Grant County
PUBLIC UTILITY DISTRICT

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March 22, 2022

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) – 2021 Pacific Lamprey Management Plan Annual Report

Dear Secretary Bose,

Please find enclosed Public Utility District No. 2 of Grant County, Washington (Grant PUD) 2021 Pacific Lamprey Management Plan (PLMP) Annual Report consistent with the requirements of Article 401(a)(12) of the Priest Rapids Project License[1] and the Washington State Department of Ecology (Ecology) 401 Water Quality Water Quality Certification Condition of 6.2(5)(b) and Appendix C for the Priest Rapids Project (Project).

The 2021 PLMP Comprehensive Annual Report summarizes the on-going activities undertaken at the Project in 2021, 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 19, 2022, Grant PUD provided the draft 2021 PLMP Annual Report to members of the Priest Rapids Fish Forum, which includes the Washington Department of Ecology (WDOE), 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 YN (Appendix C) and Grant PUD's response table is provided in Appendix D. On March 15, 2022, WDOE approved the 2020 PLMP Annual Report (Appendix E).

[1] 123 FERC ¶ 61,049 (2008)

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FERC staff with any questions should contact Tom Dresser at tdresse@gcpud.org or 509-797-5182.

Sincerely,

Shannon Lowry

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License Compliance and Lands Services Manager

CC: Breean Zimmerman – Ecology
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2021
Pacific Lamprey Management Plan
Comprehensive Annual Report

Priest Rapids Hydroelectric Project (FERC No. 2114)

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March 2022

Executive Summary

In accordance with the Priest Rapid Hydroelectric Project (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 2021, 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 thirteenth year of implementation of the PLMP, Grant PUD was unable to assess Pacific lamprey behavior and passage efficiency through fishways at Priest Rapids and Wanapum dams and their respective reservoirs to evaluate the efficacy of design enhancements that were installed during the 2009-2010 winter fish ladder maintenance outage due to COVID restrictions placed on tagging programs in the Lower Columbia River during 2021.

Grant PUD will continue monitoring as soon as tagging at downstream locations resumes. For the 2010 through 2019 migrations[1], 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. The long-term average fishway passage efficiency for 2010-2019 is 86.6% and 89.4% at Priest Rapids and Wanapum dams, respectively (2 -32% SE). Low passage efficiency estimates were associated with small sample sizes in some ladders in certain years.

Up to 2019, fish from tagging efforts downstream during the adult Pacific lamprey migration period were used to evaluate Project passage efficiency and to estimate passage times through the fishways at Priest Rapids and Wanapum dams. Pacific lamprey are HDX-PIT tagged and released at Bonneville Dam by University of Idaho and the Confederated Tribes of the Warm Springs. However, since 2020, no tagging took place at Bonneville Dam, so the HDX-PIT arrays at Wanapum and Priest Rapids dams were not operated. Passage monitoring is anticipated to occur in the future as tagging at Bonneville Dam is reinstated.

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 fourth year of the agreement, Grant PUD operated the mechanical lamprey traps at Priest Rapids Dam from July 20 to September 9, 2021. A total of 462 lamprey were trapped to provide lamprey for Public Utility District No. 1 of Douglas County's (Douglas PUD's) translocation program.

[1] Monitoring at the PRP for the 2020 and 2021 reporting years was not conducted because no lamprey were tagged at Bonneville Dam in 2020 or 2021.

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 Initiative (PLCI). As a founding participant, Grant PUD assisted in the development of the "Critical Needs and Uncertainties" document and provided information to support the Tribal Pacific Lamprey Restoration Plan (CRITFC 2011). Grant PUD continues to participate in and provide support to the regional lamprey conservation activities including the U.S. Fish and Wildlife Service (USFWS) PLCI and Lamprey Summit (2012, 2017), the Yakama Nation lamprey recovery planning efforts, and the Columbia River Inter-Tribal Fish Commission's (CRITFC) Tribal Pacific Lamprey 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 including modified fish counting facilities which improve passage efficient and that operate 24 hours a day, 7 days a week during the upstream migration period. In addition, implementation of fish collection protocols by qualified biologists during fishway dewatering procedures ensure safe recovery of all fish species present (Grant PUD 2010) and Grant PUD's avian predation and Northern pikeminnow control programs to minimize impacts to juvenile salmonid outmigrants also protect larval/juvenile lamprey.

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 larval/juvenile Pacific lamprey as well. The slotted entrances were installed prior to the 2001-2002 lamprey study (Nass et al. 2003). This study in combination with HDX-PIT assessments conducted in 2018 (Le et al. 2018) indicate that the entrance efficiency of fish ladders at the Project are 96%. In past years, the U.S. Army Corps of Engineers (ACOE) have experimented with similar entrances at lower Columbia River dams (D. Clugston, ACOE, personal communication, 2010). 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 larval/juvenile lamprey.

Also, during the 2010 adult 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 (i.e., attached to the plate and held position) 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 Plan[2] 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).

[2] 127 FERC ¶ 62,091 (2009)

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

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

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

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

In 2017, to maintain the comprehensive data set of lamprey passage efficiency through Priest Rapids and Wanapum dams with low numbers of run-of-river tags and in response to the PRFF expressed interest in estimating entrance efficiency at both dams, 100 HDX-PIT tagged adult lamprey were released downstream from both dams in August 2017. Fish were captured with mechanical traps at Priest Rapids Dam lower left and right bank fishways and implanted with HDX-PIT tags. Twenty-five tagged fish were then released downstream of each fish ladder at both dams. Entrance efficiency was estimated using the existing HDX-PIT arrays at each dam. Detection efficiency at entrance arrays is not optimal so any fish detected at any array within the

ladder or at an upstream dam was considered to have entered the ladder. The final entrance efficiency at both left and right fish ladders at Priest Rapids and Wanapum dams was 96%. Only one fish from each release group was not detected at the dam it was released below or at an upstream location. The passage efficiency at Priest Rapids Dam 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 2020 and 2021, no tagging took place at Bonneville Dam so the HDX-PIT arrays at Wanapum and Priest Rapids dams were not operated. Passage monitoring is anticipated to occur in the future as tagging at Bonneville Dam is reinstated.

In addition to the yearly monitoring effort, in April 2018 the PRFF approved a Statement of Agreement (SOA - Adult Pacific Lamprey No Net Impact Trap and Transportation), which allowed for the deployment, operation, and maintenance of mechanical lamprey traps at Priest Rapids Dam for approximately 15 days during the peak lamprey migration period (Le et al. 2019). During the fourth year of the SOA, Grant PUD operated the mechanical lamprey traps at Priest Rapids Dam from July 20 to September 9, 2021. A total of 462 lamprey were trapped to provide lamprey for Douglas PUD's translocation program (see Appendix B, Table B-1). During the first four weeks of the effort Douglas PUD transported 325 lamprey from Priest Rapids Dam to release sites above Wells Dam and over the second four weeks, an additional 137 lamprey were transported by Grant PUD to Kirby Billingsley Hydro Park where they were transferred to Douglas PUD and released upstream of Wells Dam.

For the 2010 through 2019 migrations[3], Grant PUD monitored a total of 652 and 647 HDX-PIT tagged lamprey at Priest Rapids and Wanapum dams, respectively. The long-term average fishway passage efficiency for 2010-2019 is 86.6% and 89.4% at Priest Rapids and Wanapum dams, respectively. Reduced HDX-PIT tagging effort from downstream sources in 2015-2017 resulted in a smaller quantity of run-of-river tags detected at Priest Rapids Dam than in 2010-2014, an average of 27 tags as opposed to 76 tags a year. Downstream tagging resumed in 2018 and continued in 2019 and 76 and 37 tags, respectively, were detected in those years. 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. Historical fish passage efficiencies for both Wanapum and

[3] Monitoring at the PRP for the 2020 and 2021 reporting years was not conducted because no lamprey were tagged at Bonneville Dam in 2020 or 2021.

Priest Rapids dams as well as other Columbia Basin dams are presented in Table A-3, in Appendix A.

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 are provided in Table 1 below. Median fishway passage times over the study period ranged from 5.3 hours to 49.5 hours for the Priest Right and Left fishways and 19.1 hours to 22.1 hours for the Wanapum Right and Left fishways, respectively (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, and 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.

	Number Detected		Median fishway passage time (h)			
Year	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

	Number Net Fallback			
Year	PR	WA	Median PR Reservoir passage time (d)[1]	Number of tags from previous year (overwintering fish)
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
2 Passage metrics for 2020 are unavailable as no tagging took place at Bonneville dam so the HDX-PIT arrays at Wanapum and Priest Rapids dams were not operated.

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 three river miles above Bonneville Dam.

In 2012, Grant PUD began monitoring of larval lamprey within the Project area to address a requirement in its PLMP. In June 2012, monitoring of 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 larval 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 larval 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 larval 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 larval 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 larval 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 larval 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 larval 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 larval lamprey were captured and another was observed during sampling on March 4 in the vicinity of Sunland Estates (RM 431). Small numbers of dead larval Pacific lamprey were observed in the vicinity of Walling Canyon (RM 449), Crescent Bar (RM 441), and Sunland Estates. Three years of sampling at varying reservoir elevations (2012-2014) indicates that larval 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 interim 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. In the 2020 Addendum to the 2014 Columbia River Basin Fish and Wildlife Program (NPCC 2020), the Northwest Power and Conservation Council provides the following goal for Pacific Lamprey passage: "Improve passage efficiency for adult Pacific Lamprey to an interim standard of at least 80 percent at each dam on the mainstem Columbia and Snake rivers." In addition, the following abundance goal is also provided: "Adult Pacific lamprey abundance target of a three year rolling average of 200,000 at Bonneville Dam by 2025, progressing toward 1,000,000 by 2035 (NPCC 2020).

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 (License Ob 401(a)(12)):*
>
> *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 2.0: Information from the reporting year (i.e., November 1, 2020 through October 31, 2021) 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.
- Appendix A: Background and existing information (i.e., through October 31, 2021) about Pacific lamprey ecology, life history, as well as passage and survival investigations and measures undertaken in the Columbia River Basin.

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 19, 2022. Comments were received from Yakama Nation on February 20, 2022. Washington Department of Ecology approved the 2021 PLMP Annual Report on March 15, 2021.

2.0 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 2.

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, 2020 through October 31, 2021. Per discussions with the Priest Rapids Fish Forum in March 2020, background, and existing information (i.e., through October 31, 2021) about Pacific lamprey ecology, life history, as well as passage and survival investigations and measures undertaken in the Columbia River Basin has been moved to an appendix (Appendix A). 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 2 Pacific lamprey activities in the Columbia River basin in 2021.

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	General Biology, Ecology, Behavior, and Population Status					
1.	Monitoring entrance timing, escapement, and movement patterns	No associated hydro project	Fifteenmile Creek	In 2016, adult Pacific lamprey abundance in Fifteenmile Creek was estimated at 3,433 (2,758 – 4,270). Tagging efforts at Cushing Falls between May and July produced a total of 162 tagged lamprey. 109 were detected moving upstream, 16 moved downstream after tagging and 4 were caught in the tribal fishery. 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. 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. 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 distribution and densities but data have not been entered	Confederated Tribes of the Warm Springs (CTWS)	Personal communication with Lindy Collamer, CTWS (11/10/21) Evaluate Status and Limiting Factors of Pacific lamprey in the Lower Deschutes River, Fifteenmile Creek and Hood River (Johnsen and Baker 2018)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				for densities to be calculated. In 2020 and 2021, creel surveys and mark-recapture surveys did not occur at Cushing Falls due to COVID-19 closures. Larval lamprey surveys were attempted in both years, however only a handful of surveys were completed. Not enough data was collected to determine densities within Fifteenmile Creek. All surveys will resume in 2022. .		
2.	Adult lamprey monitoring and juvenile lamprey density and distribution surveys	No associated hydro project	Deschutes and tributaries	Since 2016, CTWS has engaged in ongoing adult lamprey monitoring and juvenile lamprey density and distribution surveys. Density surveys for ammocoetes were conducted during the fall months of 2017 in Warm Springs River, and Shitike, Beaver, and Badger creeks. Densities were highest in Shitike Creek (avg 23/m^2) and averaged 17/m^2 in Warm Springs River, Beaver Creek, and Badger Creek. Total counts of ammocoetes collected were lowest in Badger Creek (71) and were 136, 139, and 151 in Warm Springs River, Beaver Creek, and Shitike Creek respectively. 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 Sherar's Falls in 2017, of which 272 were recaptured either by CTWS personnel or by Tribal harvesters. An escapement estimate of 24,017 (95% CI, 21,336 to 27,034) was thus calculated. In 2019, fieldwork for a mark-recapture escapement estimate at Sherars Falls on the Deschutes River was	CTWS	Personal communication with Lindy Collamer , CTWS (11/10/21) Evaluate Status and Limiting Factors of Pacific lamprey in the Lower Deschutes River, Fifteen Mile Creek, and Hood River (Johnsen and Baker 2017)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				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. In 2020, creel surveys and mark-recapture surveys did not occur due to COVID-19 closures. In 2021, approximately 500 lamprey were harvested at Sherars Falls. Only two were PIT tagged and there have been no antenna detections to date. In both 2020 and 2021, larval lamprey surveys were attempted but not enough data was collected to estimate densities. All surveys will resume in 2022.		
3.	Conduct adult lamprey movement study using radio telemetry	Bureau of Reclamation (BOR) projects in Yakima	Yakima	In 2016, the Annual Report for Phase 3 of the U.S. Fish and Wildlife Service (USFWS) adult Pacific lamprey passage study in the Yakima River was completed and released. Lamprey passage efficiency at Cowiche Dam was relatively high (79%), whereas at Roza Dam (0%) no tagged lamprey detected passing the complete fishway (including the Adult Fish Facility). Work is ongoing on a manuscript summarizing three years of adult Pacific lamprey mark-recapture data, and developing dam-specific passage efficiencies, inter-dam survival estimates and detection and uncertainty estimates.	USFWS	Personal communication with Ann Grote, USFWS (11/16/21) 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	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	CTWS	Personal communication with Lindy Collamer, CTWS (11/10/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				196,458, giving a total abundance of 277,577. Harvest at Willamette Falls in 2017 was 6,170 lamprey. 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. In 2020, PIT-tagging did not occur due to COVID-19 closures. However, PIT-tagging resumed in 2021 and results are pending. Creel surveys were also put on hold in 2020 but resumed in 2021 and results are pending.		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 lamprey escapement and abundance	Willamette Falls	Willamette	Since 2010, adult Pacific lamprey abundance and escapement has been monitored at Willamette Falls using capture-recapture techniques and a relatively simple closed-population estimator. The purpose of this research was to potentially improve the accuracy of escapement and abundance estimates by quantitatively evaluating the current estimation method at the falls as well as several alternative estimation techniques. Details of earlier years activities are found in Le et al. 2018. 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	CTWS and Oregon State University (OSU)	Personal communication with Lindy Collamer, CTWS (11/10/21) Assessment of Pacific lamprey Monitoring Techniques at Willamette Falls, OR. (Whitlock et al 2019) Refining Techniques for Estimating Pacific

