Ackerman, PGE (9/24/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>over the 3.5 ft flashboards. Ramps are generally installed in early summer and removed mid-September.</p> <p>In 2019, Portland General Electric (PGE) continued to operate the “old fishway” and install lamprey ramps to facilitate adult lamprey passage at Willamette Falls Dam.</p>		
50.	Passage design elements for new fishway construction	Carmen-Smith (Trail Bridge Dam)	McKenzie	<p>As part of the implementation of the Carmen-Smith Project Federal Energy Regulatory Commission (FERC) license (issued May 2019), 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.</p> <p>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.</p>	EWEB	Personal communication with Andy Talabere, EWEB (10/16/2019)
51.	Reduce water velocities at fishway entrances	Bonneville and The Dalles	Columbia	<p>Continued reduced nighttime flow operations at the Washington Shore Fish Ladder during the lamprey passage season to improve lamprey passage efficiency.</p> <p>In 2018 and 2019, as part of an ACOE-funded radiotelemetry 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. In general lamprey entrance efficiency improved however it did not result in a significant increase in dam passage efficiency.</p>	ACOE	<p>Personal communication with Sean Tackley and Ricardo Walker, ACOE (10/15/19)</p> <p>Adult Pacific lamprey passage at the four lower Columbia River Dams and lamprey behaviors in relation to nighttime fishway velocity reductions at Bonneville and The Dalles dams</p>

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						and the new UMTJ-LPS at Bonneville Dam, 2018. (Clabough et al., 2019)
52.	Lift picket leads at count station	Bonneville	Columbia	<p>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 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).</p> <p>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.</p> <p>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.</p>	ACOE	Personal communication with Sean Tackley and Ricardo Walker, ACOE (10/15/19)
53.	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 and Ricardo

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						Walker, ACOE (10/15/19)
54.	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 and Ricardo Walker, ACOE (10/15/19)
55.	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 (9/24/19)
56.	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 Hemstrom, Chelan PUD (11/4/19)
57.	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 (10/08/19)
58.	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.	ACOE and NOAA Fisheries	Personal communication Sean Tackley and Ricardo Walker, ACOE (10/16/19) Climbing Success of Adult Pacific Lamprey on a Vertical Wetted Wall (Frick et al. 2017)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				The ACOE field tested this climbing structure in the Bonneville Dam Bradford Island fishway in 2018 and 2019. Post-construction monitoring results from NOAA researchers are pending but fish have been observed using the structure.		
59.	Design and construct rounded caps and plating for fishway entrance weirs	Bonneville, The Dalles, John Day	Columbia	<p>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.</p> <p>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 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.</p> <p>Caps were fabricated and installed by ACOE staff at the following locations:</p> <ul style="list-style-type: none"> • 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). 	ACOE	Personal communication with Sean Tackley and Ricardo Walker, ACOE (10/16/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>The ACOE installed similar structures at the following locations in the winter 2018-19)</p> <ul style="list-style-type: none"> • Bonneville Washington Shore Fish Ladder North Downstream Entrance (NDE) and North Upstream Entrance (NUE); • The Dalles East Fish Ladder – Entrances E1, E2 and E3. <p>Entrance weir submergence criteria and existing configurations preclude installation of similar weir caps at Bonneville Bradford Island Ladder and the John Day South Ladder.</p>		
60.	Design and construct fishway modifications to improve lamprey passage conditions in serpentine weir (control) section of fishways	Bonneville	Columbia	<p>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.</p> <p>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.</p> <p>Results from post-construction monitoring at the Washington Shore and Bradford Island Ladders are summarized in Gallion et al. (2018 and 2019). Based on results, orifices were cut through the remaining north side weirs in the control section of the Bonneville Washington shore fish ladder.</p>	ACOE	<p>Personal communication with Sean Tackley and Ricardo Walker, ACOE (10/16/19)</p> <p>Underwater video monitoring of slot orifices installed to 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)</p>

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						Underwater video monitoring of slot orifices installed to improve Pacific lamprey passage at Bonneville Dam's Bradford Island Fish Ladder. U. S. Army Corps of Engineers, Portland District Fisheries Field Unit. Cascade Locks, OR (Gallion et al. 2019)
61.	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: <ol style="list-style-type: none"> 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 	ACOE	Personal communication Sean Tackley, and Ricardo Walker ACOE (10/16/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>HDX-PIT); other mods as needed. Completed in Winter 2016-17.</p> <p>3. Bonneville Bradford Island Ladder LPS – Extend exit chute into forebay to reduce fallback risk; counting system improvements; integrate HDX-PIT and FDX-PIT detection capability; other mods as needed. Completed in Winter 2017-18.</p> <p>4. Bonneville Cascades Island Ladder Entrance LPS – Various small-scale improvements. Completed in Winter 2017-18.</p> <p>5. Bonneville Adult Fish Facility ladder Installed a LPS to collect adult lamprey for translocation and research in 2018.</p> <p>6. John Day North Ladder Entrance LPS – Various small-scale improvements. Planned for Winter 2018-19 construction.</p> <p>A post-construction radio-telemetry study by the University of Idaho is being conducted in 2018 and 2019 (see line items #65, #66 and #67 in this Table 5 for preliminary results).</p>		
<i>Project Passage Effectiveness</i>						
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 (10/08/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>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 2019, 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 were completed and included in the 2018 PLMP annual report.</p> <p>2019 monitoring results are included in the summary section of this report.</p>		
63.	Evaluate passage at LPS structures	Threemile Falls Dam, Maxwell and Feed diversions	Umatilla	<p>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.</p> <p>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.</p> <p>Zero adult lamprey used the LPS at Feed Diversion.</p> <p>Dillon diversion was removed in summer 2017, and the Brownell Diversion was removed in summer 2018.</p> <p>Updated information was not available at time of reporting.</p>	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/01/18)
64.	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,	PGE	Personal communication with Nick

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>up to 400 adult Pacific lamprey will be trapped at River Mill Dam and hauled 14 km upstream to North Fork Reservoir. In each of the first two years 25 of the lamprey hauled upstream were radio-tagged and tracked. Maximum upstream migration distance ranged from 0.6 to 43.3 km above North Fork Reservoir. Fish remained in the mainstem Clackamas River below the confluence of the Collawash River except for one fish detected approximately 4 km upstream in the Collawash River.</p> <p>In addition, passage through the North Fork ladder is evaluated with 100 PIT-tagged adult lamprey each year. Tagged lamprey are captured at River Mill Dam and released into the River Mill forebay. Subsequent passage rates through the North Fork ladder varied between 0% and 21% between 2015 and 2019.</p>		Ackerman, PGE (9/24/19) Pacific Lamprey Upstream Passage Evaluation, 2017-2018 Annual Report [draft] (Ackerman 2019)
65.	Adult lamprey radiotelemetry study	Bonneville, The Dalles, John Day, McNary	Columbia	In 2019, 449 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.	ACOE and University of Idaho	Personal communication with Chris Caudill, University of Idaho (10/16/19)
66.	Adult lamprey HD-PIT study	Federal Columbia River Power System	Columbia and Snake	In 2019, 314 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	ACOE and University of Idaho	Personal communication with Chris Caudill,

