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March 17, 2016

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) – 2015 Pacific Lamprey Management Plan Comprehensive Annual Report

Dear Secretary Bose,

Please find enclosed the 2015 Pacific Lamprey Management Plan (PLMP) Comprehensive Annual Report consistent with the requirements of Article 401(a)(12) and the Washington State Department of Ecology 401 Water Quality Water Quality Certification Condition of 6.2(6)(b) (Appendix C) for the Priest Rapids Project.

The 2015 PLMP Comprehensive Annual Report summarizes the on-going activities undertaken at the Priest Rapids Project (Project) in 2015, 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 Priest Rapids Project; and (iii) cost effective to implement at the Priest Rapids Project.

On January 22, 2016, Grant PUD prepared and disseminated the draft 2015 PLMP Comprehensive Annual Report to members of the Priest Rapids Fish Forum including the Washington Department of Ecology (WDOE) U.S. Fish & Wildlife Service, Washington Department of Fish & Wildlife, Colville Confederated Tribes, Yakama Nation, the Columbia River Inter-Tribal Fish Commission (CRITFC), Bureau of Indian Affairs, and the Confederated Tribes of the Umatilla Indian Reservation. A request for comments on the draft plan was also distributed to the Wanapum Indians, and other participating stakeholders. No comments were received. This same report has also been provided to WDOE on January 22, 2016. On February 11, 2016 WDOE approved the report (Appendix C).

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

Sincerely,

Ross Hendrick
License Compliance Manager
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CC: Patrick McGuire – WDOE
Priest Rapids Fish Forum

2015
Pacific Lamprey Management Plan
Comprehensive Annual Report

Priest Rapids Hydroelectric Project (FERC No. 2114)

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March 2016

Executive Summary

In accordance with the Priest Rapid Hydroelectric Project's (Priest Rapids Project or Project) License Order, issued by the Federal Energy Regulatory Commission (FERC) on April 17, 2008 (FERC 2008), and the 401 Water Quality Certification (WQC), issued by the Washington Department of Ecology (WDOE) on April 3, 2007 (WDOE 2007) and amended March 6, 2008 (FERC 2008), Public Utility District No. 2 of Grant County, Washington (Grant PUD) is required to develop, in consultation with the Priest Rapids Fish Forum (PRFF), a Pacific Lamprey Management Plan Comprehensive Annual Report (PLMP Comprehensive Annual Report) to be filed with FERC on or before March 31 of each year.

The PLMP Comprehensive Annual Report summarizes the on-going activities undertaken at the Priest Rapids Project in 2015, 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 seventh year of implementation of the PLMP, Grant PUD continued, for a sixth year, its assessment of Pacific lamprey behavior and passage efficiency through fishways at Priest Rapids and Wanapum dams to evaluate the efficacy of design enhancements installed during the 2009-2010 winter fish ladder maintenance outage. For the 2010 through 2015 migrations, Grant PUD tracked a total of 407 and 374 HDX-PIT-tagged lamprey at Priest Rapids and Wanapum dams, respectively. Fishway passage efficiency for lamprey was 74% at Priest Rapids Dam over the 2010-2014 period and 73% at Wanapum Dam over the 2010-2013 period (2014 intentionally omitted due to anomalous conditions associated with the Wanapum fracture). Fishway passage efficiency for 2015 are not yet available and will be included in the 2016 annual report.

During the 2015 reporting period, 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. As such, two new stations were installed in the vicinity of the Off Ladder Adult Fish Trap (OLAFT), and one station in each of the lower fishways was removed, reducing the total number of stations to 18.

During the 2015 adult Pacific lamprey migration period, two sources of HDX-PIT tagged lamprey were used to evaluate Project passage efficiency; fish from tagging efforts downstream and fish captured at Priest Rapids Dam. In 2015, reduced HDX-PIT tagging effort from downstream sources resulted in a smaller quantity of run-of-river tags detected at Priest Rapids Project than in recent years (n=27). The median passage time at the Priest Rapids left bank fishway was 36.0 hours and right bank fishway was 5.8 hours. As in previous years, the greatest portion of time for fish ascending the Priest Rapids left bank fishway was in the section above the count station, past the OLAFT to the exit (33.4 hours), however this assessment represents a small sample (n=6) and does not compare with results from 133 fish released into the Priest Rapids left bank fishway with HDX-PIT tags to assess passage near the OLAFT in 2015 (see additional details below). At Wanapum Dam, median passage times through the left and right bank fishways were 8.6 and 21.1 hours respectively. Compared with earlier study years, this

represents reduced passage time through the left bank but increased passage time through the right bank. However, 2015 results for Wanapum right bank fishway passage were also calculated from a small sample size (n=15) of run-of-river tagged adults. In 2015, 133 lamprey were captured with mechanical traps in the lower Priest Rapids Dam fishways and implanted with HDX-PIT tags. The tagged 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. As such, it appears that the passage timing of the Priest Rapids left bank upper fishway observed in previous years is not a consistent phenomenon.