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				daily escapement estimate (IDEM) developed by Whitlock et, al. Because CTWS failed to recapture 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. Results from 2019 using these models is still pending. There will be no estimate for 2020 due to COVID-19 and 2021 results are also pending.		Lamprey Escapement and Abundance at Willamette Falls. OR. (Whitlock and Peterson 2017)
6.	Portland Harbor Superfund restoration monitoring: larval Pacific lamprey	No associated hydro project	Willamette	Larval Pacific lamprey occupancy was evaluated at Alder Point, Rinearson and Linnton restoration areas as well as six reference areas. The three additional restoration sites were not sampled. A generalized random tessellation-stratified approach was used to delineate sample quadrats (30 m X 30 m) in a random, spatially-balanced order from Willamette Falls downstream to the confluence with the Columbia, and including the Multnomah Channel. Pacific lamprey were detected in several reference sites and at Alder Point.	USFWS	Personal communication with Joe Skalicky, USFWS (10/20/21) Evaluation of Larval Pacific Lamprey Occupancy in Portland Harbor Superfund Area Restoration Sites, 2020 Annual Report (Skalicky and Whitesel 2020)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
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, Spring, and Summer. Preliminary results indicate a significant seasonal difference in larval lamprey densities in some river mouths. Work did not occur in the 2021 reporting year due to circumstances related to Covid-19 but is planned for 2022.	USFWS	Personal Communication with Joe Skalicky, USFWS (10/20/21)
8.	Pacific lamprey passage assessments at manmade barriers	No associated hydro project	N/A	In July 2020, 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. Most of the facilities evaluated were found to have significant passage issues for lamprey. Work did not occur in the 2021 reporting year due to circumstances related to Covid-19 but is planned for 2022.	USFWS	Personal Communication with Joe Skalicky (10/20/21)
9.	Thermal tolerance of larval Pacific lamprey	No associated hydro project	Umatilla	This project's objective is to determine the thermal tolerance of larval lamprey. Initially work was conducted in laboratory experiments and results suggested that larval Pacific Lamprey can tolerate temperatures up to 28-30 C. A field portion of this effort began in 2018 and continued in 2021. Work is designed to compare the occupancy of larval Pacific Lamprey in areas with different temperature profiles (those that exceed 28 C and those that don't) using the Umatilla River as a natural laboratory.	USFWS	Personal Communication with Tim Whitesel (11/17/21)
10.	Physiological response of larval Pacific lamprey to	No associated hydro project	N/A	Freshwater habitats in the Pacific Northwest of the United States are becoming warmer due to climate	OSU	Personal Communication

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	chronic temperature stress			change. The Pacific lamprey (*Entosphenus tridentatus*) is endemic to the river and lake systems of the Columbia River basin, playing an important role in the ongoing health of the system, yet have had a steady decline in abundance. The goal of this study is to establish the thermal thresholds for the larvae of this species and to determine the chronic effects of temperature onlarval 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. This work has culminated in a thesis paper published at OSU in 2020. Updated information not available at the time of reporting.		with Patrick Carilli (9/29/20) The Physiological Response of Larval Pacific Lamprey to Chronic Heat Stress (Carilli 2020)
11.	Adult lamprey abundance trends	No associated hydro project	N/A	Abundance trends of adult Pacific Lamprey were analyzed from dam counts and redd surveys in western Oregon, USA. A series of generalized additive models (GAMs) were compared to describe lamprey abundance trends. Lamprey counts varied considerably among dams but showed steep declines over 70+ years (1949–2019) at Bonneville Dam on the Columbia River, over 50+ years (1965–2019) at Winchester Dam on the North Umpqua River, and over 17 years (1993–2009) at Gold Ray Dam on the Rogue River. By contrast, redd surveys displayed synchronous abundance trends of different magnitudes among geographic management areas on	ODFW	Abundance Trends of Adult Pacific Lamprey in Western Pregon (USA): historic Declines, Recent Increases, and Relative Contributions from Coastal Rivers. (Clemens et. al 2021)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				the Oregon coast, with an overall increasing abundance over 13 years (2007–2019). This corroborates pre-existing notions that Pacific Lamprey spawning in Oregon coast rivers are from a single mixed population. The most supported GAM included a fixed effect for location and allowed abundance to vary over years as a function of location. These results suggest that abundance trends among dam counts are more variable than coastal redd surveys and that dam counts and redd surveys across this large region are not useful proxies for each other. Furthermore, counts across dams may be more variable because they record prespawning lamprey and thus may be recording a mixture of cohorts. Redd surveys, by contrast, provide a metric of a single cohort of spawning lamprey.		
12.	Lamprey monitoring	No associated hydro project	Hood	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/m^2. 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. In 2019, ammocoete surveys for distribution and densities in Hood River were completed. The 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.	CTWS	Personal communication with Lindy Collamer, CTWS (11/10/21) Evaluate Status and Limiting Factors of Pacific Lamprey in the Lower Deschutes River, Fifteenmile Creek and Hood River (Johnsen and Baker 2017)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				In 2020 and 2021, surveys did not take place regarding larval lamprey densities in Hood River. Due to Covid-19 closures, surveys of larval lamprey did not occur nor were antennas for PIT-tag detection installed. Density surveys will resume in 2022.		
13.	Ongoing Monitoring	No associated hydro project	Lower Columbia River watersheds	2021, crews continued to collected lamprey spawning, included redd counts, number of live lampreys, and number of dead lamprey data during steelhead Spawning Ground Surveys in Lower Columbia River watersheds. The surveys are conducted on tributaries from the White Salmon basin downstream to the mouth of the Columbia River, including, Gorge tributaries, Washougal, Lewis, Cowlitz Grays, and Elochoman watersheds (WRIA 25-29). Data available at: https://data.wa.gov/dataset/WDFW-SGS/idwx-fext In 2021, juvenile trap crews collect lamprey life stage data and fin clips at site within the lower Columbia watersheds. Send DNA to CRITFC for contribution to regional genetic analysis.	WDFW	Personal communication Monica Blanchard, WDFW (2/18/22)
14.	Nest surveys for Pacific lamprey	No associated hydro project	Entiat	USFWS conducted a fourth 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 (11/16/21)
15.	Lamprey artificial propagation	No associated hydro project	N/A	Since 2012, the Yakama Nation Fisheries (YNF) 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. Currently, studies are ongoing to evaluate rearing of new and older larvae as well as metamorphosis rates among larger and older larvae.	Yakama Nation, CTUIR, NOAA Fisheries, USFWS, Chelan County PUD	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Summary of past Pacific Lamprey aquaculture work by the YN, CTUIR, NOAA,

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						and USFWS (2012-2018) (Lampman 2021a)
16.	Lamprey artificial propagation	No associated hydro project	N/A	A review paper manuscript was accepted recently by the Journal of Great Lakes Research describing a blueprint for the production of 1,000 macrophthalmia (eyed juvenile) through artificial propagation and is currently in the final stages of review.	Yakama Nation, CTUIR, NOAA Fisheries, Ishikawa Prefectural University, Fisheries and Oceans Canada	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Lamprey aquaculture successes and failures: A path to production for control and conservation (Lampman et al. 2021)
17.	Influence of Pacific Lamprey origin on performance.	No associated hydro project	NA	Artificial propagation of Pacific Lamprey is being pursued to provide larval and juvenile lamprey in large quantities for research (e.g., downstream passage studies) and restoration activities. Ideally, artificially propagated (AP) lamprey would perform comparably to wild (W) lamprey. However, the long-term culture of larvae (3-10 years), until metamorphosis, could influence changes in performance of "domesticated" AP fish relative to W fish. AP and W lamprey have recently been compared using respiration rates, burrowing, and sustained swimming ability (Moser et al. 2020). The study will compare the swimming ability of tagged lamprey and describing the performance of AP and W lamprey over time in captivity. W larvae may demonstrate different behaviors than "domesticated" AP larvae and understanding when behavioral changes occur is an important consideration in decisions about when AP fish are appropriate surrogates for W fish.	USGS	Personal communication with Lisa Weiland, USGS (11/29/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Study goals include: 1) compare the swimming ability of AP and W juvenile lamprey implanted with the lamprey-eel acoustic tag (JLAT), and 2) investigate the effects of captive holding duration by evaluating night activity levels, burrowing ability, and photokinetic response to tail illumination of AP and W larvae over a 6-9-month period. Testing is planned to continue in 2022.		
18.	Collection of adult lamprey for translocation, artificial propagation and radio-telemetry studies	No associated hydro project	Umatilla	In 2018, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) collected adult lamprey from lower Columbia River mainstem dams. Approx. 1,700 adults were captured and transported to the South Fork Walla Walla lamprey holding facility throughout the fall and then moved to Minthorn Springs to over-winter. These fish will be used for translocation programs in the Umatilla and Grande Ronde basins and to support artificial propagation research occurring at the Walla Walla Community College, Water Environmental Center lab and productions of prolarve for release in the Tucannon River Basin. Genetic samples were collected for all translocated fish and brood for artificially produced pro-larvae.	CTUIR	Personal communication with Aaron Jackson, CTUIR (12/7/21)
19.	Collection of adult lamprey for translocation, artificial propagation and radio-telemetry studies	No associated hydro project	Yakima, Wenatchee, Methow, Klickitat	In 2021, the Yakama Nation collected adult lamprey from Lower Columbia River mainstem dams. Adults were captured and transported to the Prosser Fish Hatchery (Prosser, WA). These fish will be used for translocation programs in the Yakima, Wenatchee, and Methow subbasins; to support supplementation; PIT tag assessments; and to support artificial propagation research.	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Yakama Nation Adult Pacific lamprey (*Entosphenus tridentatus*)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						collection in the Columbia River Basin, 2020. (Lumley and Lampman 2021a) Guidance for the non-lethal collection of blood samples from adult Pacific Lamprey (*Entosphenus tridentatus*) (Beals and Lampman 2021a)
20.	Adult translocation supplementation	No associated hydro project	Snake River	1090, and 415 adult lamprey returned to the Snake River subbasin from spring to fall of 2019 and 2020 respectively. Genetic samples were collected for all translocated adults and provided to CRITFC for further analysis.	NPT	Personal communication, Tod Sween, NPT (2/18/22)
21.	Trap and transportation of adult Pacific lamprey	Priest Rapids Dam	Columbia	From July 20 to September 9, 2021, Grant PUD successfully collected a total of 462 adult Pacific lamprey from the fish ladders at Priest Rapids Dam. Lamprey were provided to Douglas PUD to support their translocation program. All Pacific lamprey were transported upstream of Rock Island Dam to meet and fulfill Grant PUD's No Net Impact Statement of Agreement (SOA) with the Priest Rapids Fish Forum (PRFF).	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/5/21)
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	Douglas PUD	Personal communication with Chas Kyger (10/18/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				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 July 29 and September 9, 2021, 461 adult lamprey were translocated from Priest Rapids Dam. Of the 461 fish translocated, 345 were released in the mainstem Columbia River 4km upstream on Wells Dam and 116 were released into Okanogan River tributaries by the Colville Tribes. 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. A single adult lamprey was omitted from this summary as it did not receive a PIT tag but was translocated upstream of Wells Dam and released successfully, making the total count of translocated adult lamprey 462.		
23.	Habitat restoration and effectiveness monitoring	No associated hydro project	Methow, Chewuch, and Twisp Rivers	Methow Salmon Recovery Foundation (MSRF), in partnership with Yakama Nation, USFWS, and Cascadia Conservation District initiated an assessment of salmon-based restoration projects to determine their effectiveness at providing larval lamprey rearing habitat. Several project sites in both the Entiat and Methow watersheds were assessed for the presence and type of larval rearing habitat as well as the presence and abundance or larval lamprey within those habitat patches. Planned work for the Chewuch River in the Methow was not completed due to area closures from wildfire. Sites in the Chewuch will be sampled in 2022 with a final report prepared in fall 2022. The effectiveness monitoring program in the Methow was curtailed in 2020 due to Covid and it is expected that a final report on this long-term monitoring will be completed in 2022.	MSRF, Yakama Nation, USFWS	Personal communication with John Crandall, Methow Salmon Recovery Foundation (10/25/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
24.	Restoration impacts on lamprey	No associated hydro project	S.F. McKenzie	Study began to evaluate lamprey occupancy in Stage-0 restoration projects. Year-1 sampling conducted in 2021 at S.F. McKenzie River and Fivemile-Bell site on the Oregon Coast. Year two will be surveyed in 2022.	USFWS, ODFW, USFS, CTGR, WDFW	Personal communication Monica Blanchard, WDFW (2/18/22)
25.	Electrofishing efficiency study	No associated hydro project	NA	Conducted deepwater electrofishing efficiency study to evaluate rates under various temperatures, conductivities, and substrate types. Study was conducted at Abernathy Fish Technology Center, on Abernathy Creek, WA. Experiments will conclude in 2022 and a report summarizing findings will be published	USFWS, WDFW	Personal communication Monica Blanchard, WDFW (2/18/22)
26.	Larval/Juvenile electrofish surveys	Hells Canyon Complex	Snake River	7 larvae and 1 juvenile captured during presence and absence sampling at 20 sites with genetic tissue collected for CRITFC PBT analysis.	NPT	Personal communication, Tod Sween, NPT (2/18/22)
27.	Larval lamprey surveys for status and trend, distribution, relative abundance, and habitat availability (including eDNA sampling)	No associated hydro project	Yakima, Wenatchee, Entiat, Methow, Crab, White Salmon, Klickitat	Long-term status and trend as well as exploratory electrofishing sites were surveyed for larval Pacific lamprey and *Lampetra* spp. within the Yakima, Klickitat, White Salmon, Crab subbasins. Wenatchee, Entiat, and Methow subbasin sites were not surveyed in 2020 due to travel restrictions related to Covid-19. Additional relevant sources include four appendix reports in the BPA 2020 Annual Report, including one focusing on freshwater mussels observed during larval lamprey surveys.	Yakama Nation, USFWS, USFS,	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Crab Subbasin larval lamprey monitoring report, 2020 (Lumley et al. 2021a) White Salmon and Klickitat Subbasin larval lamprey monitoring report, 2020 (Lumley et al. 2021b)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						Yakima Basin larval lamprey monitoring report, 2020 (Lumley et al. 2021c) Summary of freshwater mussel sightings within the Yakama Nation Ceded Lands during larval lamprey habitat surveys (2014-2020) (Beals et al. 2021a)
28.	Larval Pacific lamprey distribution	No associated hydro project	Wenatchee	In 2021, the Mid-Columbia Fish and Wildlife Conservation Office conducted eDNA sampling for Pacific lamprey in Icicle Creek. Analysis and reporting for this work is ongoing.	USFWS	Personal communication with Ann Grote, USFWS (11/16/21)
29.	Collection of larval Pacific Lamprey using a portable suction dredge	No associated hydro project	NA	To help fill the information gap on the direct effects of using a suction dredge to collect larval lamprey, in 2020 a pilot test with a portable suction dredge in two sediment types was conducted. Although larval lamprey prefer a mixture of sand and fine organic matter, they are also found in coarser sediments such as a mixture of sand and gravel. The coarser materials may have greater potential to injure fish as they travel together through the dredge hose lines and over the screening device. The objective of our evaluation was to compare the injury rate, survival, and burrowing capability of lamprey collected using a suction dredge and sluice box screening device with water only (control), fine sediment, and coarse sediment.	USGS and USFWS	Personal communication with Lisa Weiland, USGS (11/29/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Report is in final review stage.		
30.	Developing a gas bubble trauma (GBT) assessment protocol for Pacific Lamprey	No associated hydro project	Columbia	The research is focused solely on lamprey, specifically larvae. GBT signs and their progression are highly variable between individuals and life stages with early life stages being more sensitive. All lamprey life stages are at risk for GBT, but the protracted larval stage, with the limited ability to move out of areas of high TDG, makes them a priority. The flex spill program, and higher permitted TDG levels will result in additional risk to all Columbia River fishes for the foreseeable future. Although it's efficient to apply the salmon GBT assessment process to lamprey, there is no knowledge of what GBT signs mean for lamprey in terms of mortality risk. An extensive understanding of GBT signs is needed because not all signs will be useful for all species and life stages. Some signs may appear very near death, dissipate within a few hours, have limited prevalence, be time intensive to sample or be unrelated to mortality. Progression, severity, and linkage to mortality risk must be evaluated to select the 'best' signs to use in a lamprey-specific assessment protocol. Although the need for such a protocol is not new, the adoption of the flex spill program and corresponding increased risk of GBT, combined with declining lamprey populations, make this information gap a priority to resolve. The outcome of this work will be a quantitative, non-lethal, rapid field assessment protocol based on GBT signs that are predictable and persistent indicators of TDG supersaturation and related to the likelihood of mortality. The protocol can be added to the existing GBT monitoring program, allowing lamprey to be assessed as effectively as salmon and other bony fishes. The laboratory gas system is running and testing will begin in December 2021.	USGS	Personal communication with Lisa Weiland USGS (11/29/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
31.	Ecology of overwintered adult Pacific Lamprey and the role of spawned out carcasses	No associated hydro project	Yakima	Historically, oligotrophic Pacific Northwest (PNW) streams received annual returns of spawning anadromous fish that provided resource subsidies in the form of marine-derived nutrients (MDN), thus driving stream food web productivity. To date, many studies in the PNW have focused on Pacific salmon (*Oncorhynchus* spp.) as a resource subsidy, overlooking other anadromous fish species such as Pacific lamprey (*Entosphenus tridentatus*). Both Pacific salmon and Pacific lamprey are culturally important to PNW tribes for ceremonial, medicinal, and subsistence purposes, and have been since time immemorial. Unfortunately, both salmon and lamprey populations are in decline. Historically, lamprey have been disregarded and actively eradicated by non-tribal resource managers, and although they have recently been included in restoration considerations, their role as a resource subsidy is still poorly understood. In order to better understand how Pacific lamprey can subsidize stream food webs, a nutrient diffusing substrate (NDS) array amended with Pacific lamprey and tule fall Chinook salmon tissue were used to compare the basal food web response in the summer and fall, when lamprey and salmon spawn, respectively. This study was conducted in 2020 in the upper Yakima River basin where the Yakama Nation has an active adult lamprey translocation program. Chlorophyll *a* was measured as the autotrophic food web response and community respiration (CR) as the heterotrophic food web response. Chlorophyll *a* responded equally to lamprey and salmon but was significantly higher in the summer. Alternatively, CR had a higher response to salmon compared to lamprey and was significantly higher in the fall. Differences observed in food web response were dictated by season, where chlorophyll *a* nutrient response ratios (NRRs) were roughly twice as high as in the summer and CR NRRs were roughly twice	Central Washington University, Yakama Nation, Columbia River Inter-Tribal Fish Commission	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) An ecological comparison between resource subsidies: Pacific Lamprey (*Entosphenus tridentatus*) and Pacific Salmon (*Oncorhynchus* spp.) (Wensloff 2021)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				as high as in the fall. Stoichiometric differences in lamprey and salmon tissue likely facilitated this response and had C:N:P ratios of roughly 187:37:1 and 60:13:1 respectively. These results indicate that Pacific lamprey are equivalent to salmon as a resource subsidy for the autotrophic food web in the summer when lamprey would normally spawn and suggest that increased lamprey populations will drive stream food webs that support both lamprey and salmon.		
32.	Lamprey marine ecology	No associated hydro project	NE Pacific Ocean	Pacific lamprey during their marine phase were collected from 2017-2021 by fishery observers on the commercial hake fishery and the commercial shrimp fishery, and by NOAA surveys for hake off the WA/OR coasts and groundfish in Alaska. These fish are being used to estimate marine size and condition, ocean growth rates, feeding success, origins (from genetics [Jon Hess and Laurie Porter] and statoliths and eye lens [Jessica Miller and Keala Pelekai, OSU]), and latitudinal and depth distributions. Four 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. A manuscript describing the ocean collections effort is planned for 2022.	NOAA Fisheries NWFSC, Columbia River Inter-Tribal Fish Commission (CRITFC), OSU	Personal communication with Laurie Weitkamp, NOAA Fisheries (9/30/21)
33.	Traditional ecological knowledge on Pacific lamprey	No associated hydro project	Yakima	The Yakama Nation (YN) Pacific Lamprey Project and partners (Heritage University) has interviewed many tribal members, most of whom are tribal elders, to inquire about Pacific lamprey. 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. Beginning in March 2013, oral interviews have been conducted with many 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	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Yakama Nation cultural oral interviews on asum (lamprey eels): Summary