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				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 (10/16/19)
67.	Adult lamprey flume study	No associated hydro project	N/A	In 2019, 218 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., 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, 44 fish were tagged with HD-PIT tags and accelerometer tags for: 3) the use of biotelemetry 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.	ACOE and University of Idaho	Personal communication with Chris Caudill, University of Idaho (10/16/19)
<i>Lamprey Counts at Dams</i>						
68.	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	ACOE	Personal communication with Sean Tackley and Ricardo Walker, ACOE (11/13/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>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.</p> <p>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 (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.</p>		
69.	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 (9/23/19)
70.	Conduct 24-hour lamprey counts	Rocky Reach, Rock Island	Columbia	On-going 24-hour fishway counts of Pacific lamprey since the late 1980s.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (11/4/19)
71.	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 (10/08/19)
72.	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 in the center ladder and new volitional passage routes were added to the left ladder in 2019;	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/12/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				counts from these lamprey specific structures are tallied separately from the fishway window counts.		
<i>Predation</i>						
73.	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)
<u>Juvenile Passage at Hydroelectric Facilities</u>						
<i>Structural and Operational Fishway Modifications</i>						
74.	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 (9/24/19)
75.	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 Ricardo Walker ACOE (10/16/19) and Steve Juhnke, ACOE (9/24/19)
76.	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 (9/23/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
77.	Continue fish 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 (11/4/19)
78.	Continue recovery 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 (10/08/19)
79.	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 (11/4/19)
80.	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 (10/08/19)
81.	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 escapement. 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,	EWEB	Personal communication with Andy Talabere and Andrew Janos, EWEB (10/17/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>2018. 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.</p> <p>Preliminary Results:</p> <p>Objective 1: Assess abundance and spatial distribution just before and just after the drawdown to identify any changes in distribution that occurred because of the drawdown and re-watering.</p> <p>Average density before drawdown was estimated at ~11.4 larvae/m² for an estimated ~13,000 individuals in the whole area of interest (1,100 m²). Average density after drawdown was estimated at ~2.5 larvae/m² for an estimated ~2,800 individuals in the whole area of interest. An assessment of how environmental factors impact larval distribution both before and after drawdown and how this may impact final estimates of average density and abundance is being prepared. Spatial analysis techniques will be used to better examine the distribution of larval lamprey in the area.</p> <p>Objective 2: Evaluate four sampling techniques for collecting larvae lamprey during a drawdown or similar dewatering event.</p> <p>Eight randomly selected locations were sampled using the three techniques. From all excavated quadrats combined, at total of 146 larval lamprey were collected. A total of 65 individuals or 45% of the burrowed lamprey emerged during dewatering; the remaining 81 individuals (55%) were collected during sediment sieving.</p>		

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>A total of 63 individuals emerged during dewatering in electrofishing quadrats; if that was also 45% of the total number, an expected ~79 individuals to be still in the sediment. A total of 69 individuals were collected by “dry” electrofishing (after multiple passes), suggesting around 88% of the individuals were collected in total.</p> <p>A total of 34 individuals were collected emerging during dewatering from the observation quadrats. Again assuming that was 45% of the total lamprey burrowed in those quadrats, ~42 individuals are expected to be remaining in the sediments. A total of 6 individuals (~14%) were observed emerging after dewatering was complete; suggesting that only ~14% of the remaining individuals emerged volitionally. There was a lot of variability among the different quadrats sampled using a given technique and an assessment is currently in process to understand how different factors may impact emergence and capture probability (i.e., for electrofishing).</p>		
<i>Project Passage Effectiveness</i>						
82.	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 and Ricardo Walker, ACOE (11/16/19) and Steve Juhnke, ACOE (9/24/19)
83.	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. Entrainment rate, impingement rate, release location, and fate of juvenile lampreys exposed to two different screen angles (12 and	USGS, WDFW and Yakama Nation	Personal communication with Lisa Weiland, USGS (09/24/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>20 degrees) were compared 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.</p> <p>Testing was completed in spring of 2018. A final report was published in 2019 and this work is now complete.</p>		Effectiveness of fish screens in protecting lamprey (<i>Entosphenus</i> and <i>Lampetra</i> spp.) ammocoetes – Pilot testing of variable screen angle. (Liedtke et al. 2019a)
84.	Juvenile Pacific lamprey acoustic telemetry studies	No associated hydro project	Columbia	<p>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.</p> <p>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 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.</p> <p>In addition the work included developing a Research, Monitoring, and Evaluation (RME) Plan to inform</p>	ACOE and PNNL	<p>Personal communication with Bob Mueller, PNNL (10/25/19)</p> <p>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)</p>

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				planning and prioritization for future juvenile Pacific lamprey passage investigations in the Columbia River.		
<i>Predation</i>						
85.	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)
86.	Predation control measures and gut sampling	Rocky Reach, Rock Island	Columbia	As part of its HCP obligations, Chelan PUD implements predation control on predators of juvenile salmonids, both fish and birds and bird predators; Chelan PUD uses this activity to achieve HCP survival standards for juvenile fish. This is an annual, ongoing suite of activities	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (11/4/19)
87.	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 (10/08/19)
88.	Predation potential of various native and non-native species to larval lamprey	No associated hydro project	Yakima	A manuscript was submitted to "Ecology of Freshwater Fish" in 2019, summarizing the predation study that was conducted at Prosser Hatchery using 10 species of native/non-native predator fishes. The genetic analysis of the consumed larvae in the guts of predators were also analyzed and a separate manuscript is being drafted for a manuscript submission.	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/12/19) An experimental study to evaluate

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						predation threats on two native larval lampreys in the Columbia River Basin, USA. (Arakawa and Lampman in press)
<u>Policy/Recovery Activities</u>						
89.	Develop/implement implementation plan for Pacific lamprey restoration	All ACOE projects	Columbia and Snake	<p>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.</p> <p>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.</p>	Nez Perce, Umatilla, Yakama and Warm Springs tribes	Tribal Pacific Lamprey Restoration plan for the Columbia River Basin (Nez Perce, Umatilla, Yakama, and Warm Springs Tribes 2011)
90.	Develop/implement Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research	No associated hydro project	Columbia (Mid and Upper)	<p>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</p>	HDR Engineering, Inc. (HDR), CRITFC, Yakama Nation, and CTUIR	<p>Personal communication with Ralph Lampman, Yakama Nation (11/12/19)</p> <p>Master Plan: Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research (CRITFC, Umatilla, Yakama, and Nez</p>

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				River Basin subbasins to achieve the stated, long-term goals identified in various lamprey planning documents and restoration efforts. The Master Plan was reviewed by the Independent Scientific Review Panel (Northwest Power and Conservation Council) in 2019 and received generally favorable reviews with some recommendations.		Perce Tribes 2018) Step 1 review of Pacific Lamprey Master Plan by Independent Scientific Review Panel for the Northwest Power and Conservation Council. 2018 BOR Annual Report, Appendix 4.1 (ISRP 2019)
91.	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 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.	ACOE	ACOE Pacific Lamprey Passage Improvements Implementation Plan, 2008-2018 (ACOE 2009; revised 2014)
92.	Develop/implement management plan for	Wells	Columbia	In 2010, a Pacific Lamprey Management Plan (PLMP) was filed as part of the Wells Hydroelectric Project	Douglas PUD	Wells Pacific Lamprey