In addition to the 133 HDX-PIT tagged fish in 2015, 100 adult lamprey captured with mechanical traps from the Priest Rapids Dam lower fishways during the peak migration period in July and August were implanted with both acoustic tags (Vemco V7) and FDX-PIT tags. These fish were released in either the Priest Rapids Forebay at Desert Aire (RM 400.4; n=30) or in the Wanapum Forebay at either RM 415.8 (n=35) or at RM 419.9 (n=35). An array of fixed acoustic receivers deployed throughout the Project area was used to monitor the tagged fish after release. Additionally, mobile tracking was employed to locate tagged individuals in the study area during the remainder of the migration period. As of October 2015, 75 fish were detected in the tailrace of Rock Island Dam (RM 453.0). The median travel time to reach the Rock Island Dam tailrace was 3.6 days for fish released in the Wanapum Reservoir and 5.5 days for fish released in the Priest Rapids Reservoir. Travel rates to reach the Rock Island Tailrace ranged from 1.9-28.2 km/d for fish released in the Wanapum Reservoir and from 1.9-12.7 km/d for fish released in the Priest Rapids Reservoir. Eight fish had not been detected after release and were assumed to have either been mortalities or have failed acoustic tags. Additional results will be provided after the study concludes in June 2016.

As in previous years, Grant PUD continues to participate in regional research and forums in the 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 long and 186.5 feet 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 feet long and 179.5 feet 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 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 recent research and implementation measures required in the Project's License Order as issued by the FERC on April 17, 2008 (FERC 2008), but is largely a continuation of prior activities. Grant PUD was the first mid-Columbia River utility to assess the passage of lamprey in and through its Project area (Nass et al. 2003) and to identify potential actions and modifications to improve successful passage (Final License Application, Grant PUD 2003) without compromising adult salmonid passage. Results of the 2001-2002 lamprey telemetry studies in the Project area formed the basis of proposed modifications which are being conducted as part of implementation of the PLMP. These past studies and measures are partly the result of participation at the regional level and cooperating with tribes, agencies, and other hydroelectric

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

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

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

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 (salmon) and half-duplex (HDX; lamprey) passive integrated transponder (PIT) detection systems for project-specific and basin-wide assessments; trapping and hauling lamprey; and providing educational opportunities for the public to understand the ecological and tribal importance of lamprey in the Columbia River Basin.

As referenced in the FERC Order (Order Modifying and Approving Pacific Lamprey Management Plan, Article 401(a)(12) and Water Quality Certificate Condition 6.2(5)(b)), 127 FERC ¶ 62, 091, Grant PUD is required to develop, in consultation with the Priest Rapids Fish Forum (PRFF), and implement a comprehensive evaluation of adult lamprey passage at the Project. As outlined in its PLMP, Grant PUD implemented measures to improve lamprey passage in 2010. These efforts include conducting inspections of the Project passage facilities by the PRFF members, and the installation of passage-enhancing structures in the fishways at Priest Rapids and Wanapum dams. New structures included diffusion grate aluminum plating, ramps ascending perched orifices, and lamprey-friendly video fish count crowders; all specifically designed to facilitate lamprey passage. To facilitate tagging and fish husbandry research, Grant PUD expanded its fish handling facilities at Priest Rapids Dam by building innovative adult lamprey trapping and holding facilities for the most efficient and non-invasive processing of study fish. Following the installation of these structures, Grant PUD, in consultation with the PRFF, conducted a study of the effectiveness of these modifications during the summers of 2010 to 2012. The extensive 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 NOAA approved dewatering procedures. These lamprey are scanned for the presence of a PIT tag and released into the forebay of the respective dams. Comprehensive results of this long-term monitoring program are presented in Section 2.1.4 below.

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. Toward this goal, two new stations were installed in the vicinity of the Off Ladder Fish Trap (OLAFT), and one station in each of the lower fishways was removed, reducing the total number of stations to 18. During the peak adult Pacific lamprey migration period in July and August 2015, 133 lamprey were captured with mechanical traps in the lower Priest Rapids Dam fishways and implanted with HDX-PIT tags (Appendix A). The tagged fish were released in the lower Priest Rapids left bank fishway to assess passage through the upper fishway. Results of this fishway passage behavior assessment are presented in Section 2.1.4 below.

Also during the 2015 adult Pacific lamprey migration period, 100 adult lamprey were captured and implanted with both active acoustic tags (Vemco V7) and full-duplex PIT (FDX-PIT) tags and released into Priest Rapids (n=30) or Wanapum (n=70) reservoirs for a voluntary study (i.e., not required by the PLMP) to assess reservoir passage behavior (Appendix B). 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 2016, 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. Initial results are presented in Section 2.1.4 below.

In June 2012, monitoring of juvenile lamprey was initiated to assess their presence/absence, habitat use, and relative abundance in areas affected by Project operations. In the Wanapum Reservoir, 36 potential shoreline habit locations were sampled. In the Priest Rapids Reservoir, 12 potential shoreline habitat locations were sampled. One juvenile lamprey was captured in the Priest Rapids Reservoir and another was observed, but not captured, in the Wanapum Reservoir. On November 13-16 and December 11-14, 2012, a field crew continued efforts to assess presence/absence, habitat use, and relative abundance of juvenile Pacific lamprey in areas that may be affected by Project operations. Twenty-seven and 21 shoreline habit locations were sampled in the Wanapum and Priest Rapids reservoirs, respectively. Sampling was conducted at mid-range pool elevations of the FERC-allowed operational range; approximately 570.0 feet (ft.) above mean sea level (msl) at the Wanapum Forebay and between 485.3-487.5 ft. above msl at the Priest Rapids Forebay. No juvenile lamprey were collected. Additional sampling was completed on May 11 and 12, 2013. Ten potential shoreline habitat locations in the Wanapum Reservoir were sampled resulting in the collection of no juvenile lamprey sampled. The pool elevation at the Wanapum forebay was 569.0 above msl during this sampling event. On October 11 and 12, 2013, a final sampling of eight potential shoreline habit locations in the Priest Rapids Reservoir collected seven juvenile lamprey. An additional 10 lamprey were observed but not captured. The elevation of the Priest Rapids Forebay was 480.2 ft. above msl during this effort (near allowable minimum reservoir elevation per the FERC license). On March 4 – 7 and 13-14, 2014 a field crew assessed presence/absence of juvenile Pacific lamprey in areas affected by the abnormal drawdown. Generally, sampling was difficult and at times not feasible due to deep mud exposed by low pool elevation (543.3-544.0 ft. above msl at the Wanapum forebay). Three juvenile lamprey were captured and another was observed during sampling on March 4 in the vicinity of Sunland Estates (RM 431). Small numbers of dead juvenile Pacific lamprey were observed in the vicinity of Walling Canyon (RM 449), Crescent Bar (RM 441), and Sunland Estates. Given three years of sampling at varying reservoir elevations (2012-2014) have indicated that juvenile lamprey do not commonly occur within the Project operational zone, no additional assessments were conducted in 2015 or are currently planned in the future.