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				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.		and review Part IV (2020) (Goudy et al. 2021)
34.	Lamprey identification guide and genetics	No associated hydro project	N/A	Through several years of conducting lamprey identification in the lower, mid, and upper Columbia watersheds, and confirmation through genetic methods, separate categories of Lampetra spp., Class A and Class B (which are genetically distinct) were found. Most lamprey biologists are able to distinguish Class A from *Entosphenus* as there is a difference in both the caudal fin and caudal ridge. But Class B *Lampetra* spp. have speckles on the caudal fin and can be very confusing (many biologists will actually ID them as Entosphenus, including the YN team in the earlier years). This field lamprey ID guide was included in the BPA 2017 Annual Report as Appendix L1. Research on the relationship between Class A and Class B *Lampetra* spp. 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 regions are in draft forms and will be available in 2022.	Yakama Nation, Columbia River Inter-Tribal Fish Commission	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Eyed *Lampetra* ID guide using specimens from Nass River Zolzap Creek (BC, Canada) (Lampman 2021b)
35.	Evaluated larval lamprey survival following salvage	No associated hydro project	Yakima	In 2020, lampreys were salvaged during dewatering events at three field sites under variable environmental conditions (summer and fall) and then held in the laboratory for 60 days to monitor survival, growth, and burrowing performance. Four salvage treatments were defined to represent combinations of typical salvage techniques and stressors, including multiple passes of standard electrofishing (SEF), lamprey-specific	USGS and USFWS	Personal communication with Lisa Weiland, USGS (11/29/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				electrofishing (LEF), and modified lamprey-specific electrofishing (MLEF; probes in direct contact with dewatered, but moist substrate) as well as extended exposure on the surface and walking on sediment where lampreys were burrowed. Control groups did not experience dewatering and were collected using LEF in areas away from treatment groups. Treatments were designed to increase in intensity, from treatment 1 (walking and exposure) to treatment 4 (multiple passes of SEF, LEF and MLEF). Study sites included a hatchery rearing pond (North Toutle Hatchery) dewatered in July, and two irrigation diversions (Wapato and Sunnyside diversions on Yakama River) dewatered at the end of the irrigation season in October. Treatments were executed inside circular 1 m2 enclosures that were randomly positioned in habitats expected to be dewatered. A solid, weighted ring at the bottom of the enclosure penetrated the sediment and netting extended through the water column to a floating upper ring. Eight enclosures per treatment at each test site were deployed, four salvage treatments executed, the lamprey collected from within each enclosure and transported to the laboratory, along with the control groups, for the 60-day holding period. Burrowing performance was tested in sand 1 day after the field effort and in field-collected sediment 30 days after the field effort. Mortality was documented and lamprey were measured at 1, 30, and 60 days in the laboratory and weights were used to calculate standard growth rate (SGR) for each site and treatment group.		
36.	Evaluating larval Pacific Lamprey movement capabilities to improve dewatering guidance	No associated hydro project	NA	Dewatering events occur routinely throughout the range of Pacific Lamprey and each event may kill many thousands of larvae. The Best Management Guidelines for lampreys during in-water work recommend slow ramping rates, but effective execution can be challenging. The cross-channel shoreline slope at dewatering sites influences the likelihood that larvae	USGS	Personal communication with Lisa Weiland, USGS (11/29/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				can move over the dewatered substrate and regain access to water. Understanding how far lamprey can move over dewatered substrate (based on slope) would be a powerful addition to the BMGs. Using guidelines for ramping rates and length of dewatered shoreline, separately or in combination, provides managers with a wider range of protective dewatering strategies. The goal of this project is to evaluate larval movement capability over dewatered substrate at a range of slopes under both controlled laboratory and realistic field settings, to provide additional guidance for the BMGs.		
	Lamprey Migration in Rivers					
37.	Juvenile lamprey outmigration monitoring	No associated hydro project	Umatilla	No rotary screw trap operation (Umatilla River Rm 2.5) occurred in 2021 due to damage sustained to the trapping infrastructure in the February 2020 flood. Engineering and re-installation is planned for 2022. Although trapping has not occurred since February 2020, status and trend monitoring shows continued increases since initiating translocation. The trap is run from November to May of each year. No juvenile lamprey were PIT tagged in fall 20- spring 21 or fall 21- spring 22 from screw trap operations. In the fall 2021, CTUIR is PIT tagging larval lamprey from electrofishing surveys in the Umatilla River. Additionally, genetic samples are collected for future analysis.	CTUIR, and NOAA Fisheries	Personal communication with Aaron Jackson, CTUIR (12/7/2021)
38.	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 July/August and October/November surveying dewatered irrigation canals within the Yakima and Wenatchee subbasins for larval / juvenile lamprey within these diversions. Intensive monitoring and rescue is conducted annually	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/5/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				at Sunnyside and Wapato canals (large scale diversions in middle reach of the Yakima River which entrain the largest number of larval/juvenile lampreys). Dryden Canal also entrains many larval/juvenile lampreys and requires intensive rescue efforts by multiple agencies each year. In addition, a pilot study in 2020 was conducted to assess the effects of sediment deposition on larval and juvenile lampreys in Prosser, Washington (Chandler Canal). In an effort to guide larval/juvenile lampreys away from the canal as well as the fish screen areas at the Bachelor-Hatton Canal (Ahtanum, WA), the YNF PLP has proposed to use a Flow Velocity Enhancement System (FVES) designed by Natural Solutions, A Dam Site Better Inc. (Helena, MT) (hereby the subcontractor). The FVES consists of fish-friendly venturi pumps and are designed to navigate fish away from problematic areas. Venturi pumps were installed in two separate locations at the Bachelor-Hatton Canal: 1) immediately upstream of the headgate along the stream edge (river left), and 2) within the canal upstream of the fish screens along the shore of the diversion area (river left). The installed pumps had two objectives: 1) encourage downstream migrating lampreys away from entering the headgate, and 2) encourage lampreys that enter the canal system to successfully find and use the fish bypass route. Larval lampreys were PIT tagged and released upstream of the headgate, and within the screening area upstream of each respective pump to monitor each pumps effectiveness in manipulating the movement of larval lampreys 1) away from the headgate inlet or 2) into the fish bypass. In addition to lampreys, Coho Salmon (*Oncorhynchus kisutch*) were released in similar locations as lampreys to monitor the systems effectiveness in guiding salmonids (*Oncorhynchus* spp.).		Summary Assessment of Larval/Juvenile Lamprey Entrainment in Irrigation Diversions within the Yakima Subbasin, 2020 (Beals et al. 2021b) Intensive Monitoring of Larval/Juvenile Lamprey Entrainment in the Yakima Subbasin, 2020 (Beals et al. 2021c) A pilot study to assess the effects of sediment deposition on larval and juvenile lampreys in Prosser, Washington (Chandler Canal) (Lampman 2021b) Reduction of larval lamprey entrainment in Bachelor-Hatton Canal, Ahtanum