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	Pacific lamprey restoration			<p>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.</p> <p>Implementation of some management plan activities is ongoing.</p>		Management Plan (Douglas PUD 2009)
93.	Develop/implement management plan for Pacific lamprey passage monitoring and improvement	Rocky Reach	Columbia	<p>On-going implementation of the PLMP that was developed and finalized in 2005.</p> <p>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.</p>	Chelan PUD	Rocky Reach Pacific Lamprey Management Plan (Chelan PUD 2005)
94.	Develop/implement management plan for Pacific lamprey restoration	Priest Rapids, Wanapum	Columbia	<p>On-going implementation of the PLMP that was developed, finalized, and approved by the PRFF, Ecology, and FERC in 2009.</p> <p>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.</p>	Grant PUD	Priest Rapids PLMP (Grant PUD 2009)
95.	Lamprey Technical Work Group <ul style="list-style-type: none"> • Passage Engineering Subgroup 	All ACOE projects, Wells, Rocky Reach, Rock	Columbia and Snake	The Lamprey Technical Work Group (LTWG) is a committee of the Pacific Lamprey Conservation Agreement. The purpose of the LTWG is to provide technical review, guidance, and recommendations for activities related to lamprey conservation and	USFWS	Personal communication with Christina Wang, USFWS (11/1/19)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	<ul style="list-style-type: none"> • Juvenile Entrainment and Dredging Investigations Subgroup • Restoration Subgroup • Genetics/eDNA Subgroup • Tagging Subgroup • Critical Uncertainties Subgroup 	Island, Priest Rapids		<p>restoration. The LTWG 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.</p> <p>The Passage Engineering subgroup updated the practical guidelines for incorporating adult Pacific lamprey passage at fishways. Available online: https://www.fws.gov/pacificlamprey/Documents/2019_09.10%20LampreyPsgFINAL.pdf</p> <p>The LTWG met on 12-11 and 5-14 in 2019.</p> <p>The LTWG hosted the 2nd Annual Lamprey Information Exchange Workshop in Portland on Dec 12-13, 2018. There were sessions covering ocean phase, recolonization/restoration, climate change/temperature, juvenile entrainment/dredging, and life history/behavior. Planning is underway for the 3rd Annual Workshop Dec 12-13, 2019 in Portland. Topics for this year's focal sessions are tribal ecological knowledge, management/regulatory, contaminants, species other than Pacific lamprey, and passage. https://www.fws.gov/pacificlamprey/LTWGMainpage.cfm</p> <p>The Restoration subgroup convened a session at the River Restoration Northwest Annual Symposium in Feb 2019. They also led a course on Lamprey Ecology and Management for Portland State University's Environmental Professional Program in May 2019.</p>		
96.	Pacific Lamprey Conservation Initiative	All ACOE projects	Columbia and Snake	Pacific Lamprey Conservation Agreement partners hosted the Policy Committee 5-Year Review on Dec 11 th in Portland.	USFWS	Personal communication with Christina

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				<p>Regional Management Unit (RMU) leads revised the Pacific Lamprey Assessment in 2018. Findings were presented at the 5-Year Review in December. The revised Assessment was released in February 2019. Available online: https://www.fws.gov/pacificlamprey/Documents/PacificLamprey_2018Assessment_final_02282019.pdf</p> <p>RMUs continued to work on Regional Implementation Plans (RIPs) for all RMUs in the Columbia and Snake rivers including the mainstem Columbia and Snake. Available online: https://www.fws.gov/pacificlamprey/PlansMainpage.cfm</p> <p>The Northwest Power and Conservation Council and Bonneville Power Administration's Pacific Lamprey Conservation Initiative Columbia Basin Projects funded \$240K in high priority lamprey projects from the RIPs in 2019.</p> <p>The Initiative/Pacific Lamprey Fish Habitat Partnership received National Fish Habitat Partnership \$85K in coordination funds in fiscal year (FY) 19. Those funds will be put towards hiring a coordinator.</p> <p>FY19 RIPs were presented to the Conservation Team on August 27, 2019. Projects were prioritized for F209 BPA funding.</p> <p>Initiative partners worked with the Oregon Zoo to open a Pacific lamprey exhibit in July 2019. ShowNews.cfm?ID=68EB-C78A-E600-EED0-CDC577472A04BF2D">https://www.fws.gov/news>ShowNews.cfm?ID=68EB-C78A-E600-EED0-CDC577472A04BF2D</p>		Wang, USFWS (11/1/19)
97.	Pacific lamprey outreach	No associated hydro project	Yakama	The Yakama Nation Fisheries Resource Management Program Pacific Lamprey Project (YN) has a duty to	Yakama Nation	Personal communication

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				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, visitors are 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. In 2018, through community events and hatchery tours, YN participated and/or organized 31 events, including adult lamprey translocation release events, summer camp hands-on field trips, presentations in classrooms, and hatchery tours. YN biologists and partners gave over 17 presentations at a variety of conferences and meetings, including Upper Columbia Science Conference, California Lamprey Passage Workshop, Annual Lamprey Information Exchange Workshop, and Sitka Whalefest. Local news and social network media, and various educational blogs continue to support outreach efforts and the YN used 17 sources to reach out to the general public. Altogether, over 4,203 students, 386 teachers, 1,356 agency workers, and 45,633 people from the general public, totaling over 51,578 people were reached. A Report from 2018 is currently available and a 2019 Report will be available in 2020.		with Ralph Lampman, Yakama Nation (11/12/19) Yakama Nation Pacific Lamprey Project Outreach and Education, 2018. BPA 2018 Annual Report Appendix E1. (Lumley and Lampman 2018b)

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

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 Tessellation Stratified

HCP = Habitat Conservation Plan

HDX = half-duplex

IDEM = Integrated daily escapement estimate

LPES = Lamprey Passage Entrance Structure
LPS = lamprey passage system/structure
LTWG = Lamprey Technical Work Group
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
RMU = Regional Management Unit
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
WDFW = Washington Department of Fish and Wildlife
WFUFP = Wanapum Future Unit Fish Bypass

YN = Yakama Nation

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 2019, 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 2019	Variation from Schedule (if applicable)
<u>Objective 1: Identify, address, and fully mitigate Project effects to the extent reasonable and feasible to achieve No Net Impact (NNI)</u>					
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, 2020.	No
<u>Objective 2: Provide safe, effective, and timely volitional passage for adult upstream and downstream migration</u>					
2.	Maintain adult fishways.	Annually for the period 2009-2019	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 – 2019	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 652 unique PIT tags at Priest Rapids and 647 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 2019	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 2009-2019	Yes	<p>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.</p> <p>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.</p>	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2019	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 fishway facilities during 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 2019	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 19% at Priest Rapids Dam over the 2010-2018 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 2015-2018 periods (2014 intentionally omitted).	Yes, ahead of schedule. An evaluation program was implemented in 2010 and was continued in 2019.
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 2019	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 5 th 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 10 th 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 Lamprey Technical Work Group (LTWG).	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
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