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 (see Section 2.1.4). 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.

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 capital resources to achieve the goals and objectives of the PLMP.

1.3 Purpose of the Report

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

> *License Order: The licensee shall file annually with the Commission by March 31, beginning 2010, their Annual Pacific Lamprey Management Report. The report shall include the reporting requirements identified under implementation measure 1 of the Biological Objectives and Implementation Measures under Appendix C of the Washington State Department of Ecology 401 Water Quality Certification. Additionally, the licensee's report shall include an updated implementation schedule and identify any variations from the schedule provided in the licensee's filed plan. The licensee shall prepare their report in consultation with the Priest Rapids Fish Forum and allow the Priest Rapids Fish Forum 30 days to review and comment on the report prior to filing with the Commission. The licensee's report shall include any resource agency and Tribe comments and the licensee's response to any comments. The Commission reserves the right to require changes to their plan based upon review of the report.*
>
> *401 Water Quality Certification, Appendix C: By March 31 following issuance of the New License, and each year thereafter for the term of the New License, [Grant PUD shall] provide an annual report summarizing activities undertaken to identify and address impacts of the Priest Rapids Project on Pacific lamprey, including results of those activities. This report shall include a compilation of information on other Pacific lamprey passage and survival investigations and measures being undertaken in the Columbia River Basin in order to determine if adult and juvenile measures being investigated and/or implemented at the Priest Rapids Project are: (i) consistent with similar measures taken at other projects; (ii) appropriate to implement at the Priest Rapids Project; and (iii) cost effective to implement at the Priest Rapids Project.*

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

- Section 2.1: Background and existing information (i.e., through October 31, 2015) about Pacific lamprey passage and survival investigations and measures undertaken in the Columbia River Basin.
- Section 2.2: Information from the reporting year (i.e., November 1, 2014 through October 31, 2015) about passage and survival investigations and measures being undertaken throughout the Columbia River Basin.
- Section 3.0: Status report on Pacific lamprey activities underway at the Project, including identification of any variations from the schedule provided in the PLMP (Grant PUD 2009).
- Section 4.0: An evaluation of whether recent activities in the Columbia River Basin should be considered for the Project.

- Section 5.0: A summary of preliminary conclusions regarding Pacific lamprey activities to date, anticipated activities in the Columbia River Basin, and future activities at the Project for the upcoming year.

1.4 Consultation

Pursuant to the reporting requirements, Grant PUD provided a complete draft of the PLMP Comprehensive Annual Report to the PRFF and WDOE on January 22, 2016 for review. No comments were received. On February 11, 2016, WDOE sent a letter approving the annual report (Appendix C).

2.0 Pacific Lamprey Activities in the Columbia River Basin

2.1 Background and Existing Information

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

The Pacific lamprey is an important fish of cultural, utilitarian, and ecological significance (Close et al. 2002). Close et al. (1995) reported that Native American tribes of the Pacific Coast and interior Columbia Basin harvested Pacific lamprey for subsistence, ceremonial, and medicinal purposes. In addition, a commercial fishery for Pacific lamprey also occurred during the 1940s and was used as food for livestock and cultured fish. Pacific lamprey are important ecologically throughout their life in terms of nutrient cycling, both as predator and prey. As juveniles, lampreys are filter feeders of detritus and algae, and a food source for fish and birds (Close et al 2002). In the past when they were more numerous, downstream migrants were likely an important food source to fish and birds and may have provided a buffer for juvenile salmon migrants. As adults, lamprey are opportunistic feeders and prey on a variety of fish species, thereby minimizing their impact on any particular one species. Adult Pacific lamprey are also a prey item to marine mammals such as sea lions and likely attract predation away from adult salmon (Close et al. 2002). Pacific lamprey carcasses are a food source to sturgeon, and decomposition provides marine-derived nutrients to riverine systems.