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				In addition, a paper that summarized the use of a customized portable deepwater electrofisher to assess larval lamprey populations in irrigation canals was published in 2021.		Creek Subproject Report (Beals and Lampman 2021b) Using a customized portable deepwater electrofisher to assess larval lamprey populations in irrigation canals (Mueller et al. 2021)
39.	Juvenile lamprey outmigration monitoring	Sunnyside, Wapato, Chandler diversion dams	Yakima	Juvenile/larval lampreys collected from Yakima River tributary screw traps, Chandler Juvenile Fish Monitoring Facility (Lower Yakima R.) were PIT-tagged and released for outmigration studies. PIT tagged juvenile/larval lampreys were released in various locations between mid-Yakima River to lower Yakima River. The detection analysis is ongoing. In addition, a comprehensive guide to share best management practices focusing on juvenile Pacific Lamprey capture, holding, tagging, and treatments were summarized and published as one of the appendix reports for the BPA/BOR annual report.	Yakama Nation, USGS, and BOR	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Summary assessment of juvenile/larval lamprey trapping and PIT tagging in the Yakima Basin, 2019-2020 water year (Beals et al. 2021b) Columbia Basin juvenile Pacific Lamprey guide (Beals et al. 2021e)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
40.	Migration data from translocated adults	No associated hydro project	Yakima, Wenatchee, Methow, Klickitat	Adult Pacific lamprey are released within the Yakima, Wenatchee, Methow, and Klickitat subbasins and analysis of migration data from those adults that were PIT-tagged are summarized annually. From the 2020-2021 broodstock (adults collected in summer 2019 that primarily matured in 2021), adult Pacific lamprey were released in the summer of 2020 in Wenatchee and Methow subbasins, and during the spring of 2021, adults were also released into the Yakima Subbasin. Analysis is ongoing and new reports will be available in spring 2022.	Yakama Nation, USFWS	Personal communication with Ralph Lampman, Yakama Nation (11/5/21)
41.	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. Use of the LPS was up in 2021 from 2020.	USFWS, and CTWS	Personal communication with Joe Skalicky, USFWS (10/20/21)
	Adult Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
42.	Conduct ladder tours	All Army Corps of Engineers (ACOE) projects	Columbia and Snake	No tours (for this purpose) were given at Portland District or Walla Walla District dams in 2021 due to COVID restrictions, though ACOE staff did hold several small group project-specific site visits.	ACOE	Personal communication with Jacob Macdonald, ACOE (10/21/21)
43.	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 2021, Grant PUD conducted a tour during scheduled maintenance outages 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	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/5/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				potential passage problem areas. Due to Covid 19 restrictions in 2021, PRFF members were not present.		
44.	Adult passage improvement work	Prosser, Sunnyside, Wapato, Horn Rapids dams	Yakima	A total of five vertical wetted wall (VWW) passage structures are currently installed at Prosser Dam (two each on the left and center fish ladders and one on the right fish ladder). These structures are maintained and checked regularly throughout the migration season (spring – fall). Those on the left ladder are volitional system, but monitoring is ongoing to ensure the video monitoring system is counting all lamprey as they pass through the volitional 4" flexible PVC tubes. Passage structure designs (VWW structures) for Sunnyside and Wapato diversions were completed in the summer of 2019. Fabrication is scheduled in 2021 and implementation is scheduled for fall 2021. Planning is ongoing for Roza and Horn Rapids dams. The use of VWWs and 4" flexible PVC tubes are being considered.	Yakama Nation, USFWS, and BOR	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Evolution of lamprey passage structures within the Yakima Basin (Lampman 2020) Adult Pacific Lamprey (Entosphenus tridentatus) passage improvement final designs for Sunnyside Diversion Dam, 2019 (Lampman and Simonson 2020a) Adult Pacific Lamprey (Entosphenus tridentatus) passage improvement final designs for Wapato Diversion Dam, 2019

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						(Lampman and Simonson 2020b)
45.	Adult passage improvement work	No associated hydro project	Klickitat	Passage improvement planning and design work started in 2019 and is ongoing. Implementation was scheduled in summer 2020 originally, but due to Covid-19 restrictions, this project was extended to July 2021. The latest design is a vertical wetted wall within the first weir inside the fish ladder to help adults circumvent the problematic fast velocity weirs within the lower fish ladder.	Yakama Nation, Yakima-Klickitat Fisheries Project	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Klickitat Passage Research and improvement Subproject Report (Lampman 2021d)
46.	Passage improvement design	McNary	Columbia	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. 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. Entrance weir caps are being designed for the Oregon Shore and Washington Shore entrances at McNary, to be installed in 2023.	ACOE	Personal communication with Jacob Macdonald, ACOE (10/21/21) Evaluation of Adult Fish Ladder Modifications to Improve Pacific Lamprey Passage at McNary and Ice Harbor Dams, 2014 (Thompson et al. 2015) Evaluation of Adult Fish Ladder Modifications to Improve Pacific Lamprey Passage at McNary Dam,

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						2015 (Thompson et al. 2016)
47.	Passage improvement design	Ice Harbor	Snake	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. 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. A prototype juvenile lamprey turbine cooling water exclusion hood will be installed at Ice Harbor unit 1 in 2023 and evaluated for effectiveness in 2024-2025. If effective, plans will be made to implement turbine cooling water exclusion throughout the Columbia River System.	ACOE	Personal communication with Jacob Macdonald, ACOE (10/21/21)
48.	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 (10/5/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
49.	Modify dewatering procedures	All ACOE projects	Columbia and Snake	Modifications to dewatering procedures to reduce stranding and mortalities have occurred over the past several years. These include managing dewatering to better flush fish down to the tailrace; to keep fish remaining in the ladder in standing water while dewatering to reduce the efforts by lamprey to move through gratings when stranded; and adequate personnel and equipment to ensure timely salvage. This is an ongoing action.	ACOE	Personal communication with Jacob Macdonald, ACOE (10/21/21)
50.	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 (10/18/21)
51.	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 Bill Towey, Chelan PUD (10/5/21)
52.	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 (10/5/21)
53.	Operate old fishway for lamprey passage	Willamette Falls	Willamette	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 of 2012 and continues to be operated annually when flows decrease below a river elevation (upstream of the falls) of 54 ft to allow for volitional passage to the forebay of the project. Additionally, 3 lamprey ramp structures are installed along the concrete cap to provide passage for lamprey	PGE	Personal communication with Dan Cramer, PGE (10/21/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				over the Falls after flashboard construction is complete. These structures provide a smooth attachment surface over the 3.5 ft flashboards. Ramps are generally installed in early summer and removed late-August. In 2021, Portland General Electric (PGE) continued to operate the "old fishway" and install lamprey ramps to facilitate adult lamprey passage at Willamette Falls Dam.		
54.	Passage design elements for new fishway construction	Carmen-Smith (Trail Bridge Dam)	McKenzie	As part of the implementation of the Carmen-Smith Project Federal Energy Regulatory Commission (FERC) license (issued May 2019), the Eugene Water & Electric Board (EWEB) has made provisions for design elements in the Trail Bridge Dam trap and haul that will assist in the upstream passage of Pacific lamprey if and when their distribution extends to the dam. A lamprey ramp or other passage system for Pacific lamprey that 1) integrates with the trap and haul, 2) which could be installed at a future date if necessary, and 3) will exclude lamprey from the trap pool.	EWEB	Personal communication with Andy Talabere, EWEB (10/21/21)
55.	Passage improvements to spawning channel	Carmen-Smith (Trail Bridge Dam)	McKenzie	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 made passage improvements to the Carmen-Smith spawning channel that include chamfered corners and edges on all concrete structures within the channel. This work was completed in 2021.	EWEB	Personal communication with Andy Talabere, EWEB (10/21/21)
56.	Reduce water velocities at fishway entrances	Bonneville and The Dalles	Columbia	Continued reduced nighttime flow operations at the Washington Shore Fish Ladder during the lamprey passage season to improve lamprey passage efficiency. In 2018 and 2019, as part of an ACOE-funded radio-telemetry study, reduced nighttime flow operations were conducted at Bonneville's Powerhouse 1 (Bradford Island Fish Ladder, A-Branch) and at The	ACOE	Personal communication with Jacob Macdonald, ACOE (10/21/21) Adult Pacific lamprey passage

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Dalles East Fish Ladder. In general lamprey entrance efficiency improved however it did not result in a significant increase in dam passage efficiency. Reduced nighttime flows for lamprey continued through 2021 and are planned for 2022.		at the four lower Columbia River Dams and lamprey behaviors in relation to nighttime fishway velocity reductions at Bonneville and The Dalles dams and the new UMTJ-LPS at Bonneville Dam, 2018. (Clabough et al., 2019)
57.	Lift picket leads at count station	Bonneville	Columbia	In 2011, lifted picket leads by 1 inch at Bradford Island Fish Ladder count station to improve access to auxiliary water supply (AWS) channel LPS. The 1-inch spacers were removed mid-passage season (June 29) due to an incident in which dozens of sockeye salmon were found milling behind picket leads. During an emergency dewatering on June 30, it appeared that the sockeye were able to get behind the picket leads via inconsistencies in the floor surface at the base of the picket leads (some gaps were up to 3 inches). ACOE modified picket leads at Bradford Island during winter 2011-12 to allow lifting picket leads by 1 inch while ensuring a contiguous floor surface. University of Idaho monitored these picket leads in summer 2012. Results suggest that adult salmonids, including relatively small-bodied sockeye salmon, jack Chinook salmon, and steelhead, did not attempt to or successfully enter the AWS channel at Bradford Island during the viewing period. Observations from project biologists at Bonneville Dam also did not see sockeye milling behind picket leads, despite the record-sized run.	ACOE	Personal communication with Jacob Macdonald, ACOE (10/21/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				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.		
58.	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 Jacob Macdonald, ACOE (10/21/21)
59.	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 Jacob Macdonald, ACOE (10/21/21)
60.	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 Jacob Macdonald, ACOE (10/21/21)
61.	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 and maintained	Chelan PUD	Personal communication with Bill Towey, Chelan PUD (10/5/21)
62.	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 (10/5/21)
63.	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	ACOE and NOAA Fisheries	Personal communication Jacob Macdonald, ACOE (10/21/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				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 (Frick et al. 2017). 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 of fish having been observed using the structure were published in a manuscript (Frick & Corbett, 2019). In the future, the Bradford Island prototype wetted wall will be converted to a trap for Tribal collection and translocation. Another wetted wall will be designed for the Bonneville Dam Washington Shore fishway.		Development and evaluation of a wetted wall for adult lamprey passage at the Bradford Island Fishway, 2019 (Frick & Corbett 2019) Climbing Success of Adult Pacific Lamprey on a Vertical Wetted Wall (Frick et al. 2017)
64.	Design and construct rounded caps and plating for fishway entrance weirs	Bonneville, The Dalles, John Day	Columbia	Modulating weirs located at fishway entrances are used to maintain consistent attraction flows under a variety of tailrace elevations. Radio-telemetry data have consistently shown delays and passage efficiency issues for Pacific lamprey at fishway entrances throughout the Columbia River Basin, presumably due to the high velocities (> 8 ft/sec) and turbulence associated with these features, and entrance weir geometry that makes attachment and entry challenging. As part of a broader minor fishway modifications project, in 2014 the ACOE designed novel, radiused weir caps to be installed on the flat crests of existing entrance weirs at the Bonneville Washington Shore 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	ACOE	Personal communication with Jacob Macdonald, ACOE (10/21/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				of weirs to provide attachment surface for lamprey that are approaching the top of the weir. Caps were fabricated and installed by ACOE staff at the following locations: • Bonneville Washington Shore Fish Ladder South Upstream Entrance (SUE) and South Downstream Entrance (SDE) (Winter 2014-15); • The Dalles North and East entrance weirs, except E1, E2 and E3 entrances at East Fish Ladder (Winter 2017-18). The ACOE installed similar structures at the following locations in the winter 2018-19) • Bonneville Washington Shore Fish Ladder North Downstream Entrance (NDE) and North Upstream Entrance (NUE); • The Dalles East Fish Ladder – Entrances E1, E2 and E3. Entrance weir submergence criteria and existing configurations preclude installation of similar weir caps at Bonneville Bradford Island Ladder. A variable width entrance weir with rounded crest is in design for this location, to be installed for the 2024 passage season. ACOE is fabricating caps for the John Day South entrance weir to be installed prior to the 2023 passage season.		
65.	Design and construct fishway modifications to improve lamprey passage conditions in serpentine weir (control) section of fishways	Bonneville	Columbia	The serpentine weir (control) sections of the Bradford Island and Washington Shore ladders at Bonneville Dam are known to be problematic for adult Pacific lamprey. This is probably due to a combination of high velocities, turbulence, confusing directional changes, cumulative effects of the passage experience, and lack of suitable cover/resting areas within the fishways.	ACOE	Personal communication with Jacob Macdonald, ACOE (10/21/21) Underwater video monitoring of slot

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				As part of a broader minor fishway modifications project, in 2015 the ACOE designed 1.5-in x 18-in weir orifices and prototype refuge boxes for testing in the serpentine weir sections of Bonneville Dam fishways. These structures were installed for initial evaluation at the Bonneville Washington Shore Ladder in Winter 2016-17 and the Bonneville Bradford Island Ladder in Winter 2017-18. Results from post-construction monitoring at the Washington Shore 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. No new control section modifications were made in 2020. The Washington Shore ladder serpentine section will be reconfigured to be a vertical slot and orifice configuration similar to those at Ice Harbor and John Day Dams. Initial design work began in 2021, anticipating construction in Winter 2024-2025. Lamprey orifices and refuge structures will be added to the Bradford Island ladder serpentine section Winter 2021-2022. Additional minor modifications, including rounded corners and velocity reducing structures will be added Winter 2023-2024.		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) 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)
66.	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 modified LPSs	ACOE	Personal communication Jacob Macdonald ACOE (10/21/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				and installed new structures at Bonneville and John Day through 2019including: 1. Bonneville Washington Shore –NDE Lamprey Flume System, completed in 2015 2. Bonneville Washington Shore Ladder AWS LPS,Completed in Winter 2016-17. 3. Bonneville Bradford Island Ladder exit section LPS – Extended exit chute into forebay to reduce fallback risk; completed counting system improvements; integrated HDX-PIT and FDX-PIT detection capability; other mods in Winter 2017-18. 4. Bonneville Cascades Island Ladder Entrance LPS – Various small-scale improvements. Completed in Winter 2017-18, additional improvement to lower the transport flume and eliminate lift pumps planned for Winter 2022-2023. 5. Bonneville Adult Fish Facility Ladder installed a LPS to collect adult lamprey for translocation and research in 2018. 6. John Day North Ladder Entrance LPS – Gravity feed (no pumps) water supply and collection tank upgrades are being designed for Winter 2022-2023 construction. ACOE received additional funding in 2020 to expand the network of LPS in the lower river dams. New LPS at The Dalles East Fish Ladder junction pool and Bonneville Bradford Island entrance are in design, to be installed 2023-2024. New LPS at Bonneville		