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2019	Variation from Schedule (if applicable)
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. While juvenile tag technology continues to advance, a scientifically-rigorous study methodology and model, and sufficient number of actively migrating juveniles in the mid-Columbia River is not available to effectively evaluate juvenile Pacific lamprey survival.	No
15.	Develop juvenile Pacific lamprey passage criteria	No later than 10 years following license issuance (2018)	Yes	None. At this time, a scientifically rigorous methodology and model, nor a sufficient number of actively migrating juveniles in the mid-Columbia River is not available to effectively evaluate juvenile Pacific lamprey survival.	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 LTWG.	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 2019	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	Per the PLMP requirement, Grant PUD implemented a PRFF approved study plan to determine juvenile lamprey presence / absence, habitat use, and relative abundance in areas affected by Project operations in 2012 and 2013. Additional sampling was completed in the Wanapum Reservoir in 2014 during the Wanapum fracture. Only a few lamprey were captured or observed during these surveys. Three years of sampling at varying reservoir elevations (2012-2014) have indicated that juvenile lamprey do not commonly occur within the Project operational zone (see Section 1.2 for additional details). A report addressing results from 2012-2013 was included as Appendix B in the 2016 annual report (Le et al. 2017).	No
Objective 1: Identify, address, and fully mitigate Project effects to the extent reasonable and feasible to achieve No Net Impact (NNI)					
18.	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, 2020.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2019	Variation from Schedule (if applicable)
Objective 2: Provide safe, effective, and timely volitional passage for adult upstream and downstream migration					
19.	Maintain adult fishways.	Annually for the period 2009-2019	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
20.	Develop adult Pacific lamprey passage criteria.	To be determined by the Priest Rapids Fish Forum (PRFF) Annual passage detection monitoring initiated in June 2010 – 2019	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 2019	Variation from Schedule (if applicable)
21.	Continue to operate and maintain fish count systems at the Project (upgrade count systems as new technology becomes available).	Annually for the period 2009-2019	Yes	<p>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.</p> <p>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.</p>	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2019	Variation from Schedule (if applicable)
22.	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 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
23.	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 2019	Variation from Schedule (if applicable)
24.	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.
25.	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 2019	Variation from Schedule (if applicable)
26.	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
27.	Complete a biological objectives status report for Washington Department of Ecology (WDOE) 401 water quality certification.	Every 5 th 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
28.	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 10 th 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
29.	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 (LTWG).	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 2019	Variation from Schedule (if applicable)
30.	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					
31.	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. While juvenile tag technology continues to advance, a scientifically-rigorous study methodology and model, and sufficient number of actively migrating juveniles in the mid-Columbia River is not available to effectively evaluate juvenile Pacific lamprey survival.	No
32.	Develop juvenile Pacific lamprey passage criteria	No later than 10 years following license issuance (2018)	Yes	None. At this time, a scientifically rigorous methodology and model, nor a sufficient number of actively migrating juveniles in the mid-Columbia River is not available to effectively evaluate juvenile Pacific lamprey survival.	No
33.	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 LTWG.	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 2019	Variation from Schedule (if applicable)
Objective 4: Avoid and mitigate Project impacts on rearing habitat					
34.	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	Per the PLMP requirement, Grant PUD implemented a PRFF approved study plan to determine juvenile lamprey presence / absence, habitat use, and relative abundance in areas affected by Project operations in 2012 and 2013. Additional sampling was completed in the Wanapum Reservoir in 2014 during the Wanapum fracture. Only a few lamprey were captured or observed during these surveys. Three years of sampling at varying reservoir elevations (2012-2014) have indicated that juvenile lamprey do not commonly occur within the Project operational zone (see Section 1.2 for additional details). A report addressing results from 2012-2013 was included as Appendix B in the 2016 annual report (Le et al. 2017).	No

Notes:

CRITFC = Columbia River Inter-Tribal Fish Commission

FDX = Full Duplex

FERC = Federal Energy Regulatory Commission

FLA = Final License Application

FPE = Fish Passage Efficiency

LTwG = Lamprey Technical Work Group

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 #19 #27	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 = PR¹	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
			Columbia	#31			
4.	Determine the extent of juvenile rearing habitat	No associated hydro projects (I)	Fifteenmile Creek Deschutes and tributaries Willamette	#1 #2 #18	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. Three years of sampling at varying reservoir elevations (2012-2014) have indicated that juvenile lamprey do not commonly occur within the Project operational zone (see Section 1.2 for additional details). A report summarizing methodology and results from 2012-2013 was included as Appendix B in the 2016 annual report (Le et al. 2017).
5.	Develop measures to protect juvenile rearing habitat	Leaburg-Walterville (I) No associated hydro project (I) Wells (P)	McKenzie Fifteenmile Creek Columbia, Snake Columbia	#8 #1 #35 N/A ²	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 = PR¹	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 (P)	Columbia	N/A ³			
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 Methow, Chewuch, and Twisp Rivers Yakima, Wenatchee, Entiat, Methow, White Salmon, and Klickitat Wenatchee, Okanogan Yakima, Wenatchee	#2 #6 #7 #12 #23 #25 #26 #29	No	No. PLMP Objective 4 required the assessment of juvenile presence / absence and relative abundance within the operational zone of the reservoirs. However, monitoring juvenile population status and trends is not a requirement of the PLMP.	N/A.
7.	Evaluate lamprey physiology, energy use,	No associated hydro project (I)	Umatilla	#10	No	No. This activity is not required by the PLMP.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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	
	swimming performance, and behavior		N/A	#11		Evaluating lamprey physiology, energy use, and swimming performance are not objectives, goals, or measures outlined in the PLMP.		
8.	Evaluate, implement and/or monitor translocation, supplementation, and artificial propagation programs	No associated hydro project (I)	N/A	#15, 16, 17	Yes	No. This activity is not required by Grant PUD's 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.	N/A	
		Priest Rapids Dam (I)	Columbia	#21		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.		
		No associated hydro projects (I)	N/A	#14				
			Willamette	#18				
			Umatilla	#19				
			Yakima	#20, 36				
			Wenatchee	#20, 36				
			Methow	#20, 22, 36				
			Klickitat	#20, 36				
			Okanogan	#22				
			Columbia	#31				
			Columbia (Mid and Upper)	#90				

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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
9.	Evaluate the need for a lamprey aquaculture facility based upon a limiting factor analysis	No associated hydro project (I)	Columbia (Mid and Upper)	#90	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) No associated hydro project (PR)	Willamette Willamette N/A N/A	#5 #6 #14 #30	No	No. This activity is not required by the PLMP. While technologies for sampling juvenile lamprey in deep water exist, this activity is not an objective, goal, or measure outlined in the PLMP.	N/A
11.	Use of eDNA to monitor lamprey population status	No associated hydro project (I)	Methow, Chewuch, and Twisp rivers Multiple watersheds Yakima, Wenatchee, Entiat, Methow, White Salmon, Klickitat	#23 #24 #25	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 = PR¹	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 and Okanogan	#26			
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	No associated hydro project (I)	N/A	#9 #37	Yes	Yes. The PLMP does not include a specific protection, mitigation and	Yes. Monitoring of lamprey through the Project reservoirs was