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

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

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

2.1.1 General Biology and Ecology

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

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

Table 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]	Unk	▒	▒	▒	■	■	▒	▒	▒	▒	▒	Unk
Young adult downstream migration[1]	Unk	▒	▒	■	■	▒			▒	▒	▒	Unk
Metamorphosis / Transition[2]						▒	▒	▒	▒			
Parasitic feeding initiated[3]									▒	▒	▒	
Entry into saltwater[2]	▒	▒	▒	▒	▒	▒					▒	▒

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

Pacific lamprey then enter a transformation phase characterized by morphological and physiological changes that begin in the latter period of substrate residence. The young adult stage continues during stream residence and into the period of downstream migration from their parent streams to the ocean. The causal mechanisms which initiate the transformation process, trigger

emergence from the substrate, and result in migratory behavior are unknown or undocumented. Young adult lamprey are also termed macrophthalmia following major morphological changes, but prior to parasitic feeding (Hardisty and Potter 1971 as cited in Beamish 1980). Pacific lamprey transform from ammocoetes to macrophthalmia from July to November (Hammond 1979 and Close et al. 2002). During transformation, the shape and angle of the head and mouth changes, and the gut develops to allow consumption of flesh and fluids (Hart 1973). The onset of transformation occurs over a relatively large range in lengths. Beamish (1980) observed characteristics associated with metamorphosis in lamprey ranging from 47 millimeters (mm) to 160 mm in length. As such, there is overlap in the length distribution of larval ammocoetes and macrophthalmia. The macrophthalmia migrate to the ocean between late fall and spring (Table 1).

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 (Table 1), 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).

Lamprey are considered adults once all transformations are complete and parasitic feeding begins; a process that is likely completed in salt water (Richards and Beamish 1981 as cited in Beamish and Levings 1991). In addition, laboratory research by Beamish (1980) surmised that completely transformed lamprey (i.e., adults) must move into a saline environment within a

relatively short period of time, or they will die. Specifically young adults completing the transition to adulthood between June and September need to be in salt water by January. Physiological experiments showed that Pacific lamprey in the Fraser River begin entering saltwater in December and continue through June (Beamish 1980; Table 1). 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 recent 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).

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 are being implemented. Monitoring activities associated with documenting key habitat related to spawning, rearing, and overwintering are being conducted annually in the Deschutes, Hood, and Umatilla rivers. In the Yakima and Umatilla watersheds, tracking adult movement patterns (via radiotelemetry) to overwintering and spawning areas and identifying passage bottlenecks is occurring. In-river and irrigation canal juvenile lamprey distribution and abundance sampling is also occurring in the Yakima basin. Multi-year juvenile distribution and abundance sampling, habitat, and larval trend monitoring is occurring in the Klickitat, Entiat, Yakima, and Methow watersheds. Surveys to assess juvenile distribution and relative abundance have also been conducted in several of the mid- and lower Columbia River reservoirs. Additional work on the general biology and ecology of Pacific lamprey includes monitoring adult harvest and escapement at Willamette Falls; translocation activities; the development of a larval lamprey identification guide; evaluating re-introduction above Pelton Round Butte Dam; assessing mercury concentrations in Lower Columbia River fine sediment; continued development of artificial propagation techniques including the development of a supplementation framework; testing larval lamprey movements in response to dewatering events; and lamprey use of the lower Columbia River estuary (see Section 2.2: Updated Information for additional details).

2.1.2 Migration in Rivers

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

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

Median upstream migration rates have been estimated at 10 RM/day and 13.7 RM/day on the Columbia River (Jackson et al. 1997b and Vella et al. 2001, respectively), and 6.8 RM/day on the John Day River (Bayer et al. 2001). HDX-PIT tagged lamprey migrated at rates of 7.7 RM/day to 8.5 RM/day between Bonneville and McNary dams (~146 miles). As with timing, migration rates were correlated with water temperatures and inversely related to discharge (Keefer et al. 2009b). At Priest Rapids and Wanapum reservoirs, median upstream migration rates were 3.0 RM/day and 6.8 RM/day, respectively (Nass et al. 2003). Pacific lamprey that are migrating upstream are likely heading to holding and/or spawning areas to overwinter. 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).

Spawning occurs in the summer (June and July) following the upstream migration year (Beamish 1980 as cited in Close et al. 2002). Lamprey prefer low-gradient reaches, with gravel-pebble-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 feet (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), but 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 are occurring in reservoirs of the ACOE projects in the Lower Columbia and Snake rivers and in the Willamette River. Additional large-scale monitoring programs have also utilized half duplex (HDX) passive integrated transponder (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 (see Section 2.2: Updated Information for additional details).

Information regarding juvenile migration in rivers is limited. Much of the information available has been collected anecdotally during tributary operations targeting juvenile salmonid outmigrants and is consistent with previous information regarding timing and the environmental variables associated with such movements. Juvenile lamprey have been observed using dual frequency identification sonar (DIDSON) during an evaluation of the emergency wheelgate slot exclusion screens at Priest Rapids and Wanapum dams (Wright et. al., 2010). These results

suggested that downstream run timing of juvenile lamprey coincides with spring runoff upstream of the Priest Rapids Project and throughout the Columbia Basin and supports historical run timing trends of juvenile lamprey, and the size of lamprey recorded by the DIDSON also supports the distribution of recorded lamprey to be primarily juveniles (Wright et. al, 2010).

Over the past decade the lack of available tag technology has limited researchers and fish managers' ability to collect more detailed information to better understand and address challenges of juvenile lamprey movement. BioAnalysts (2000) summarized anecdotal information on the distribution of juvenile lamprey in tributaries of the mid-Columbia, which include the Wenatchee, Entiat, Chelan, and Methow rivers. Recent evidence indicates the presence of lamprey in the Similkameen River, a tributary of the Okanogan River (T. Holder, Washington Department of Fish and Wildlife, personal communication) previously thought unused by Pacific lamprey. Further, juvenile Pacific lamprey have been captured in rotary trapping operations on the Okanogan River near Malott (M. Rayton, Colville Tribes Fish & Wildlife, personal communication). 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.