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Washington Shore and John Day South ladder transition pools are also being considered for construction in 2024.		
	Project Passage Effectiveness					
67.	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 was used to collect data from fish tagged 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 2020 and 2021, Grant PUD, in consultation with the PRFF, temporarily suspended monitoring adult Pacific lamprey with HDX-PIT-tags to evaluate fish passage efficiency due to lack of tagging at downstream dams due primarily to Covid-19 restrictions. Cumulative data analysis will continue in 2022 and will be included in the 2022 PLMP annual report.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/5/21)
68.	Evaluate passage at LPS structures	Threemile Falls Dam, Maxwell and Feed diversions	Umatilla	In the Umatilla River watershed, LPS have been completed and are operational at Threemile Falls Dam (July 2009), Feed Diversion (October 2010), and Dillon Diversion (2011-since removed). A flat plate was installed to aid upstream lamprey movement at Maxwell Diversion (damaged in Flood 2020). Refinement of LPSs continued in 2020-2021. 1318, and 204 adult lamprey returned to the Umatilla River from spring to fall of 2019 and 2020 respectively. 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.	CTUIR	Personal communication with Aaron Jackson, CTUIR (12/7/2021)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Less than 10 adult lamprey used the LPS at Feed Diversion in both 2019 and 2020. Dillon diversion was removed in summer 2017, and the Brownell Diversion was removed in summer 2018.		
69.	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, up to 400 adult Pacific lamprey will be trapped at River Mill Dam and hauled 14 km upstream to North Fork Reservoir. From 2017 – 2020, 249 to 267 individuals per a year were trapped and hauled. In 2021, 342 individuals were trapped and hauled. In 2017 and 2018 a subset of fish (n = 25) were radio-tagged. Fish readily migrated upstream with maximum distance above North Fork Reservoir ranging from 0.6 to 43.3 km. 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. In addition, passage through the North Fork ladder is evaluated using 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% from 2017 – 2020. In 2021, passage through the North Fork ladder could not be estimated.	PGE	Personal communication with Margaret David, PGE (10/22/21) Pacific Lamprey Upstream Passage Evaluation, 2021/2022 Annual Report[draft] (David et al. 2021)
70.	Modeling to optimize fishway design	No associated hydro project	N/A	Typically, fish passage design is informed by a critical velocity model whereby fish are assumed to fail passage if the water velocity is higher than the critical swim speed, an assumption that may not be met when locomoting fish are partially submerged.	J-U-B Engineers Inc. and University of Idaho	Personal communication with Chris Caudill,

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				A drag force model (DFM) approach was applied for use in design of Pacific Lamprey (*Entosphenus tridentatus*) Passage Structures (LPS) where lamprey may be partially or fully submerged. Our investigation assessed the dead-drag forces at four levels of static submergence: fully submerged (120 mm), equally submerged (40mm), partially submerged (15mm), and skin-flow (5mm) for a Pacific Lamprey physical model by varying simulated LPS slope and discharge conditions. The results were then used to establish drag force thresholds corresponding to the known critical velocity thresholds of Pacific Lamprey to predict passage success under partial and full submergence conditions. Consideration of drag force in fish passage could be used to improve or create species-specific design recommendations for fishways, or to inform the design of barriers to prevent invasive species passage. The results suggest consideration of drag force in addition to velocity is beneficial to predict Pacific Lamprey passage success under partial submergence conditions.		University of Idaho (9/20/21) Pacific lamprey drag force modeling to optimize fishway design (Zobott et. al 2020)
	Lamprey Counts at Dams					
71.	Conduct 24-hour lamprey counts	Bonneville, The Dalles, John Day, McNary, Lower Granite	Columbia and Snake	Count station window counts for Bonneville, The Dalles, John Day, McNary and Lower Granite dams include nighttime video. Validated LPS counts from Bonneville Dam are currently reported in tabular format to interested parties via email but are not currently posted directly to the ACOE or Fish Passage Center (FPC) fish count websites. All Bonneville Dam LPS counting systems will be upgraded Winter 2021-2022 to a passive system of optical sensors modeled after the prototype in service in the Washington Shore AWS LPS and wired directly to	ACOE	Personal communication with Jacob Macdonald, ACOE (10/21/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				the count stations for real-time integration with window counts and reporting.		
72.	Conduct 24-hour lamprey counts	Wells	Columbia	On-going 24-hour fishway monitoring since the 1990's.	Douglas PUD	Personal communication with Chas Kyger Douglas PUD (10/18/21)
73.	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 Bill Towey, Chelan PUD (10/5/21)
74.	On-going 24-hour fishway monitoring since the mid 1990's.	Priest Rapids, Wanapum	Columbia	On-going 24-hour fishway monitoring since the mid 1990's.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/5/21)
75.	Conduct 24-hour lamprey counts	Prosser and Roza	Yakima	On-going 24-hour fishway monitoring since 1996 at Prosser Dam and since 1997 at Roza Dam. New vertical wetted wall structures were constructed and installed at Prosser Dam in the center ladder and new volitional passage routes were added to the left ladder in 2019; counts from these lamprey specific structures are tallied separately from the fishway window counts.	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/5/21)
	Predation					
76.	Establish predation control measures (sea lions)	Bonneville	Columbia	Ongoing implementation of predation control measures, such as sea lion removal efforts - although planned for salmon, are also expected to benefit adult Pacific lamprey. Efforts are being made to be sure to include concerns for lamprey and adequate monitoring of lamprey predation in future efforts.	ACOE	ACOE Pacific lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	Juvenile Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
77.	Delayed deployment of extended length screen during outmigration	McNary	Columbia	Installation of extended screens has been delayed each year since 2013 to reduce impacts to juvenile lamprey migrating out early. This is an ongoing action.	ACOE	Personal communication with Jacob Macdonald, ACOE (10/21/21)
78.	Continue salvage activities during ladder maintenance de-watering	All ACOE projects	Columbia and Snake	Modifications to dewatering procedures to reduce stranding and mortalities have occurred over the past several years. These include managing dewatering to better flush fish down to the tailrace; to keep fish remaining in the ladder in standing water while dewatering to reduce the efforts by lamprey to move through gratings when stranded; and adequate personnel and equipment to ensure timely salvage. This is an ongoing action.	ACOE	Personal communication with Jacob Macdonald, ACOE (10/21/21)
79.	Continue salvage activities during ladder maintenance de-watering	Wells	Columbia	Pursuant to the Wells Habitat Conservation Plan (HCP; Douglas PUD 2002), a dewatering protocol is in place. Any adult lamprey captured during salvage activities are released upstream of Wells Dam, juveniles downstream per the Wells PLMP. This is an ongoing action.	Douglas PUD	Personal communication with Chas Kyger Douglas PUD (10/18/21)
80.	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. This is an ongoing action.	Chelan PUD	Personal communication with Bill Towey, Chelan PUD (10/5/21)
81.	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. This is an ongoing action.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/5/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
82.	Maintain bypass operations criteria	Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island Fish Passage Plan (Chelan PUD 2012), bypass operations criteria are in place. This is an ongoing action.	Chelan PUD	Personal communication with Bill Towey, Chelan PUD (10/5/21)
83.	Maintain bypass operations criteria	Priest Rapids, Wanapum	Columbia	Grant PUD has existing bypass systems, which includes gatewells, spillways, the Wanapum Future Unit Fish Bypass (WFUFB), and Priest Rapids Top-Spill Bypass. This is an ongoing action.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/5/21)
	Project Passage Effectiveness					
84.	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 Jacob Macdonald, ACOE (10/21/21)
	Predation					
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 Bill Towey, Chelan PUD (10/5/21)
87.	Predation control measures	Priest Rapids, Wanapum	Columbia	Grant PUD implements predation control measures (avian and aquatic) to protect outmigrating, anadromous	Grant PUD	Personal communication

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				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.		with Mike Clement, Grant PUD (10/5/21)
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 was published by the Transactions of the American Fisheries Society journal in 2021. Other monitoring is ongoing to enhance our understanding of predation impacts for larval/juvenile lamprey, including monitoring of predator fishes by hook-and-line angling in the Chandler Canal.	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Whose kids did you eat? Genetic identification of species and parents of larval lampreys in fish predator guts (Arakawa et al. 2021)
	Policy/Recovery Activities					
89.	Develop/implement implementation plan for Pacific lamprey restoration	All ACOE projects	Columbia and Snake	In May 2009, the Nez Perce, Umatilla, Yakama and Warm Springs tribes ("tribes") developed a Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin. A final draft of the Plan was completed in December 2011. The tribes propose the plan for restoration of the species to numbers adequate for tribal use and ecological health	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)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				of the region. Activities to support the objectives identified in the plan are ongoing.		
90.	Develop/implement Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research	No associated hydro project	Columbia (Mid and Upper)	This Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research is a phased approach, emphasizing adaptive management, with the goal of making progress towards the supplementation, artificial propagation, and aquaculture research goals and biological objectives identified in the Tribal Pacific Lamprey Restoration Plan (TPLRP) (CRITFC 2011), Lamprey Conservation Agreement (USFWS 2012), the Framework for Pacific Lamprey Supplementation research in the Columbia River Basin (CRITFC 2014), subbasin plans, and the Columbia Basin Fish Accords within a feasible, cost effective, and biological conservative manner. The Master Plan intends to continue utilizing adult translocation as well as the structured, strategic, and phased release of artificially reared Pacific lamprey to reintroduce, augment, and/or supplement Pacific lamprey within select Columbia River Basin subbasins to achieve the stated, long-term goals identified in various lamprey planning documents and restoration efforts. 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. Environmental compliance consultation is ongoing with USFWS and NOAA Fisheries and the current plan is to begin the experimental release starting in spring/summer 2021.	HDR Engineering, Inc. (HDR), CRITFC, Yakama Nation, and CTUIR	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Master Plan: Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research (CRITFC, Umatilla, Yakama, and Nez 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	ACOE	ACOE Pacific Lamprey Passage Improvements

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				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.		Implementation Plan, 2008-2018 (ACOE 2009; revised 2014)
92.	Develop/implement management plan for Pacific lamprey restoration	Wells	Columbia	In 2010, a Pacific Lamprey Management Plan (PLMP) was filed as part of the Wells Hydroelectric Project FERC License Application. In addition to fishway evaluations and activities to improve adult lamprey passage and juvenile passage and survival (when technology exists), management plan activities also include implementation of adult fishway and juvenile bypass operations criteria at the Project, regional data sharing, protocol development, and participation in regional conservation and recovery activities. Implementation of some management plan activities is ongoing.	Douglas PUD	Wells Pacific Lamprey Management Plan (Douglas PUD 2009)
93.	Develop/implement management plan for Pacific lamprey passage monitoring and improvement	Rocky Reach	Columbia	On-going implementation of the PLMP that was developed and finalized in 2005. In addition to fishway evaluations and activities to improve adult lamprey passage and juvenile passage and survival (when technology exists), management plan activities also include implementation of adult	Chelan PUD	Rocky Reach Pacific Lamprey Management Plan (Chelan PUD 2005)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				fishway and juvenile bypass operations criteria at the Project, regional data sharing and protocol development, and participation in regional conservation and recovery activities.		
94.	Develop/implement management plan for Pacific lamprey restoration	Priest Rapids, Wanapum	Columbia	On-going implementation of the PLMP that was developed, finalized, and approved by the PRFF, Ecology, and FERC in 2009. 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.	Grant PUD	Priest Rapids PLMP (Grant PUD 2009)
95.	Lamprey Technical Work Group • Passage Engineering Subgroup • Juvenile Entrainment and Dredging Investigations Subgroup • Restoration Subgroup • Genetics/eDNA Subgroup • Tagging Subgroup • Critical Uncertainties Subgroup • Contaminants Subgroup	All ACOE projects, Wells, Rocky Reach, Rock Island, Priest Rapids	Columbia and Snake	The Lamprey Technical Work Group (LTWG) is a committee of the Pacific Lamprey Conservation Initiative. The purpose of the LTWG is to provide technical review, guidance, and recommendations for activities related to lamprey conservation and 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. The LTWG released the Overview of eDNA and Applications for Research and Monitoring of Lampreys. It is available online: https://www.fws.gov/pacificlamprey/Documents/Overview_of_eDNA_Applications_for_Lampreys.pdf. The LTWG released Monitoring and Minimizing Effects of Dredging on Lampreys. It is available online:	USFWS	Personal communication with Christina Wang, USFWS (10/27/21) Overview of eDNA and Applications for Research and Monitoring of Lampreys (Lamprey Technical Workgroup 2021a) Monitoring and Minimizing Effects of

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	• Outreach Subgroup • Climate Change Subgroup • Ocean Subgroup • SOLAR Subgroup			https://www.fws.gov/pacificlamprey/Documents/Dredging_%20and_Lampreys_03.19.21.pdf. The LTWG met on 12-4-20 and 7-9-21. The LTWG hosted the 4th Annual Lamprey Information Exchange Webinar Series from January-June 2021. Topics for this year's sessions were Cultural Significance of Lamprey & Importance of Outreach; Lamprey Ecology & Ecosystem Services; Juvenile Lamprey Migration & Passage; Larval Lamprey Electrofishing & Capture Techniques; Learning from North American Sea Lamprey Research & Experiences; Diversity in Lampreys: Within-Species and Across Species. Sessions were recorded and can be accessed here: www.gotostage.com/channel/plci. Planning is underway for the 5th Annual Lamprey Information Exchange webinar series December 2021 – May 2022. It will kick off with a week's worth of activities during Lamprey Week, December 6-10, 2021.		Dredging on Lampreys (Lamprey Technical Workgroup 2021b)
96.	Pacific Lamprey Conservation Initiative (PLCI)	All ACOE projects	Columbia and Snake	Pacific Lamprey Conservation Initiative (PLCI) partners hosted the annual Policy Committee meeting virtually on 12-8-20. The Northwest Power and Conservation Council and Bonneville Power Administration's PLCI Columbia River Basin Projects funded $300K in high priority lamprey projects from the Regional Implementation Plans (RIPs) in 2021. PLCI funded two projects with National Fish Habitat Partnership coordination funds in 2021. Starting in FY23, PLCI will receive NFHP project funds as well as coordination funds. Seventeen lamprey proposals were received this year for funding consideration.	USFWS	Personal communication with Christina Wang, USFWS (10/27/21)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				All 18 RMUs completed or revised their RIPs. Current RIPs are available online: https://www.fws.gov/pacificlamprey/PLCI_RIPs.cfm FY21 RIPs were presented to the Conservation Team on August 18, 2021. Projects were prioritized for FY22 BPA and FY23 NFHP funding. Planning is underway for Lamprey Summit V in December 2022. The PLCI Conservation Team revised the Conservation Agreement in 2021. It will go out to new and existing signatories for their review and approval in advance of the Summit.		
97.	Pacific lamprey outreach	No associated hydro project	Yakima	The Yakama Nation Fisheries Resource Management Program Pacific Lamprey Project (YN) has a duty to educate the public about Pacific lamprey. The team members give various presentations about the life cycle, history, cultural significance, medicinal uses of lamprey, and the problems they face. Due to ongoing COVID-19 pandemic, outreach activities were severely limited in 2020/2021 and was mostly available online. However, the team is regularly updating the social media pages, including Facebook Page "Pacific Lamprey" with ongoing field work and other lamprey updates as a means to keep the public educated and interested in Pacific Lamprey during the current pandemic. A collection of Yakama Nation resources focusing on salmon, lamprey, and associated tribal culture was also synthesized and shared as an appendix report.	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (11/5/21) Yakama Nation Pacific Lamprey Project Outreach and Education, 2020 (Lumley and Lampman 2021b) Resource guide for lamprey outreach media by the Yakama Nation Pacific Lamprey Project (Washines 2021)

ACOE = Army Corps of Engineers
AWS = auxiliary water supply
BOR = U.S. Bureau of Reclamation
BPA = Bonneville Power Administration
CI = Confidence interval
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
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
HCP = Habitat Conservation Plan
HDX = half-duplex
IDEM = Integrated daily escapement estimate
ISRP = Independent Scientific Review Panel
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
NPT = Nez Perce Tribe
NUE = North upstream entrance
NWFSC = Northwest Fisheries Science Center
ODFW = Oregon Department of Fish and Wildlife
OSU = Oregon State University
PGE = Portland General Electric
PIT = passive integrated transponder
PTAGIS = PIT Tag Information System
PLCI = Pacific Lamprey Conservation Initiative
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
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 3. 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 during the 2021 reporting year, and any variations in schedule. In general, measures are currently on or ahead of schedule.