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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			<p>enhancement (PM&E) measure related to this 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).</p> <p>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.</p>	<p>conducted using HDX-PIT tags in 2010 through 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.</p>
16.	Assess impacts of irrigation water withdrawal structures on juvenile passage/habitat	No associated hydro project (I)	Yakima, Wenatchee	#33	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 = PR¹	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 (general)	Sunnyside, Wapato, Chandler diversion dams (I) No associated hydro project (I)	Yakima Umatilla Yakima, Wenatchee	#34 #32 #33	No	No. While assessing juvenile Pacific lamprey survival at the Project is a requirement within the PLMP, assessing the outmigration impacts of irrigation water withdrawal are not objectives, goals, or measures outlined in Grant PUD's PLMP.	N/A
Adult Passage at Hydroelectric Facilities							
<i>Structural and Operational Fishway Modifications</i>							
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) Bonneville (I) Wells (P)	Columbia and Snake Columbia Yakima Columbia Columbia	#39 #40 #41 #58 #60 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 = PR¹	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	#93 #94 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) Ice Harbor (I) Carmen Smith (Trail Bridge Dam) (I) Bonneville (I) John Day (I)	Yakima Columbia Snake McKenzie Columbia Columbia	#41 #42 #43 #50 #60, 61 #61	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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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
21.	Install / evaluate / operate slotted “keyhole” fishway entrances	Priest Rapids and Wanapum (I) John Day (P)	Columbia Columbia	#44 N/A ⁵	Yes	Yes. Keyhole entrances are currently utilized at both Wanapum and Priest Rapids dams.	Yes. See adjacent response.
22.	Develop / implement / evaluate ladder dewatering procedures	No associated hydro project (I) All ACOE projects ⁶ (I) Wells (I) Rocky Reach, Rock Island (I) Priest Rapids and Wanapum (I)	Yakima, Wenatchee Columbia, and Snake Columbia Columbia	#33 #45 #46 #47 #48	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 and release for all fish.
23.	Rehabilitate and/or operate old or existing fishway for lamprey passage	Willamette Falls (I)	Willamette	#49	Yes	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) Priest Rapids (P)	Columbia Columbia	#51 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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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
							Rapids and Wanapum dams in 2010. 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	#52 #53 #54 #55 #55 #55 #55	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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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
26.	Develop and/or maintain fishway operations criteria	Rock Island (I) Priest Rapids and Wanapum (I) Wells (I) Rocky Reach (I)	Columbia Columbia Columbia Columbia	#56 #57 #92 #93	Yes	Yes. PLMP Objective 2 requires Grant PUD to maintain its fishways in a manner that is consistent with the NOAA Fisheries 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.	Yes. Specific operations criteria are presented in Grant PUD's Project Adult Fishways Operational Plan (Grant PUD 2008).
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 (I)	Columbia Columbia	#60, 61 #61	Yes	Yes. PLMP Objective 2 requires installation of plating along the edges and	Yes. Grant PUD installed permanent aluminum plating on diffuser grates at

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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 orifices in the pools with diffusion chambers at Priest Rapids Dam.	Priest Rapids during the 2009-2010 winter fish ladder maintenance outage. The effectiveness of the plating was evaluated 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	The Dalles (I) Bonneville (I)	Columbia Columbia	#59 #60	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). 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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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
31.	Establish protocol for formal inspection of passage facilities	Priest Rapids and Wanapum (I)	Columbia	#94	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.
32.	Fishway guidelines for adult Pacific lamprey passage	All ACOE projects, Wells, Rocky Reach, Rock Island, Priest Rapids (I)	Columbia and Snake	#95	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).
<i>Project Passage Effectiveness</i>							
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) Threemile Falls Dam, Maxwell and Feed diversions (I) Clackamas (I) Bonneville, The Dalles, John Day, McNary (I)	Columbia Umatilla Clackamas Columbia	#62 #63 #64 #65	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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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)					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. 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) Bonneville, The Dalles, John Day, McNary (I) Federal Columbia River Power System (I) No associated hydro project (I)? [Note: evaluations performed on existing structural / operational	Columbia Columbia Columbia N/A	#62 #65 #66 #67	Yes	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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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
		improvements at ACOE dams are identified earlier in this table, under the heading, Structural and Operational Fishway Modifications.]					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. 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.
<i>Lamprey Counts At Dams</i>							
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	#68 #69 #70 #71 #72	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹		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
<i>Predation</i>								
37.	Establish predation control measures (sea lions)	Bonneville (I)	Columbia	#73	Yes	No. Sea lions are not present in the PRPA.	N/A	
Juvenile Passage at Hydroelectric Facilities								
<i>Structural and Operational Fishway Modifications</i>								
38.	Conduct a literature review of juvenile Pacific lamprey passage and survival	Priest Rapids and Wanapum (I) Wells (P)	Columbia Columbia	#94 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	#74	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	#74	Yes	No. Grant PUD has existing bypass systems, which includes gatewells,	N/A	

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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
						spillways, the Wanapum Fish Bypass (WFB), and Priest Rapids Top-Spill Bypass. The WFB and Priest Rapids Top-Spill Bypass are primarily operated to achieve safe passage of out-migrating salmonids. While it would be expected that juvenile Pacific lamprey would likely travel downstream via turbine passage, both the WFB and Priest Rapids Top-Spill Bypass upstream ogees extend well below the surface (WFB extends 68 feet in depth and the PR Top-Spill bypass extends 20 feet in depth on the upstream sides of each respective dam). Although not the focal species, juvenile lamprey could also benefit as a result of these operations.	
42.	Establish/continue salvage activities during ladder maintenance dewatering	All ACOE projects (I) Wells (I) Rocky Reach, Rock Island (I)	Columbia, Snake Columbia Columbia	#75 #76 #77	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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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 (I)	Columbia	#78				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	#76 #77 #77, 79 #78, 80	Yes	Yes. Grant PUD has existing bypass systems, which includes gatewells, spillways, the WFB, and Priest Rapids Top-Spill Bypass.	Yes. The WFB and experimental Priest Rapids Top-Spill Bypass are operated to achieve safe passage of out-migrating salmonids. Although not the focal species, juvenile lamprey could also benefit as a result of these structural modifications and spill operations.
44.	Planning / permit acquisition for reservoir drawdown for silt removal	Leaburg and Waltermville (I)	McKenzie	#81	No	No. This activity is not required by the PLMP.	N/A
<i>Project Passage Effectiveness</i>							
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	#82 #82	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)	Columbia and Snake Columbia	#83 #84	No	No. While tag development and testing is occurring within the region, 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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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
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 a scientifically rigorous evaluation and methodology exists to measure juvenile lamprey passage and survival.
48.	Evaluate downstream passage and survival when technology and proven scientifically rigorous methodology is available	Wells (P) Rocky Reach (P) Priest Rapids and Wanapum (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 safe, effective and timely passage which could be evaluated when adequately tested methodology exists.	Yes
<i>Predation</i>							
49.	Continue predation control measures (Northern pikeminnow and birds)	Pikeminnow and birds All ACOE projects (I) Pikeminnow and birds Rocky Reach (I) Pikeminnow and birds Rock Island (I)	Columbia, Snake Columbia Columbia	#85 #86 #86	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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
		Pikeminnow and birds Priest Rapids and Wanapum (I)	Columbia	#87			
50.	Evaluate predation potential of various native and non-native species to larval lamprey	No associated hydro project (I)	Yakima	#88	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 ongoing 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.
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	#89, 91, 95, 96 #92 #93 #94	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)	Columbia, Snake Columbia Columbia	#89, 91, 95, 96 #92 #93	Yes	Yes. PLMP Objectives 2 and 3 require “Regional Studies” which includes participation and cooperation in studies where useful information	Yes. Grant PUD participates in regional forums such as the Lamprey Technical Work Group (LTWG) the USFWS Lamprey Conservation Initiative and