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

2.1.3 Population Status

2.1.3.1 Distribution

Pacific lamprey are native to the Columbia River Basin and their spawning migration extends into many inland rivers draining Oregon, Washington and Idaho (Kan 1975; Hammond 1979; and Simpson and Wallace 1982). Collections and historic observations of Pacific lamprey are common in the Columbia River below the mouth of the Deschutes River. Areas include numerous small tributaries such as Fifteenmile Creek, Gnat Creek, Elochoman River, and larger tributaries such as the Lewis, Willamette, and Klickitat rivers. Lamprey probably used all accessible watersheds in the Lower Columbia, including mainstem and slough habitats. A comparison of counts at Bonneville Dam to harvest at Willamette Falls during the 1940s indicates that Pacific lamprey were probably more abundant in the Willamette subbasin at that time than they were anywhere upriver of the Columbia River Gorge (Kostow 2002).

Watersheds upstream of the Columbia River Gorge, specifically noted in historic collections and observations, include the Deschutes extending into the Crooked River above Pelton/Round Butte Dam, John Day, Umatilla, Walla Walla, Yakima, Entiat, Okanogan and Kootenay Lake. In the Snake River Basin, collections and historic observations have been made in the lower Palouse, Clearwater, Salmon, Grand Ronde, Imnaha, and upstream to at least the Powder River. Historic records are too sparse to determine the full extent of historic occupation of these basins; however recent work has focused on collecting more current distribution information and a report documenting the current status of Pacific lamprey in some of these river basins was published in

2011 (IDFG 2011). A study conducted by Idaho Fish and Game from 2000 to 2006 determined that Pacific lamprey currently occupy only about 25% of their historic distribution in the Snake River Basin (Hyatt et al. 2006). In the upper Columbia River Basin, distribution information is being collected in the Wenatchee, Entiat, and Methow rivers while past adult translocation activities by the Nez Perce Tribe indicated that juvenile lamprey in Asotin, Lolo, Newsome and Orofino creeks in the Snake River were primarily the progeny of translocated adults (Chris Peery, USFWS, personal communication).

The current distribution of Pacific lamprey is substantially reduced from the historic distribution. Lamprey have been lost from all areas that are blocked by impassible barriers. These barriers include the Willamette subbasin dams, and other high dams such as the Pelton/Round Butte complex (Deschutes), Dworshak (Clearwater), Hells Canyon complex (Snake), and Chief Joseph Dam (Columbia) that block upstream passage by all migratory fish. Lesser barriers that may pass salmonids also block upstream passage by lamprey, including smaller dams, small water diversion dams, culverts, tide gates and numerous other barriers. Adult Pacific lamprey are known to pass through the Project, but no radio-tagged lamprey were observed to use tributaries in the Project area (Nass et al. 2003).

2.1.3.2 Abundance

Pacific lamprey populations of the Columbia River have significantly declined in abundance in recent years 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. Specific reasons for this decline 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 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 recently beginning 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 limited information of juvenile use in Upper Columbia River tributaries may be an indication of the decline of Pacific lamprey.

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

Year	McNary	Priest Rapids	Wells	Ice Harbor	Lower Granite
2006	2,139	3,273	21	255	35
2007	3,389	3,419	32 [2]	288	34
2008	1,530	5,083	7 [2]	264	61
2009	676	2,713	9	57	12
2010	825	1,114	2	114	15
2011	868	3,868	1	269	48
2012	971	4,025	3	494	48
2013	1,570	5,968	21	328	19
2014[3]	1,813	7,586	7	721	84
2015[3]	1,748	6,749	0	764	50

Notes:

[1] Ice Harbor and McNary day counts only. Wells and Priest Rapids 24-hour counts. Lower Granite counts have been conducted 24 hours a day since 2009.

[2] The Pacific lamprey adult passage counts at Wells Dam are not reflective of actual run size during 2007-2008. Trapping, monitoring, and research efforts at Wells Dam artificially lowered the passage numbers for Pacific lamprey, i.e., more fish would have passed without tagging and trapping efforts.

[3] Counts through December 9, 2014 and December 6, 2015.

2.1.3.3 Population Structure

Genetic stock information suggests there is uncertainty among different Pacific lamprey stocks regionally. Powell and Faler (2001) determined that Pacific lamprey do not appear to have genetically different stocks, at least between some lower and mid-Columbia 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. (2007; 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. Work based upon microsatellite analysis of 21 sites along the west coast of North America found low levels of genetic differentiation, providing support for a lack of natal homing in Pacific lamprey. The report noted that Pacific lamprey from most of the sites examined in this study can be managed as one unit but recommended future investigations to confirm whether this conclusion is applicable to all sites (Docker 2010). The most recent genetic analyses have continued to add uncertainty to Pacific lamprey population structure. Spice et al. (2012) evaluated the hypothesis of natal homing in Pacific lamprey and had results that were inconsistent with philopatry, suggesting that anadromous lampreys are unusual among species with long migrations, but suggest that limited dispersal at sea precludes panmixia. Work done by Hess et al. (2012) may provide context for observed genetic divergence among

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

One recovery strategy for Pacific lamprey is the translocation of pre-spawn adults from downstream Columbia River locations and supplementation with hatchery spawned ammocoetes into suitable habitat upstream. Cummings (2007) found that trapping and translocating adult lamprey did not appear to affect their migration success but the implications to population structure are currently unknown. Since the late 1990's and 2006, the Umatilla and Nez Perce tribes, respectively, have been implementing Pacific lamprey translocation programs as a conservation measure to maintain some level of lamprey production in target spawning streams. In 2014, the Confederated Tribes of Grand Ronde captured lamprey at Willamette Falls and translocated them to Fall Creek (see Section 2.2: Updated Information for additional details about active efforts).