Table 3 Schedule and status of Pacific Lamprey Management Plan implementation measures at the Priest Rapids Project.

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Summary of Measure and Action Taken in 2021	Variation from Schedule (if applicable)
Objective 1: Identify, address, and fully mitigate Project effects to the extent reasonable and feasible to achieve No Net Impact (NNI)					
1.	Provide an annual report summarizing activities undertaken to identify and address Project impacts.	Annually (by March 31), starting 2010	Yes	Yes, report will be filed on or before March 31, 2022.	No
Objective 2: Provide safe, effective, and timely volitional passage for adult upstream and downstream migration					
2.	Maintain adult fishways.	Annually for the period 2009-2021	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

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Summary of Measure and Action Taken in 2021	Variation from Schedule (if applicable)
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 – 2021	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. (Note that due to Covid 19 restrictions, tagging in the lower Columbia River and passage monitoring at the Project did not occur in 2020 and 2021. Monitoring is anticipated to continue in the future as tagging occurs). Regarding adult passage criteria, based upon cumulative fish passage efficiency monitoring, Grant PUD, in consultation with PRFF members, entered into an Adult Lamprey Trap and Transportation SOA to offset PRP adult passage impacts in fulfillment of this measure.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Summary of Measure and Action Taken in 2021	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 2009-2021	Yes	Grant PUD maintains video stations at the Project to count fish in accordance with the Pacific Lamprey Management Plan (PLMP), NOAA Fisheries Biological Opinion and agreements included in the Federal Energy Regulatory Commission (FERC) License. Newly designed and fabricated fish crowder facilities were installed and operated at both Priest Rapids and Wanapum dams prior to April 2010. Fish counts for all species including adult lamprey are expected to be extremely accurate and are available at www.gcpud.org for review.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Summary of Measure and Action Taken in 2021	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. PUD biologists conducted an on-site inspection of the Priest Rapids and Wanapum fishway facilities during winter fish ladder maintenance outage. Covid restrictions excluded the ability for PRFF members to participate.	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	Summary of Measure and Action Taken in 2021	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)	No	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 50.0 to 100.0% with a standard error range of 0 to 19% at Priest Rapids Dam over the 2010-2019 period and ranged from 59.9 to 100.0% with a standard error range of 2 to 32% at Wanapum Dam over the 2010-2013, and 2015-2019 periods (2014 intentionally omitted).	Yes, ahead of schedule. An evaluation program was implemented in 2010 and was continued through 2019. No monitoring occurred in 2020 or 2021 due to no downstream lamprey tagging at Bonneville Dam these years. Monitoring is anticipated to continue in the future as tagging occurs.
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)	No	Grant PUD previously completed the required improvements proposed in the FLA and included in the FERC License (see #6 above). Grant PUD will consider additional modifications based on the ongoing evaluation of the effectiveness of fishway modifications.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Summary of Measure and Action Taken in 2021	Variation from Schedule (if applicable)
9.	Begin investigation of the efficacy and advisability of reducing fishway flows at night during peak lamprey migration periods.	Following implementation and evaluation of identified fishway modifications	No	Grant PUD began to investigate the efficacy and advisability of reducing fishway flows at night and had incorporated this objective into the 2010 study plan. However, after consideration by the PRFF and NOAA Fisheries, this objective of the study plan was determined to be considered following evaluations of existing fishway modifications (see PRFF meeting minutes for May 5, 2010) if needed in the future.	No
10.	Complete a biological objectives status report for Washington Department of Ecology (WDOE) 401 water quality certification.	Every 5th year of the license term (Aug. 2013, 2018, 2023, etc.)	No	The status report is not required for the 2021 report. Biological objectives status report update for 2017 was included in the 2017 report filed in March 2018. The next status report will be included in this annual report in 2023.	No
11.	Conduct a monitoring and evaluation study of adult Pacific lamprey passage at Project; if based on the 10-year status report, WDOE concludes that a Pacific Lamprey Biological Objective has not been met; Grant PUD shall continue to implement the Adaptive Management process.	Every 10th year of the license term (2018, 2028, 2038, 2048, 2058) or as recommended by the PRFF	No	Grant PUD and the PRFF have been conducting monitoring and evaluation studies for the past ten years through HDX PIT detection at both Priest Rapids and Wanapum dams. These results were summarized in the Biological Objectives Status Report Update for 2017 and was included in the 2017 report filed in March 2018. Based upon results of the monitoring, Grant PUD, in consultation with PRFF members, entered into an Adult Lamprey Trap and Transportation SOA to offset PRP adult passage impacts.	Yes

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Summary of Measure and Action Taken in 2021	Variation from Schedule (if applicable)
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 include (but are 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 Pacific Lamprey Conservation Initiative, its associated committee, the Pacific Lamprey Technical Workgroup. Refer to Section 2.0 for specific activities.	No
13.	Continue to operate and maintain the adult PIT-tag detection system [both half-duplex and full-duplex (FDX)] at the Priest Rapids Dam fishway.	Annually for the life of the license	No	Grant PUD continues to maintain the adult PIT-tag detection system (FDX) at Priest Rapids Dam, however, in 2020, monitoring did not occur because Covid restriction did not allow for downstream tagging programs to be implemented.	No
Objective 3: Provide safe, effective and timely volitional passage for juvenile migration					
14.	Identify and mitigate for Project effects on larval/juvenile Pacific lamprey	No later than 10 years following license issuance (2018)	No	Currently, options for measuring Project effects on larval/juvenile Pacific lamprey are under consideration by the PRFF. While juvenile tag technology continues to advance, a scientifically-rigorous survival study with sufficient numbers of larval and juveniles has not occurred to date. In addition, more discussion is required on how to collect actively migrating juveniles in the mid-Columbia River to effectively evaluate larval/juvenile Pacific lamprey survival.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Summary of Measure and Action Taken in 2021	Variation from Schedule (if applicable)
15.	Develop larval/juvenile Pacific lamprey passage criteria	No later than 10 years following license issuance (2018)	No	None. Currently, options for developing passage criteria for larval/juvenile Pacific Lamprey are still under consideration by the PRFF. While larval/juvenile tag technology continues to advance, a scientifically/statistically rigorous survival study with sufficient number of larval and juveniles has not occurred to date. In addition, more discussion is required on how to collect actively migrating larval/juveniles in the mid-Columbia River to effectively evaluate larval/juvenile Pacific lamprey survival. In the 2020 Addendum to the 2014 Columbia River Basin Fish and Wildlife Program (NPCC 2020), the Northwest Power and Conservation Council provides the following goal for larval/juvenile Pacific Lamprey passage: "For juvenile lamprey, improve passage efficiency and survival progressing toward standards used to measure juvenile salmonid survival." (NPCC 2020).	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 be limited to) the LTWG.	Annually for the life of the license	Yes	Grant PUD currently participates in regional forums such as the Pacific Lamprey Technical Workgroup and the Pacific Lamprey Conservation Initiative). Refer to Section 2.0 for specific activities.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Summary of Measure and Action Taken in 2021	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)	No	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 limited number of 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 4 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 2 of Section 2.0: 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 2. For planned or proposed efforts (which are not identified as current activities in Table 2) the source of the information is noted at the end of Table 4.

Table 4 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 2 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 #14	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/model 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 N/A Umatilla N/A (NE Pacific Ocean)	#3 #4 #1 #2 #11, #12 #18 #32	No	No. This activity is not required by Grant PUD's PLMP.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
4.	Determine the extent of juvenile rearing habitat	No associated hydro projects (I)	Fifteenmile Creek Deschutes and tributaries	#1 #2	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	No associated hydro project (I) Wells (P) Rocky Reach (P)	Fifteenmile Creek Columbia Columbia	#1 N/A[2] N/A[3]	No	No. This activity is not required by Grant PUD's PLMP, however, note that from 2012-2014 surveys to address the PLMP's juvenile lamprey requirement, no impacts were identified.	N/A
6.	Monitor/model juvenile population status and trends (unrelated to	No associated hydro projects (I)	Deschutes and other tributaries	#2	No	No. PLMP Objective 4 required the assessment of juvenile presence / absence and relative abundance	N/A.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
	counting at hydroelectric projects)		Willamette Columbia Hood Lower Columbia River Watersheds Methow, Chewuch, and Twisp Rivers S.F. McKenzie Yakima, Wenatchee, Entiat, Methow, Crab, White Salmon, and Klickitat Wenatchee Yakima Snake River	#6 #7 #12 #13 #23 #24 #27 #28 #35 #26		within the operational zone of the reservoirs. However, monitoring juvenile population status and trends is not a requirement of the PLMP.	
		Hells Canyon Complex (I)					
7.	Evaluate lamprey physiology, energy use,	No associated hydro project (I)	Umatilla	#9	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 = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
	nutrient transport, swimming performance, and behavior		N/A Columbia Yakima	#10, #29 #30 #31		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) Priest Rapids Dam (I) No associated hydro projects (I)	N/A Columbia N/A Umatilla Yakima Wenatchee Methow Klickitat Snake River Okanogan Columbia (Mid and Upper)	#16 #21 #15, #17 #18, #19, #36 #19, #41 #19, #22, #41 #19, #41 #20 #22 #90	Yes	No. This activity is not specifically 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. Grant PUD successfully trapped and transported 462 adult Pacific lamprey above Rock Island Dam during 2021 as a result of fish trapping and translocation for Douglas PUD. Grant PUD and the PRFF have also continued coordination with upstream PUD forums to strategize and plan for most appropriate allocation for translocation efforts among upstream basins.	N/A
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.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
10.	Develop and test new technologies / methodologies / protocols for lamprey	Willamette Falls (I) No associated hydro projects (I)	Willamette Willamette Yakima N/A N/A N/A	#5 #6 #35 #25 #36 #15	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 Yakima, Wenatchee, Entiat, Methow, Crab, White Salmon, Klickitat Wenatchee	#23 #27 #28	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
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	PR (as identified in the Tribal Pacific	N/A	N/A[1]	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 = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
	projects on lamprey and implement actions to mitigate these impacts	Lamprey Restoration Plan for the Columbia River)				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.	
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 Warm Springs	#8 #41	Yes	Yes. While the PLMP does not include a specific protection, mitigation and enhancement (PM&E) measure related to this activity, 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).	Yes. Monitoring of lamprey through the Project reservoirs was 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. Also in 2016, Grant PUD tagged and released 100

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
							adult lamprey with both acoustic tags (Vemco V7) and full-duplex (FDX)-PIT tags. An array of fixed acoustic receivers deployed throughout the Project area was used to monitor the tagged fish after release. This evaluation will help determine and inform trends in reservoir and upstream tributary passage.
16.	Assess impacts of irrigation water withdrawal structures on larval/juvenile passage/habitat	No associated hydro project (I)	Yakima, Wenatchee	#38	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
17.	Assess larval/juvenile lamprey outmigration (general)	Sunnyside, Wapato, Chandler diversion dams (I) No associated hydro project (I) Priest Rapids and Wanapum (P) Wells (P) Rocky Reach (P)	Yakima Umatilla	#39 #37 N/A N/A N/A	No	No. Assessing larval/juvenile Pacific lamprey survival at the Project is a requirement within the PLMP. Grant PUD will implement monitoring of larval/juvenile outmigration characteristics when effective and adequately tested methodologies become available. However, at this time, it is not appropriate to implement at the Project	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
						given the lack of methodology/technology.	
Adult Passage at Hydroelectric Facilities							
Structural and Operational Fishway Modifications							
18.	Inspect / inventory / document / assess structural improvements for fishway	All ACOE projects (I) Priest Rapids and Wanapum (I) Prosser, Sunnyside, Wapato, Horn Rapids dams (I) Bonneville (I) Bonneville (I) Carmen-Smith (Trail Bridge Dam) (P) Wells (P) No associated hydro project (P)	Columbia and Snake Columbia Yakima Columbia Columbia McKenzie Columbia Klickitat	#42 #43 #44 #63 #65 #55 N/A[2] #45	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) and passage times are being calculated. Following the 2016 migration period, the 2010-2016 cumulative passage dataset have been empirically and statistically