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR¹	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 (I)	Columbia	#94		may be obtained about project impacts to lamprey.	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	#28, 97 #29 #94	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) Rocky Reach (I) Priest Rapids and Wanapum (I)	Columbia, Snake Columbia Columbia Columbia	#89, 91, 95, 96 #92 #93 #94	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 LTWG the USFWS Lamprey Conservation Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.
55.	Environmental analysis and feasibility investigations	All ACOE projects (I)	Columbia, Snake	#95, 96	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

CRITFC = Columbia River Inter-Tribal Fish Commission

FDX = full-duplex

FPE = Fish Passage Efficiency

HDX = half-duplex

LPS = lamprey passage system

LTWG = Lamprey Technical Work Group

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 eleventh 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 2019, 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 – 2018 was completed and is presented in Section 1.2 of this report. During this time period, fishway passage efficiency of the comprehensive dataset was 94.6% and 100.0% 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 2019 were not available at the time of reporting and will be included in the 2020 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 for 2010-2016, and 2019. 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 (see Le et al. 2019, Appendix A). For the second year of the agreement, Grant PUD operated the mechanical lamprey traps at Priest Rapids Dam from August 5 to September 17, 2019. A total of 152 lamprey were trapped from August 6 to August 23 to provide lamprey for Douglas PUD's translocation program. The lamprey were transferred to Douglas PUD and released upstream of Wells Dam (Appendix A, Table A-1). Grant PUD continued to operate the traps from August 27 to September 17, 2019. Lamprey trapped during that time period were transported and released upstream of Rock Island Dam at Kirby Billingsley Hydro Park. A total of 263 lamprey were trapped and transported during the entire effort (Appendix A, Table A-1).

In 2019, Grant PUD also continued its regional approach to monitoring lamprey by coordinating among other utilities, participating in forums, and the sharing of HDX PIT data with other researchers.

In 2020, 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 2019-2020 winter fish ladder maintenance outage.
2. Entrance and exit HDX-PIT antennas at the Wanapum right-bank fishladder will be refurbished and completed during this time for continued monitoring of tagged adult Pacific lamprey.
3. 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.
4. Tracking lamprey enumeration statistics for the Priest Rapids Project and lower Columbia River dams.
5. Continue to execute the terms of the Adult Pacific Lamprey No Net Impact SOA. (Le et al. (2019)

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
Data Table of Adult Pacific Lamprey Trapped in Four Mechanical Traps at Priest Rapids Dam

Table A-1 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
8/6/2019	1	1	1	6	9	33	27	DPUD
8/7/2019	2	2	2	0	6	16	38	DPUD
8/8/2019	6	3	3	4	16	16	100	DPUD
8/9/2019	1	1	1	7	10	37	27	DPUD
8/13/2019	4	5	4	2	15	34	44	DPUD
8/14/2019	2	10	3	3	18	24	75	DPUD
8/15/2019	2	4	2	4	12	54	22	DPUD
8/16/2019	0	1	6	11	18	69	26	DPUD
8/20/2019	3	2	2	3	10	55	18	DPUD
8/21/2019	7	0	3	0	10	85	12	DPUD
8/22/2019	4	2	0	6	12	36	33	DPUD
8/23/2019	4	3	4	5	16	95	17	DPUD
8/27/2019	3	2	0	5	10	46	22	KBHP
8/28/2019	16	6	0	10	32	49	65	KBHP
8/29/2019	8	3	2	8	21	38	55	KBHP
8/30/2019	6	1	0	3	10	25	40	KBHP
9/4/2019	1	0	1	6	8	50	16	KBHP
9/5/2019	0	1	0	6	7	50	14	KBHP
9/6/2019	3	0	0	4	7	43	16	KBHP
9/10/2019	0	1	1	4	6	8	75	KBHP
9/11/2019	0	0	0	0	0	24	0	KBHP
9/12/2019	0	0	0	1	1	19	5	KBHP
9/13/2019	3	0	0	1	4	9	44	KBHP
9/17/2019	1	0	0	4	5	3	160	KBHP
Total	77	48	35	103	263	918	30	

Appendix B

Stakeholder Comments

From: [Ralph Lampman](#)
To: [Mike Clement](#); [Tracy Hillman](#) (Tracy.hillman@bioanalysts.net)
Cc: [Doris Squeochs](#); [Keith Hatch](#) (keith.hatch@bia.gov); [Tom Skiles](#) (SK1T@critfc.org); [Patrick Verhey](#) (Patrick.Verhey@dfw.wa.gov); [Chad Jackson](#) (chad.jackson@dfw.wa.gov); [Stephen Lewis](#); [Breean Zimmerman](#); [Aaron Jackson](#) (AaronJackson@ctuir.org); [Gary James](#) (GaryJames@ctuir.org); [Kirk Truscott](#) (Kirk.Truscott@colvilletribes.com); [Jason McLellan](#) (Jason.McLellan@colvilletribes.com); [Laura Heironimus](#) (Laura.Heironimus@dfw.wa.gov); [CarlMerkle](#) (CarlMerkle@ctuir.com); [Ross Hendrick](#); [Tom Dresser](#); [Chris Mott](#); [Erin Harris](#); [Debbie Firestone](#)
Subject: Re: Grant PUD's 2019 Draft Pacific Lamprey Management Plan Report
Date: Wednesday, February 19, 2020 5:23:30 PM

Hi Mike,

Attached are my comments for the final report.

The "meat" of this report (the new stuff) is more towards the end, so I wonder if there are ways to bring that up first and then put the things that show up every year as an appendix (sure there are some updates needed even in that section - which I appreciate), but it is really the last part that we need to examine carefully and discuss (but by the time I get to it, I'm exhausted already, so Mike's "strategy" here seems to be working :-))

So I would advice Bao (or whoever is incorporating these comments) to start from the end (as those ones are more important).

It is a pretty comprehensive report - but the key issue is where do we go from here and don't want us to lose sight of that (& get us buried in this voluminous report).

Thanks,

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



On Tue, Jan 21, 2020 at 7:41 AM Debbie Firestone <Dfirest@gcpud.org> wrote:
Good morning,

Attached please find Grant County PUD's 2019 Draft Pacific Lamprey Management Plan annual report for a 30 day review and comment period. This report is a requirement of the Federal Energy Regulatory Commission license article 401(a)(12) and the Washington Department of Ecology's 401 Water Quality Certification Condition 6.2(6)(b) and (Appendix C).

Please provide your comments by February 21, 2020.

If you have questions regarding this report, please contact Mike Clement at 509-754-5088 Ext. 2633 or Mclemen@gcpud.org<<mailto:Mclemen@gcpud.org>>.

Have a great day!

Deb Firestone
Regulatory Specialist II
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509-793-1583

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Please take care when opening links, attachments, or responding to this email as it originated outside of Grant.