In 2009, the CRBLTWG was asked to develop a review paper on lamprey translocation and artificial propagation. Due to the uncertainty surrounding the potential implications related to unknown genetic stock structure related to translocation and differing opinions by CRBLTWG members, the CRBLTWG concluded that it would not be able endorse a position or shared opinion at this time and instead completed a literature review paper outlining the potential benefits and risks of translocation (CRBLTWG 2010).

2.1.4 Adult Passage at Hydroelectric Facilities

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

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

In recent years passage efficiency has been estimated for radio and HDX-PIT tagged individual adult Pacific lamprey at Columbia and Snake River dams (Stevens et al. 2015; Keefer et al. 2015; LGL and Douglas County 2014; Keefer et al. 2011). Sample sizes for these studies has varied widely based on availability of lamprey in different regions of the CRB. Passage efficiency estimates (Table 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 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	LGL and Douglas County PUD (2014)
		2007-2008	33.0%	Radio	LGL and Douglas County PUD (2008)
		2004	25.0%	Radio	Nass et al. (2005)
	Rocky Reach	2014	66.0%	HDX PIT	Blue Leaf Environmental (2015)
		2004	55.5%	Radio	Stevenson et al. (2005)
	Wanapum	2014	Not included due to spillway fracture and resulting abnormal fishway operations		
		2013	79.0%	HDX PIT	Blue Leaf Environmental (2014)
		2010-2012	67.0%	HDX PIT	Blue Leaf Environmental (2013)
	Priest Rapids	2014	80.0%	HDX PIT	Blue Leaf Environmental (2015)
		2013	77.0%	HDX PIT	Blue Leaf Environmental (2014)
		2010-2012	66.5%	HDX PIT	Blue Leaf Environmental (2013)
	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)

[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 method of collection 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 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 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 (20 total receivers) at Priest Rapids and Wanapum dams since 2010. For the 2010 through 2015 migrations, Grant PUD monitored a total of 407 and 374 HDX-PIT tagged lamprey at Priest Rapids and Wanapum dams, respectively. Fishway passage efficiency for lamprey was 74% at Priest Rapids Dam over the 2010-2014 period and 73% at Wanapum Dam over the 2010-2013 period (2014 intentionally omitted due to anomalous conditions associated with the Wanapum fracture).

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. This apparent delay at Priest Rapids left bank was associated with the upper fishway as fish ascended beyond the count station and past the 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. However, passage times of HDX-PIT tagged adult lamprey that volitionally ascended fishways in 2014 were different than previous years, possibly due to modified operations (lamprey trapping activities related to the trap-and-haul effort). At Priest Rapids Dam the median passage time in the left bank fishway improved to 17 hours, while median passage time through the right bank remained consistent with previous years at 5 hours. Fallback of HDX-PIT tagged adult lamprey was relatively uncommon during the 2010-2015 period. Only one fish at each dam was detected falling back and failing to re-ascend the fishway. 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 was 4.4 days during the 2010-2013 period and 5.9 days in 2014. In 2015 the median reservoir passage time was 4.9 days, which is similar to passage times prior to 2014. 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. Eleven such fish were detected during the 2010-2013 period (4.5% of detected tags) and 3 in 2014 (2.1% of detected tags). The proportion of tags from a previous study was greater in 2015 (11 tags, or 35.4% of detected tags) but this apparent increase was largely an artifact of the overall lower downstream tagging effort in 2015 (n=349). The presence of these fish suggests that estimating passage efficiency for adult lamprey requires a nuanced approach.

Table 4 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 the 2010-2015 period.

Year	Qty Detected		Median fishway passage time (h)			
	PR	WA	PR Left	PR Right	WA Left*	WA Right*
2010-2015	407	374	70.3	5.2	23.1	20.9

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

Year	Qty Net Fallback		Median PR Reservoir passage time (d)*	Qty tags from previous year (overwintering fish)
	PR	WA		
2010-2015	1	1	4.2	25

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

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

On February 27, 2014, a horizontal fracture was discovered in the spillway monolith No. 4 at Wanapum Dam. The fracture opened a crack on the upstream face of the structure approximately 2 inches high by 65 feet long on the spillway monolith. Grant PUD immediately initiated its EAP (level B) and began to draw the Wanapum Reservoir down in a steady controlled state. As of March 4, 2014, the Wanapum Reservoir was lowered to a safe operating elevation range between 545 feet and 541 feet. As a result of the drawdown, the fish ladder exits at Wanapum Dam were dewatered, preventing upstream migrating fish from passing Wanapum Dam. The fish ladder entrances at Wanapum remained operational, due to the tailwater elevation. At an elevation of 560-562 feet, the Wanapum Dam fish ladders exits would be able to be operated within criteria and without modifications. Fishway Exit Passage Systems were installed at Wanapum Dam on April 15 (on left-bank) and April 26 (right-bank) and were operated throughout the fish passage season. The Wanapum Fishway Exit Passage Systems (WFEPS) successfully passed adult

salmonids (spring Chinook), steelhead and other species (mountain white fish). To facilitate adult lamprey passage at the both the left and right bank fishways at Wanapum Dam, lamprey ramps were designed and incorporated into the WFEPS.

In order to assess the WFEPS, 28 adult lamprey were tagged with HDX PIT tags and released at dusk on July 25, 2014 into the upper Wanapum Dam left bank fishway. Within six days, 26 of the tagged fish were last detected at the left bank exit PIT reader, 1 fish moved downstream within the fishway, and 1 fish was not detected after release.