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
							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	#893 #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 was completed and is documented in this PLMP Comprehensive Annual Report (see Section 2.0: 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) No associated hydro project (P)	Yakima Columbia Snake McKenzie Columbia Columbia Klickitat	#44 #46 #47 #55 #65, 66 #66 #45	Yes	No. The LPS has been evaluated with respect to application in the Project (2001-2002 radio-telemetry study; Nass et al. 2003) and determined that because there are no areas where lamprey concentrate at either facility, this method would not be appropriate to implement.	N/A
21.	Install / evaluate / operate slotted "keyhole" fishway entrances	Priest Rapids and Wanapum (I) John Day (P)	Columbia Columbia	#48 N/A[5]	Yes	Yes. Keyhole entrances are currently utilized at both Wanapum and Priest Rapids dams.	Yes. See adjacent response.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
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 Columbia	#38 #51 #50 #51 #52	Yes	Yes. Dewatering procedures are in place for 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 of all recovered fish.
23.	Rehabilitate and/or operate old or existing fishway for lamprey passage	Willamette Falls (I)	Willamette	#53	Yes	Yes. Subsequent to fishway modifications completed in 2009-2010 outage at Priest Rapids and Wanapum dams, Grant PUD and the PRFF continues to operate Project fishways to support lamprey passage and will 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	#56 N/A[7]	Yes	Yes. PLMP Objective 2 requires that Grant PUD and the PRFF evaluate the efficacy of reducing fishway flows at night.	Yes. Grant PUD developed a PRFF-approved comprehensive study plan to evaluate improvements and modifications to the fish ladders at Priest Rapids and Wanapum dams in 2010.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
							Grant PUD began to investigate the efficacy and advisability of reducing fishway flows at night and had incorporated this objective into the 2010 study plan. However, after consideration by the PRFF and NOAA Fisheries, this objective of the study plan was considered to be unnecessary (see PRFF meeting minutes for May 5, 2010).
25.	Lift picket leads at count station	Bonneville (I) The Dalles (I) John Day (I) McNary (I) Ice Harbor (I) Lower Monumental (I) Little Goose (I) Lower Granite (I)	Columbia Columbia Columbia Columbia Snake Snake Snake Snake	#57 #58 #59 #60 #60 #60 #60 #60	No	No. Picketed leads at count stations at Priest Rapids and Wanapum dams were specifically designed (11/16" gap size) to preclude passage through the leads and force fish through the count station resulting in 100% count accuracy.	N/A
26.	Develop and/or maintain fishway operations criteria	Rock Island (I) Priest Rapids and Wanapum (I)	Columbia Columbia	#61 #62	Yes	Yes. PLMP Objective 2 requires Grant PUD to maintain its fishways in a manner that is consistent with the NOAA Fisheries	Yes. Specific operations criteria are presented in Grant PUD's Project Adult Fishways Operational Plan (Grant PUD 2008).

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
		Wells (I) Rocky Reach (I)	Columbia Columbia	#92 #93		Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). In 2011, Grant PUD implemented a Standard Operating Procedure (SOP) for operation of the Off-ladder Adult Fish Trap (OLAFT) vertical orifice gate to remain open when the OLAFT is not operating.	
27.	Address issues with diffuser gratings and picket leads, e.g., replace gratings with material of ¾-inch spacing (and replace other related structures: e.g., trash rack cleaning system and grating support system)	Other ACOE projects (exact one unspecified) (P) Wells (P)	Columbia, Snake Columbia	N/A[5] N/A[2]	No	Yes. PLMP Objective 2 requires installation of plating along the edges and through the orifices in the pools with diffusion chambers at Priest Rapids Dam. In addition, 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) John Day (I)	Columbia Columbia	#65, #66 #66	Yes	Yes. PLMP Objective 2 requires installation of plating along the edges and through the orifices in the pools with diffusion chambers at Priest Rapids Dam.	Yes. Grant PUD installed permanent aluminum plating on diffuser grates at Priest Rapids during the 2009-2010 winter fish ladder maintenance outage. The effectiveness of the plating was evaluated

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
							through the use of underwater video as part of the 2010 assessment of Pacific lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams (Nass et al. 2009). This study showed that lamprey effectively used the plating to move through a weir orifice or past the counting station.
29.	Modify/evaluate weir head differentials	The Dalles (I) Bonneville (I)	Columbia Columbia	#64 #65	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
31.	Establish protocol for formal inspection of passage facilities	Priest Rapids and Wanapum (I)	Columbia	#94	Yes	Yes. PLMP Objective 2 requires inspection of passage facilities by PRFF members.	Yes. Inspection by the PRFF is coordinated with annual winter fish ladder maintenance outages.

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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
							the effective use of these structures by migrating lamprey. Analysis of the data available from 2010 – 2021 was completed and is presented in Section 1.2 of this report. During this time period, the long-term average fishway passage efficiency was 86.6% and 89.4% at Priest Rapids and Wanapum dams, respectively (2-32% SE).
35.	Evaluate upstream passage modifications	Priest Rapids, Wanapum (I) No associated hydro project (I) [Note: evaluations performed on existing structural / operational improvements at ACOE dams are identified earlier in this table, under the heading, Structural and Operational Fishway Modifications.]	Columbia N/A	#67 #70	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 passively monitored at Priest Rapids Project facilities as directed by the PRFF. The assessment of

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
							plating and count station use in 2010 documented the effective use of these structures by migrating lamprey. Analysis of the data available from 2010 – 2020 was completed and is presented in Section 1.2 of this report. During this time period, long-term average fishway passage efficiency was 86.6% and 89.4% at Priest Rapids and Wanapum dams, respectively (2-32% SE).
Lamprey Counts At Dams							
36.	Develop feasibility, techniques, and protocols to improve 24-hour counting / conduct counts	Bonneville, The Dalles, John Day, McNary, Lower Granite (I) Wells (I) Rocky Reach, Rock Island (I) Priest Rapids, Wanapum (I) Prosser and Roza (I)	Columbia and Snake Columbia Columbia Columbia Yakima	#71 #72 #73 #74 #75	Yes	Yes. PLMP Objective 2 requires maintenance and feasible improvements to adult fish counting systems.	Yes. Grant PUD currently provides counts of all fishes 24 hours per day, 7 days per week for the period April 15 – November 15, annually.

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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 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 de-watering	All ACOE projects (I) Wells (I) Rocky Reach, Rock Island (I)	Columbia, Snake Columbia Columbia Columbia	#78 #79 #80 #81	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 = PR[1]	River(s)	Table 2 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)					recovery of all fish during all maintenance activities.
43.	Develop and/or maintain bypass operations criteria	Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia Columbia Columbia Columbia	#79 #80 #80, #82 #81, #83	Yes	Yes. Grant PUD has existing bypass systems, which includes gatewells, spillways, the 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.
Project Passage Effectiveness							
44.	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	#84 #84	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
45.	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.
46.	Evaluate downstream passage and survival	Wells (P)	Columbia	N/A[2]	No	Yes. The PLMP does not include a specific PM&E	Yes

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
	when technology and proven scientifically rigorous methodology is available	Rocky Reach (P) Priest Rapids and Wanapum (P)	Columbia Columbia	N/A[3] N/A[4]		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.	
Predation							
47.	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) Pikeminnow and birds Priest Rapids and Wanapum (I)	Columbia, Snake Columbia Columbia Columbia	#85 #86 #86 #87	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.
48.	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.	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. Monitoring of Northern

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
							pikeminnow diet contents (i.e., larval lamprey) is included as part of this on-going program.
Policy and Recovery Activities							
49.	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.
50.	Establish regional data protocols for collection, storage and analysis; develop means to widely access and share information	All ACOE projects (I) Wells (I) Rocky Reach (I) Priest Rapids and Wanapum (I)	Columbia, Snake Columbia Columbia Columbia	#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 Lamprey Technical Work Group (LTWG) the USFWS Lamprey Conservation Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.
51.	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P Proposed = PR[1]	River(s)	Table 2 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
52.	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.

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 thirteenth year of implementation of the PLMP, Grant PUD was unable to assess Pacific lamprey behavior and passage efficiency through fishways at Priest Rapids and Wanapum dams and their respective reservoirs to evaluate the efficacy of design enhancements that were installed during the 2009-2010 winter fish ladder maintenance outage due to Covid-19 restrictions on tagging programs in the Lower Columbia River during 2020 and 2021. Grant PUD will continue monitoring as soon as downstream tagging resumes. 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.

Similar to 2020, no tagging took place at Bonneville Dam in 2021 so the HDX-PIT arrays at Wanapum and Priest Rapids dams were temporarily suspended due to Covid 19 restrictions for a second consecutive year. Passage monitoring is anticipated to occur in the future as tagging at Bonneville Dam is reinstated. The intent of the HDX PIT data collection program is to provide sufficient sample size over time to calculate relevant passage metrics within the Project area and to collect and share regional data with on-going research activities. Analysis of the data available from 2010 – 2019 was completed and is presented in Section 1.2 of this report. During this time period, the long-term average fishway passage efficiency of the comprehensive dataset was 86.6% and 89.4% at Priest Rapids and Wanapum dams, respectively (2-32% SE). Note that 2014 data for Wanapum Dam was intentionally omitted due to anomalous conditions associated with the Wanapum fracture. 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[4]. These detections indicate the complexity of adult lamprey migration behavior. No overwintering fish were detected in 2017 and 2018.

In addition to the monitoring efforts, 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 B). For the fourth year of the agreement, Grant PUD operated the mechanical lamprey traps at Priest Rapids Dam from July 20 to September 9, 2021. A total of 462 lamprey were trapped to provide lamprey for Public Utility District No. 1 of Douglas County's (Douglas PUD) translocation program (see Appendix B, Table B-1). During the first four weeks of the effort Douglas PUD transported 325 lamprey from Priest Rapids Dam to release sites above Wells Dam and over the second four weeks 137 lamprey that were trapped were transported by Grant PUD to Kirby

[4] Overwintering lamprey may include both 1-year and 2-year overwintering adults.

Billingsley Hydro Park where they were transferred to Douglas PUD and released upstream of Wells Dam.

In 2021, Grant PUD also continued its regional approach to monitoring lamprey by coordinating among other utilities and participating in forums.

In 2022, 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 2021-2022 winter fish ladder maintenance outage and in-season fish ladder inspections.
2. Entrance and exit HDX-PIT antennas at the Wanapum right-bank fish ladder have been refurbished and will be tested prior to the 2021 migration season for continued monitoring of tagged adult Pacific lamprey.
3. Pre-season testing and calibration of HDX-PIT arrays, and maintenance of all 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).
6. Continue ongoing discussions regarding remaining juvenile requirements in the PLMP as requested by PRFF members (i.e., request that a topic be added to a 2022 PRFF meeting).
7. Continued participation in the LTWG and USFWS Pacific Lamprey Conservation Initiative.

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
Pacific Lamprey Activities in the Columbia River Basin: Background and Existing Information

1.0 Pacific Lamprey Activities in the Columbia River Basin

1.1 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.

1.1.1 General Biology and Ecology

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

Pacific lamprey are cartilaginous, jawless, anadromous fish that develop morphologically and physiologically in three primary stages. First, Pacific lamprey begin as larvae that hatch after approximately 19 days at 15°C (Close et al. 2002). After hatching, larvae drift freely downstream until encountering suitable substrate (silt and sand) and flow conditions (low velocities) for a sedentary lifestyle (Pletcher 1963 as cited in Close et al. 2002). Ammocoetes reside burrowed in fine sediment (Close et al. 2002) for a period of 4 to 6 years filter feeding on diatoms, algae, and detritus by pumping water through their branchial chamber (Beamish and Levings 1991). Beamish and Levings (1991) observed peak downstream movement of ammocoetes during May and June (Table A-1) and determined ages to range from two to six years (using statolith analysis; Volk 1986 as cited in Beamish and Levings 1991). In general, downstream movement of juvenile lamprey has been observed to coincide with high flow events.

Table A-1 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] Beemish 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 lamprey then enter a transformation phase characterized by morphological and physiological changes that begin in the latter period of substrate residence. The young adult stage continues during stream residence and into the period of downstream migration from their parent streams to the ocean. The causal mechanisms which initiate the transformation process, trigger emergence from the substrate, and result in migratory behavior are unknown or undocumented. Young adult lamprey are also termed macrophthalmia following major morphological changes, but prior to parasitic feeding (Hardisty and Potter 1971 as cited in Beamish 1980). Pacific lamprey transform from ammocoetes to macrophthalmia from July to November (Hammond 1979 and Close et al. 2002). During transformation, the shape and angle of the head and mouth changes, and the gut develops to allow consumption of flesh and fluids (Hart 1973). The onset of

transformation occurs over a relatively large range in lengths. Beamish (1980) observed characteristics associated with metamorphosis in lamprey ranging from 47 millimeters (mm) to 160 mm in length. As such, there is overlap in the length distribution of larval ammocoetes and macrophthalmia. Macrophthalmia migrate to the ocean between late fall and spring (Table A-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. A recent publication by Quintella et al (2021) discusses direct evidence for lamprey feeding ecology, as observed through lamprey-induced wounds on hosts and prey and lamprey attachments on hosts and prey; and analysis of fatty acids, stable isotopes, contaminants, and bioenergetics modeling.

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*).

A recent paper (Larson et al. 2020) provides evidence of the existence of a landlocked population of Pacific Lamprey that resided upstream of two high-head flood control dams (Dexter and Lookout Point) in the Middle Fork Willamette River for approximately five generations. This is the first known report of Pacific Lamprey surviving for multiple generations upstream of impassable impoundments. However, no Pacific Lamprey have been detected in recent targeted surveys, indicating that this population has since been extirpated or exists in very low numbers.

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 2.0: Updated Information for additional details).

1.1.2 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 amprey 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 PLMP 2020 Annual Report Section 2.0: 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 macropthalmia) 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 PLMP 2020 Annual Report Section 2.0: 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 PLMP 2020 Annual Report Section 2.0: Updated Information for additional details).

1.1.3 Population Status

1.1.3.1 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 impassible 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).

1.1.3.2 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 date[5] 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, pollution and chemical eradication, reductions of prey in the ocean, and juvenile and adult passage problems at dams. Comparison of counts between dams and between years is complicated by variable and inconsistent sampling protocols (BioAnalysts 2000), potential over-wintering between dams, changes in personnel, and counting station passage efficiency (the ability of count station equipment to force individuals through a counting area for observation). Annual counts of adult Pacific lamprey passing select mainstem dams in the Columbia River Basin are summarized below in Table A-2.

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.

[5] December 2, 2019

Table A-2 Annual counts (via Columbia River Data Access in Real Time [DART]) of adult Pacific lamprey at select Columbia and Snake River basin dams.[1]

Year	McNary	Priest Rapids	Wells	Ice Harbor	Lower Granite
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
2020	960	1,750	20	161	20
2021	1,368	2,482	11	399	31

Notes:

1 Ice Harbor, Lower Granite and McNary day counts only. 24-hour counts at Wells (since 1998) and Priest Rapids (since 2008)..