From: [Lewis, Stephen](#)
To: [Ralph Lampman](#); [Mike Clement](#); [Tracy Hillman](#) (Tracy.hillman@bioanalysts.net)
Cc: [Doris Squeochs](#); [Hatch, Keith](#); [Tom Skiles](#) (SKIT@critfc.org); [Patrick Verhey](#) (Patrick.Verhey@dfw.wa.gov); [Chad Jackson](#) (chad.jackson@dfw.wa.gov); [Breean Zimmerman](#); [Aaron Jackson](#) (AaronJackson@ctuir.org); [garyjames@ctuir.org](#); [Kirk Truscott](#) (Kirk.Truscott@colvilletribes.com); [Jason McLellan](#) (Jason.McLellan@colvilletribes.com); [Laura.Heironimus@dfw.wa.gov](#); [CarlMerkle@ctuir.com](#); [Ross Hendrick](#); [Tom Dresser](#); [Chris Mott](#); [Erin Harris](#); [Debbie Firestone](#)
Subject: Re: [EXTERNAL] Re: Grant PUD's 2019 Draft Pacific Lamprey Management Plan Report
Date: Friday, February 21, 2020 3:28:22 PM

Hi Mike-

Yes, this report is very voluminous as Ralph describes. I simply didn't have time to peruse through the whole document, but did see a few general items that caught my eye. Included below for your consideration:

- 1.) Reduction of fishway flows at the Wells Hydroelectric Project was not mentioned in this document (Table 5). Needs to be placed in this table.
- 2.) The pathway for the development of a juvenile lamprey study at Priest Rapids/Wanapum is unclear. This needs to be clarified in the document.
- 3.) The document states, "Grant PUD is committed to continue into the future in a similar manner" (page 8). Is this a reference predominantly towards translocation efforts? Or to future tagging to monitor fishway efficiency on an annual basis?
- 4.) Table 6 states, "Begin investigation of the efficacy and advisability of reducing fishway flows at night during peak lamprey migration periods." It's unclear what it means when an Implementing Measure has been considered. The PRFF put this measure on the backburner since there were other options to implement for fishway modifications. Has the door been closed on this measure?

S-

From: Ralph Lampman <lamr@yakamafish-nsn.gov>
Sent: Wednesday, February 19, 2020 5:22 PM
To: Mike Clement <Mclemen@gcpud.org>; Tracy Hillman (Tracy.hillman@bioanalysts.net)
<Tracy.hillman@bioanalysts.net>
Cc: Doris Squeochs <Dsqueoc@gcpud.org>; Hatch, Keith <Keith.Hatch@bia.gov>; Tom Skiles (SKIT@critfc.org) <SKIT@critfc.org>; Patrick Verhey (Patrick.Verhey@dfw.wa.gov)
<Patrick.Verhey@dfw.wa.gov>; Chad Jackson (chad.jackson@dfw.wa.gov)
<chad.jackson@dfw.wa.gov>; Lewis, Stephen <stephen_lewis@fws.gov>; Breean Zimmerman <bzim461@ecy.wa.gov>; Aaron Jackson (AaronJackson@ctuir.org) <AaronJackson@ctuir.org>; garyjames@ctuir.org <garyjames@ctuir.org>; Kirk Truscott (Kirk.Truscott@colvilletribes.com)
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Subject: [EXTERNAL] Re: Grant PUD's 2019 Draft Pacific Lamprey Management Plan Report

Hi Mike,

Attached are my comments for the final report.

The "meat" of this report (the new stuff) is more towards the end, so I wonder if there are ways to bring that up first and then put the things that show up every year as an appendix (sure there are some updates needed even in that section - which I appreciate), but it is really the last part that we need to examine carefully and discuss (but by the time I get to it, I'm exhausted already, so Mike's "strategy" here seems to be working :-))

So I would advice Bao (or whoever is incorporating these comments) to start from the end (as those ones are more important).

It is a pretty comprehensive report - but the key issue is where do we go from here and don't want us to lose sight of that (& get us buried in this voluminous report).

Thanks,

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



On Tue, Jan 21, 2020 at 7:41 AM Debbie Firestone <Dfirest@gcpud.org> wrote:

Good morning,

Attached please find Grant County PUD's 2019 Draft Pacific Lamprey Management Plan annual report for a 30 day review and comment period. This report is a requirement of the Federal Energy Regulatory Commission license article 401(a)(12) and the Washington Department of Ecology's 401 Water Quality Certification Condition 6.2(6)(b) and (Appendix C).

Please provide your comments by February 21, 2020.

If you have questions regarding this report, please contact Mike Clement at 509-754-5088 Ext. 2633 or Mclemen@gcpud.org<mailto:Mclemen@gcpud.org>.

Have a great day!

Deb Firestone
Regulatory Specialist II

Grant County PUD
P.O. Box 878
Ephrata, WA 98823
509-793-1583

[http://home.gcpud.org/logoSignage/images/GrantPUD_hi-res.jpg]

Please take care when opening links, attachments, or responding to this email as it originated outside of Grant.

Appendix C
Grant PUD's Response to Stakeholder Comments

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
YN	2/19/2020	Email	<p>Attached are my comments for the final report. The "meat" of this report (the new stuff) is more towards the end, so I wonder if there are ways to bring that up first and then put the things that show up every year as an appendix (sure there are some updates needed even in that section - which I appreciate), but it is really the last part that we need to examine carefully and discuss....."</p> <p>It is a pretty comprehensive report - but the key issue is where do we go from here and don't want us to lose sight of that (& get us buried in this voluminous report).</p>	Comment noted. The format for the PLMP Annual Comprehensive Report was developed in consultation with the PRFF (2009 to present). The report follows the specific outline (Implementation Measure #1 – Reporting) as required in Appendix C of the WA State 401 Water Quality Certification (401) for the Priest Rapids Project. Grant PUD would be open to future discussions to modify the report in collaboration with the PRFF and WDOE in the future if the parties agree.
YN	2/19/2020	Executive Summary i	I would omit the previous 2 sentences above this - of course passage efficiency can't be greater than 100%, so not worth sharing a stat that suggests it.	Grant PUD has modified the Executive Summary to reflect this recommendation.
YN	2/19/2020	Executive Summary i	How many?	Comment noted. Grant PUD has modified and included this information/sample size in this report.
YN	2/19/2020	Executive Summary ii	Is this this report? If so, do you need to state it? (can't you just say Appendix A?) Or is it something else?	This citation is in reference to the 2019 PLMP Annual Comprehensive Report.
YN	2/19/2020	2	Could you remind me what type of support was provided for these two programs?? (I'm probably just spacing out here, but can't think of any...) The 2017 adult transfer effort?	This statement is in reference to the 316 adult Pacific lamprey trapped at Priest Rapids in 2017 and transferred to YN Fisheries staff for translocation research.
YN	2/19/2020	3	what happens to the 21%?	These calculations were based on the percentage of adult Pacific lamprey that used the aluminum plating. All other individuals passing the count station passed successfully without using the plating.
YN	2/19/2020	5	what do you think explains this increase in passage time in the last 2 years?	Median passage times were based off small sample sizes (n = 35 at Priest Rapids, and n = 27 at Wanapum) and other speculation is