In addition to volitional passage, Grant PUD trapped and transported 2,263 adult Pacific lamprey collected from Priest Rapids and Wanapum dam fishways via 36 tube style traps distributed between the two dams and four mechanical weir traps at Priest Rapids. All trapped lamprey were scanned for a PIT tag, and previously tagged lamprey (n=45) were transported and released immediately upstream of the dam where they were trapped. Untagged lamprey were then held in a circular holding tank at Wanapum Dam until there were sufficient numbers to haul them upstream to the Kirby Billingsley Hydro Park (RM 461), approximately eight miles upstream from Rock Island Dam. Trap and transport activities occurred from July 17 to September 30, 2014, through the peak of the upstream adult lamprey migration.

In 2015, reduced HDX-PIT tagging effort from downstream sources resulted in a smaller quantity of run-of-river tags detected at Priest Rapids Dam than in recent years (n=27; Table 3 above). Therefore sample sizes for calculating passage times of HDX-PIT tagged adult lamprey at Priest Rapids dam were correspondingly small and should be interpreted accordingly. The median passage time at the Priest Rapids left bank fishway was 36.0 hours and right bank fishway was 5.8 hours. As in previous years, the greatest portion of time for fish ascending the Priest Rapids left bank fishway was in the section above the count station, past the OLAFT to the exit (33.4 hours), however this assessment represents a small sample (n=6) and does not comport with results from 133 fish released into the Priest Rapids left bank fishway with HDX-PIT tags to assess passage near the OLAFT in 2015 (see additional details below). At Wanapum Dam, median passage times through the left and right bank fishways were 8.6 and 21.1 hours respectively. Compared with earlier study years, this represents reduced passage time through the left bank but increased passage time through the right bank. However, 2015 results for Wanapum right bank fishway passage were calculated using a small sample size (n=15).

In addition to monitoring the run-of-river adults, 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 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. 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. 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.

Additionally in 2015, 100 adult lamprey captured with mechanical traps from the Priest Rapids Dam lower fishways during the peak migration period in July and August were implanted with both acoustic tags (Vemco V7) and FDX-PIT tags. These fish were released in either the 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). An array of fixed acoustic receivers deployed throughout the Project area was used to monitor the tagged fish after release. Additionally, mobile tracking was employed to located tagged individuals in the study area during the migration period. As of October 2015, 75 fish were detected in the tailrace of Rock Island Dam (RM 453.0). The median travel time to reach the Rock Island Dam tailrace was 3.6 days for fish released in the Wanapum Reservoir and 5.5 days for fish released in the Priest Rapids Reservoir. Travel rates to reach the Rock Island Tailrace ranged from 1.9-28.2 km/d for fish released in the Wanapum Reservoir and from 1.9-12.7 km/d for fish released in the Priest Rapids Reservoir. Eight fish had not been detected after release and were assumed to have either been mortalities or have failed acoustic tags. Additional results will be provided after the study concludes in June 2016.

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

A potential physiological problem facing successful passage of Pacific lamprey at dams may be related to their unique method of movement as it relates to specific areas within fish ladders. Typically, lamprey move through an adult fishway in a repeated series of motions consisting of attaching to the ladder floor with their mouths, surging forward, and re-attaching. Adult lamprey have an estimated critical swimming speed of about 2.8 feet per second at 15°C (Mesa et al. 2003) and a burst swimming speed calculated at 6.9 feet per second (Bell 1990). Fishway operational criteria at Wanapum and Priest Rapids dams include average velocities over submerged weirs that are approximately 2 to 4 feet per second and 4 to 6 feet per second 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 feet per second. 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 full-duplex (FDX) PIT tags used to monitor salmonids in the basin. In 2005, HDX detectors were installed at Bonneville Dam to evaluate lamprey passage systems (LPS) in the Bradford Island makeup water channel and at the

entrance to the Washington-shore main ladder. Detectors were also installed at McNary and Ice Harbor dams to monitor lamprey in a parallel study (Cummings 2007). In 2006, additional detectors were installed at the tops of ladders at The Dalles and John Day dams. Daigle (2008) concluded that the prototype HDX detectors used in 2005-2006 appeared to be reasonably efficient (e.g., 20-100%) at detecting tagged lamprey passing antennas. Studies comparing the use of radio-telemetry and the HDX-PIT tags were conducted in 2007-2009. Study results indicated higher escapement rates for HDX-PIT tagged fish versus radio-telemetry tagged fish at and between dams. Larger fish of both tag types were significantly more likely than smaller fish to pass through most monitored dam-to-dam reaches. The results suggest a tradeoff between tagging effects and the collection of high resolution, fine-scale data provided by the active radio telemetry system (Keefer et al. 2009a, 2009b and 2010).

Since the cumulative evidence on adult lamprey passage at dams has indicated that fishway entrances may be a major passage bottleneck, a significant effort was undertaken by the ACOE to develop and evaluate new entrance designs and operations. In 2007, a study was undertaken at Bonneville Dam to evaluate the use of reduced water velocities at entrances at night to improve entrance rates for lamprey (Johnson et al. 2009a). Lowering entrance head levels to 0.5 ft. (4 feet per second target velocity level) from 2200 to 0400 hrs. at PH2 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 PH2 entrances were placed in standby mode (0 feet per second velocity) at night, entrance efficiencies were 2 and 12% at the north and south-shore entrances versus 9 and 30% during normal conditions, respectively (Johnson et al. 2009b). Lamprey were also more likely to drop out of the fishways during the standby operations. In 2009, the telescoping weir bulkheads at the Cascade Island fishway entrance at Bonneville Dam were replaced with a variable-width entrance bulkhead. Bollard structures were also added out- and inside the fishway to provide an area of low velocity along the floor as a potential route for lampreys to enter. Preliminary results from radio- and HDX-PIT tag monitoring indicated that lamprey entrance use was improved in 2009 at the Cascades Island entrance but further analyses are planned. In 2009 and 2010, Douglas PUD utilized DIDSON to evaluate lamprey entrance efficiency at the Wells Dam fishways in response to three alternative entrance flow velocities. Although number of observations were low, the data indicated that adult lamprey were able to volitionally enter fishways under reduced nighttime flows (P.N. Johnson et al. 2011). The Wells Dam 2013 passage study conducted by Douglas PUD also included a treatment with alternative entrance flow velocities.