2 Counts through [November 27, 2021].

1.1.3.3 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 PLMP 2020 Annual Report Section 2.0: 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.

1.1.4 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 A-3) 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 A-3 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	2019	66.3-100.0% (SE 10-32%)	HDX-PIT	Section 1.2 of this report
		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	2019	50.0-100.0% (SE 0-16%)	HDX-PIT	Section 1.2 of this report
		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 A-3; 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 A-3 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 2010-2019 comprehensive dataset is 93.8% and 100.0% at Priest Rapids and Wanapum dams, respectively. In 2020, no tagging took place at Bonneville Dam so the HDX-PIT arrays at Wanapum and Priest Rapids dams were not operated. Passage monitoring is anticipated to occur in the future as tagging at Bonneville Dam is reinstated. Complete results are reported in Section 1.2 of the 2020 PLMP Annual Report.

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 PLMP 2020 Annual Report Section 2.0: Updated Information for additional details).

1.1.5 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 PLMP 2020 Annual Report Section 2.0: Updated Information for additional details).

1.1.5.1 Effects of Hydrologic Pressures on Juvenile Lamprey

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

National Laboratory (PNNL) on the effects of rapid and prolonged decompression simulating hydroturbine passage were conducted on juvenile Pacific lamprey. Generally, no mortalities or barotrauma were observed for lamprey exposed to these decompression scenarios (Colotelo et al. 2012).

1.1.5.2 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).

1.1.5.3 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 PLMP 2020 Annual Report Section 2.0: Updated Information for additional details).

1.1.5.4 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).

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

Table B-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
7/20/2021	6	2	4	12	24	35	41	DPUD
7/21/2021	8	3	4	2	17	28	38	DPUD
7/22/2021	1	0	2	12	15	42	26	DPUD
7/27/2021	4	2	0	1	7	19	27	DPUD
7/28/2021	7	0	0	22	29	8	78	DPUD
7/29/2021	6	1	5	19	31	32	49	DPUD
8/3/2021	8	10	1	15	34	20	63	DPUD
8/4/2021	26	6	8	1	41	33	55	DPUD
8/5/2021	18	7	5	9	39	28	58	DPUD
8/10/2021	19	5	0	12	36	19	65	DPUD
8/11/2021	12	5	3	9	29	27	52	DPUD
8/12/2021	5	6	1	11	23	29	44	DPUD
8/17/2021	2	0	1	7	10	8	56	DPUD
8/18/2021	2	0	0	4	6	12	33	DPUD
8/19/2021	11	1	0	0	12	11	52	KBHP
8/24/2021	1	1	3	17	22	9	71	KBHP
8/25/2021	5	1	7	16	29	33	47	KBHP
8/26/2021	8	0	1	1	10	29	26	KBHP
8/31/2021	1	0	2	12	15	22	41	KBHP
9/1/2021	0	0	1	5	6	20	23	KBHP
9/2/2021	0	0	0	2	2	35	5	KBHP
9/7/2021	1	0	1	6	8	22	27	KBHP
9/8/2021	0	0	1	0	1	18	5	KBHP
9/9/2021	0	0	1	15	16	11	59	KBHP
Total	**151**	**50**	**51**	**210**	**462**	**550**	**43**	

Appendix C
Stakeholder Comments

From:	Ralph Lampman
To:	Deb Firestone
Cc:	Aaron Jackson (AaronJackson@ctuir.org); Andrew Gingerich; Breean Zimmerman; Carl Merkle; Donnella Miller; Erin Harris; Jason McLellan (Jason.McLellan@colvilletribes.com); Keith Hatch (keith.hatch@bia.gov); Kirk Truscott (Kirk.Truscott@colvilletribes.com); Laura.Heironimus@dfw.wa.gov; Marcie Clement; Verhey, Patrick M (DFW); RD Nelle; Lewis, Stephen; Tom Skiles (SKIT@critfc.org); Tracy Hillman (Tracy.hillman@bioanalysts.net); Tom Dresser; Shannon Lowry; Chris Mott; Mike Clement; Le, Bao
Subject:	Re: Grant County PUD"s Draft 2021 Pacific Lamprey Management Plan Annual Report - For Review and Comment
Date:	Sunday, February 20, 2022 8:01:48 AM
Attachments:	2022_01_19 GCPUD Draft PLMP Annual Report_RL.pdf

Dear Deb and Mike,

Attached are my edits/comments to this PLMP annual report.
(comments are attached to the yellow highlights - 79 total)

It is one day late, but I figured no one will be checking it over the weekend :-)
I did my best to try to be as thorough as possible (but as you know it is a rather large report).
The organizational changes incorporated in this draft was much appreciated
(a lot of the background info placed into the appendix make it a lot more streamlined to the specific project year activities).
The only thing I would suggest on the organization end is to bring up Appendix B to section 3 or 5 (the main part of the report).

thank you,

~Warm Regards~

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

On Wed, Jan 19, 2022 at 8:24 AM Deb Firestone <Dfirest@gcpud.org> wrote:

> Good morning,
>
> Attached please find Grant County PUD's 2021 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 19, 2022.**

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

Have a great day!

Deb Firestone

Regulatory Specialist II – Environmental Affairs

CELL 509.989.5824

EMAIL Dfirest@gcpud.org

grantpud.org

Appendix D
Grant PUD Responses to Stakeholder Comments

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
Yakama Nation (Ralph Lampman)	2/20/2022	Email	Attached are my edits/comments to this PLMP annual report. It is one day late, but I figured no one will be checking it over the weekend :-) I did my best to try to be as thorough as possible (but as you know it is a rather large report). The organizational changes incorporated in this draft was much appreciated (a lot of the background info placed into the appendix make it a lot more streamlined to the specific project year activities). The only thing I would suggest on the organization end is to bring up Appendix B to section 3 or 5 (the main part of the report).	Comment noted. Grant PUD generally accepted and incorporated administrative comments directly into the report. Comments requiring more discussion are listed below.
		Page 3, Paragraph 3	It would be good to do a tour again (it has been a while).	Comment noted. COVID restrictions have not allowed for the annual tour however, Grant PUD anticipates having a tour with PRFF members as soon as restrictions are lifted.
		Page 5, Paragraph 2	Regarding passage efficiency rates: What about passage efficiency rates?	Passage efficiency rates are presented in Table A-3.
		Page 5, Paragraph 2	Regarding ladder travel times: the duration seemed to have increased considerably at both dams . What explains this? (poor antenna performance won't explain this as they have to have the initial and end detection to get those duration)	The variance of travel times is an artifact of highly variable individual travel times and small sample sizes (n=2,6,14,25) leading to the overall variation. The differences are more likely related to samples sizes than any changes in ladder or operational characteristics.
		Page 5, Paragraph 4	Regarding MARK and Cormack – Jolly – Seber model: why do you need to use a survival model to estimate passage efficiency? Why is this added complexity needed?	The CJS model calculates detection probabilities of specific antennas by using subsequent detections at further upstream sites. This allows calculation of passage efficiencies and the confidence or standard error of those calculations. The survival portion of the model is not used.

		Page 6, Paragraph 1	Regarding overwintering - There are actually two potential scenarios here and would be good to distinguish: 1. adults are overwintering and being detected in the next spring & early summer immediately prior to spawning (regular 1 year overwintering). 2. adults are overwintering twice and being detected in both summers (2 year overwintering). I estimate #1 spring/early summer passage timing to be predominantly prior to end of June. I estimate #2 summer passage timing to be predominantly past July 1. It would be good to understand the ratio of both (is #1 or #2 more common?) I can help decipher this if you need any help.	Grant PUD's comprehensive lamprey telemetry database will be updated in 2022 and a retrospective analysis of overwintering timing will be included in the 2022 report.
		Page 6, Paragraph 1	Regarding fallback - Is the # here coming equally from both bank fishways? or one fishway have more?	Additional analysis of the proportions of ladders used during fallback events will be assessed and included in the 2022 report.
		Page 6, Paragraph 2	Regarding FDX-PIT detections: any tributary detections?	The acoustic telemetry report Maenhout 2015 (A Monitoring Study to Quantify Migration Characteristics of Adult Pacific Lamprey in the Priest Rapids Project Area) describes tributary detections of FDX tags. Additionally, there are currently no tributaries within the Priest Rapids Project that have PIT tag detection capabilities.
		Page 7, Paragraph 4	Regarding 36 shoreline habitat locations sampled: approximate pool elevation for these surveys?	A presentation of the 2012-2013 juvenile lamprey presence/absence, habitat use and relative abundance surveys can be found in appendices of the 2012 annual report. The final report of the 2012-2013 work is appended to the 2016 annual report. Additionally, a memo detailing the opportunistic surveys conducted as part of the Wanapum fracture is appended to the 2014 annual report.

		Page 7, Paragraph 4	Regarding juvenile sampling and elevations at which sampling was conducted: The best timing would be during the lowest pool elevations (larval lamprey tend to stay deeper in these large rivers with regular fluctuations). Another effort would be helpful in the near future.	Sampling was conducted at high, medium, and low elevations. The 2014 Wanapum fracture and subsequent drawdown provided an opportunity beyond normal operations. This PLMP objective has been completed. See above response for locations of available information.
		Page 8, Paragraph 1	How large were these larval lamprey (small, medium, large)?	See above response for locations of available information.
		Page 8, Paragraph 1	Does this incorporate our YN findings? We found both larval and juvenile PL (I'll attach the report).	This is a summary of Grant PUD's specific assessment and as such does not include YN's findings. Those would be appropriate in Table 2 of the specific reporting year.
		Page 63, line item #9	Regarding reduction in fishway flows: Seems like we have not discussed this since the fishway modifications?	This is generally correct. Reduction in fishway flows was discussed in the past however was not supported by NOAA Fisheries and determined to be unnecessary (see PRFF meeting minutes for May 5, 2010). If there is interest in a discussion, Grant PUD encourages the Yakama Nation to propose this topic as an agenda topic at a future PRFF meeting where NOAA Fisheries can be present.
		Page 68, line item #4	Regarding activity to determine extent of juvenile rearing habitat; Nex Perce and partners are doing some work by Hells Canyon now.	Per previous input from PRFF members, Table 2 and this related line item have been updated per input from several entities working in Idaho including the Nez Perce.
		Page 71, line item #12	Does GPUD conduct any eDNA (for other species)?	Grant PUD conducts some eDNA activities for zebra and quagga mussel monitoring and in support of the Northern pike early warning program but note that these programs are in the mainstem Columbia River only.
		Page 71, line item #12	This should be "I" as well as "P" under CRITFC (is CRITFC activities completely missing from Table 2?). Another entity to add to contact list	While Grant PUD has collaborated with CRITFC on their activities in past years, a lack of activity has

			(Laurie Porter, Greg Silver, and Jon Hess)	removed them from reporting this year. Grant PUD will add CRITFC staff to annual reporting outreach for the 2022 reporting year.
		Page 78, line item #27	Regarding grating replacements to 11/16 inches: are any of the gratings (or other types of openings) larger than ¾ inch?	Yes, however all grating in PRP fishways that are ¾ " wide are supplemented with solid plating to facilitate lamprey attachment and passage through these areas.
		Page 82, line item #39	Regarding lifting/removing extended length screens during outmigration: is this talking about a separator? I thought this was about lifting the screens prior to turbines?	Grant PUD does not have turbine intake screens at either Priest Rapids or Wanapum dams.
		Page 85, line item #46	Regarding evaluating downstream passage and survival: if it is cost effective, why is it not being done? Should this be "N/A" since we're waiting on technology?	The table is structured so that if it is "appropriate to implement at the PRP" it would also, by default, be "cost effective for the PRP" which means that if it is a PLMP measure, it would be implemented as determined appropriate by Grant PUD and the PRFF. N/A is not an option for this column but Grant PUD does acknowledge that this activity cannot be implemented at the PRP for reasons identified in the comment table.
		Page 86, line item #48	Regarding evaluating predation potential of various native and non-native species: eDNA & metabarcoding are new molecular tools available to test predation of lamprey (given that lamprey degrade quickly within the predators guts).	Comment noted.
		Page 87, line item #51	It would be good to partner on Wanapum Indian Archaeological Days (would love to interview tribal elders from the Wanapum Tribe and Bands).	Grant PUD encourages Yakama Nation to contact the Wanapum Band and representative on the PRFF directly and/or request that this request be added as an agenda topic to a future PRFF meeting.
		Page A-2, Table A-1	Not sure this is worth changing but table timing is not accurate.	Grant PUD appreciates the comment. The table was developed to support the first year of this annual report with updates in subsequent years however given the high rate at which lamprey information

				becomes available, Grant PUD requests that Yakama Nation provide proposed edits and supporting references that can be incorporated into the 2022 annual report.
		Page A-10, Table A-2	McNary, Ice Harbor, and Lower Granite now all have 24 hour counts. These can be requested from FPC (or downloaded online).	Grant PUD consulted with Chris Peery, ACOE who noted that all counts reported on FPC and DART are daytime counts. Note that Table A-2 reports DART as the source so the footnote has been revised to indicate that all federal facility counts are day counts only. Grant PUD will consider incorporating data to make this table 24 hour counts as part of the 2022 annual report.
		Page A-14, Table A-3	This could be updated with latest study results.	These updates will be incorporated into the 2022 annual report.
		Page B-2, Table B-1	I suggest this be added to Section 1.0. Also, could you add window count for each fishway and the associated trap efficiency (two extra columns)? Could you also provide an annual summary trap efficiency rate as well (maybe in the table description)?	Grant PUD suggests not moving this table. Section 1.0 already contains a summary of this information at the appropriate level of detail for the main body of the annual report. Detailed information such as location of trapping, daily catch data, trapping dates, etc. is included in the appendix and remains easily accessible for readers. Additional requests will be considered for incorporation in the 2022 annual report.

Appendix E
Washington Department of Ecology's Approval Letter

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

1250 W Alder St • Union Gap, Washington 98903-0009 • (509) 575-2490
711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

March 15, 2022

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 –*Draft 2021 Pacific Lamprey Management Plan Comprehensive Annual Report*
Priest Rapids Hydroelectric Project No. 2114

Dear Mr. Dresser:

Ecology has reviewed the *Draft 2021 Pacific Lamprey Management Plan Comprehensive Annual* e-mailed to Ecology on January 19, 2022. 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,

Breean Zimmerman
Hydropower Projects Manager
Water Quality Program

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