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
				associated with poor antenna performance.
YN	2/19/2020	8	I'm confused as to what the two phases are?	As cited in the text, Phase 1 included members of the Lamprey Technical Working Group who were tasked with developing basin-wide adult lamprey passage standards and objectives for measurable and biologically relevant metrics (CRBLTWG 2007). Phase 2 included members establishing regional passage standards: identifying potential research metrics and determining which metrics were measurable with scientific rigor (CRBLTWG 2010b).
YN	2/19/2020	Page 85, #8	"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.".... Is this something we should look into now that the modifications have been done?	Previous discussions related to reduction of fishway flows were discontinued based on the concern by NOAA Fisheries and the PRFF that reduction of fish ladder entrances could have a negative impact on listed and non-listed salmonid passage and timing. Because members of the PRFF expressed interest in evaluating entrance efficiency at fish ladders at Priest Rapids and Wanapum dams, Grant PUD conducted a study in 2017. To estimate entrance efficiency at both dams, 100 HDX-PIT tagged adult lamprey were released downstream from both dams. 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

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
				<p>existing HDX-PIT arrays at each dam. 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. A full description of this study was provided in the 2018 Pacific Lamprey Comprehensive Report.</p> <p>Based on the data above, adult Pacific lamprey do not appear to have difficulty entering or passing the fishways at Priest Rapids or Wanapum dams.</p>
YN	2/19/2020	Page 86 #14	“Currently, options for measuring Project effects on juvenile Pacific lamprey are under consideration by the PRFF. While juvenile tag technology continues to advance, a scientifically-rigorous study methodology and model, and sufficient number of actively migrating juveniles in the mid-Columbia River is not available to effectively evaluate juvenile Pacific lamprey survival.”..... The tag is available, now we just need to discuss the methodology and source of fish	Comment noted. As stated, discussions related to measuring Project effects on juvenile lamprey have been ongoing and continue to be discussed by the PRFF.
YN	2/19/2020	Page 96 #1	“No. This activity is not required by Grant PUD’s Pacific Lamprey Management Plan (PLMP). Radio-	Comment noted. Identification of spawning areas is not a requirement of

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
			telemetry studies conducted in 2001-2002 did not show use of any tributaries in the Priest Rapids Project Area (PRPA) (Nass et al. 2003).”.....what about mainstem spawning?	Grant PUD’s PLMP, nor is it consistent with similar reasonable and feasible mitigation measures at other projects.
YN	2/19/2020	Page 97 #5	“No. This activity is not required by Grant PUD’s PLMP.”... if habitat exists within the project area, wouldn’t it be required? (seem like some explanation / assumptions are missing here)	<p>In 2012, Grant PUD began monitoring of juvenile and larval lamprey within the Project area to address a requirement in its PLMP. In June 2012, monitoring of juvenile or larval lamprey was initiated to assess their presence/absence, habitat use, and relative abundance in areas affected by Project operations. Existing Grant PUD bathymetry data were used to identify areas affected by the Project’s operations, and aerial photographs were used to segregate the Project operational zone into habitat types with high (Type 1), medium (Type 2), and low potential (Type 3) for use by juvenile lamprey (Close and Aronsuu 2003; Hansen et al 2003). Sample sites were chosen favoring Type 1 habitat, but including Type 2 and Type 3 habitat, and water less than 1 meter in depth.</p> <p>Following the three years of sampling at varying reservoir elevations in both Priest Rapids and Wanapum reservoir shorelines (2012-2014), the lack of collected juvenile or larval Pacific lamprey suggests that juvenile and larval lamprey are present, but rare in the operational zone of the Priest Rapids Project (Grant PUD 2017).</p>
YN	2/19/2020	Page 100 #11	“However, Grant PUD does provide accurate 24/7 adult Pacific lamprey fish count numbers at www.grantpud.org	To clarify, the use of eDNA to monitor lamprey populations and count data

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
			for interested parties to review.”.... eDNA vs adult counts? (not seeing a clear relationship here)	in the Priest Rapids Project is not necessary, as Grant PUD provides accurate adult Pacific lamprey and other fish counts to determine run size, presence/absence, and trend information.
YN	2/19/2020	Page 120 Bullet #6	I recommend that we include "discussion of juvenile lamprey passage evaluation planning" (doesn't have to be exactly those words, but something similar to that) so we can continue the discussion on this topic (it seems timely now that the tag technology is available). It is listed in the Douglas PUD annual plan.	Comment noted. The 2020 Planning Activities section has been amended to include this activity.
YN	2/19/2020	Appendix A, page A-1	seems like, unless all trapped adults are also counted through the window, you would want to divide it by the sum total of trapped and window count (instead of just window count)? 160% efficiency does not make any sense - should be 37.5% for that last day, for example).	This calculation was discussed and approved by the PRFF as the most feasible method to approach calculating “Trap Collection Efficiency” because there is no way to calculate the number of adult Pacific lamprey that are passing the traps until they reach the fish count stations. The YN is correct that there are several assumptions that are violated concerning the correctness of the sum such as that all adults which are in the ladder would pass the count stations, the assumption that all adults make it from the tailrace to the count station in a single day, the fact that all the traps are located below the fish count stations, etc., and others. Grant PUD would be open to discussions related to modifying this calculation in the future if approved by the PRFF.
USFWS	2/21/2020	General comment.	Yes, this report is very voluminous as Ralph describes. I simply didn't have time to peruse through the whole document, but did see a few general items that caught my eye. Included below for your consideration:	Comment noted.
USFWS	2/21/2020	Comment #1	1.) Reduction of fishway flows at the Wells Hydroelectric Project was not	To clarify, Table 5 “Pacific lamprey activities in the Columbia River basin in

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
			mentioned in this document (Table 5). Needs to be placed in this table.	2019" is a compilation of Pacific lamprey research activities that were conducted in 2019. The reduction of fishway flows at Wells Hydroelectric Project was an activity that occurred in 2018 and is summarized in Grant PUD's 2018 Pacific Lamprey Plan Annual Comprehensive Report.
USFWS	2/21/2020	Comment #2	2.) The pathway for the development of a juvenile lamprey study at Priest Rapids/Wanapum is unclear. This needs to be clarified in the document.	Comment noted. The 2020 Planning Activities section has been amended to include this activity.
USFWS	2/21/2020	Comment #3	3.) The document states, "Grant PUD is committed to continue into the future in a similar manner" (page 8). Is this a reference predominantly towards translocation efforts? Or to future tagging to monitor fishway efficiency on an annual basis?	Page 8, paragraph 3 has been modified to clarify this statement.
USFWS	2/21/2020	Comment #4	4.) Table 6 states, "Begin investigation of the efficacy and advisability of reducing fishway flows at night during peak lamprey migration periods." It's unclear what it means when an Implementing Measure has been considered. The PRFF put this measure on the backburner since there were other options to implement for fishway modifications. Has the door been closed on this measure?	See response to YN Comment, Page 85 #8 above.

Appendix D
Washington Department of Ecology's March 6, 2020 Approval Letter



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

March 6, 2020

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 –2019 Pacific Lamprey Management Plan Comprehensive Annual Report.
Priest Rapids Hydroelectric Project No. 2114**

Dear Mr. Dresser:

Ecology has reviewed the *2019 Pacific Lamprey Management Plan Comprehensive Annual Report* e-mailed to Ecology on March 5, 2020 (a draft document was emailed to Ecology on January 21, 2020). Ecology has **no comments**. 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,

A handwritten signature in blue ink that reads "Breean Zimmerman".

Breean Zimmerman
Hydropower Projects Manager
Water Quality Program

Cc: Mike Clement, Senior Biologist, Grant County PUD, via e-mail