In recent years, Columbia River Basin hydroelectric facilities have begun modifying fishways and fishway operations to facilitate the upstream passage of adult lamprey. ACOE and utilities with hydroelectric facilities 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, lamprey passage systems LPS in various fishway locations, lamprey entrance flume systems, lamprey orifices in control section weir walls, diffuser grating plating, ramps at perched orifices, rounded edges of fishway walls, temporary velocity reductions at fishway entrances, and lifting picket leads at count stations. Researchers have also begun testing passage efficiency of an experimental vertical climbing wall and using network theory to evaluate passage behavior (see Section 2.2: Updated Information for additional details).

2.1.5 Juvenile Passage at Hydroelectric Facilities

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

The lamprey's ability to survive turbine passage, including response to changes in pressure, turbulent flow, and shear stress are not clearly understood. Another concern is how juvenile lamprey respond to diversion screens which are designed to bypass or divert fish into or toward preferred fish passage routes. For example, investigators reported large numbers of juvenile lamprey impinged between individual bars of fixed bar screens at The Dalles and McNary dams (Hatch and Parker 1998). The effects of blade strike or sub-lethal effects, such as increased vulnerability to predation following turbine passage, are not known (Becker et. al. 2003). Although the necessary tag technology to evaluate the potential impacts to juvenile lamprey passage through hydroelectric facilities is currently unavailable (see Section 2.1.5.3), increased efforts that include 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 (see Section 2.2: Updated Information for additional details).

2.1.5.1 Effects of Hydrologic Pressures on Juvenile Lamprey

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

To further evaluate Pacific lamprey's ability to survive turbine passage, Pacific Northwest National Laboratory (PNNL) scientists conducted laboratory tests designed to measure a juvenile Pacific lamprey's response to the absolute change in pressure or "pressure drop" during passage through a Kaplan turbine simulation (Neitzel et al. 2000). Tests conducted by PNNL used a hyperbaric chamber to test a single worst-case scenario for lamprey: bottom-acclimated with a surface return. Juvenile lamprey were acclimated to an equivalent pressure of 60-foot depth for 24 hours prior to passage. The entire pressure sequence lasted about 90 seconds (Becker et al. 2003). Results from the simulated turbine passage tests showed no immediate external injuries or mortalities for lamprey exposed to rapid changes in pressure, i.e., ~400 kPa to ~5 kPa in 0.1 second. That juvenile lamprey lack a swim bladder may be one reason for their resistance relative to bluegill sunfish (Becker et al. 2003). In 2011, continued testing by PNNL on the effects of rapid and prolonged decompression simulating hydroturbine passage were conducted

on juvenile Pacific lamprey. Generally, no mortalities or barotrauma were observed for lamprey exposed to these decompression scenarios (Colotelo et al. 2012).

2.1.5.2 Effects of Bar Screens on Juvenile Lamprey

Swim trials in a laboratory flume showed that juvenile Pacific lamprey are fair to weak swimmers as compared to salmonids, with an average burst speed of 2.3 feet per second. Sustained juvenile lamprey swim speeds averaged 0.75 feet per second over a five-minute interval and 0.5 feet per second 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 feet per second. 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 feet per second, 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 feet per second. 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 feet per second 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 feet per second. The findings showed lamprey were far more susceptible to become impinged on horizontal bars than on vertical ones. At water velocities of 4 feet per second, 50% of lamprey became impinged on the horizontal bars but none were stuck on the vertical bars. At 5 feet per second, 55% of the lamprey were impinged on the horizontal bars but just 25 became impinged on the vertical bars (Moursund et al. 2002). 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 2/29-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 feet per second, none remained stuck on the bars having the

smaller 2/29-inch spacing, and just 15% were permanently impinged on the 1/8-inch square mesh (Moursund et al. 2002).

2.1.5.3 Need for Active Tag Technology

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

2.1.5.4 Gatewell Exclusion Screen Evaluation

During the spring and early summer months of 2010, turbine intake emergency gatewell exclusion screens were monitored at Priest Rapids and Wanapum dams (Grant PUD 2011). Prior to the juvenile salmonid outmigration, a DIDSON camera was installed on the end of the screen that allowed 69% of the screen surface to be effectively imaged. Fishes were enumerated as they passed within the insonified area near the screen, and interactions with the screen were classified by type (contact or non-contact). A total of 18 days of data collection throughout the spring and summer salmonid migration periods were analyzed at each dam. These results showed that fishes observed had a low level of interaction with the screens and a very low level of multiple or extended contact. At Wanapum Dam, 10,632 fishes were observed near the exclusion screen with 784 (7.4%) coming in contact with the screen and at Priest Rapids Dam, 29,340 fishes were observed with 360 (1.2%) contacts with the screen (Wright et. al., 2010). Although the study was originally developed to evaluate juvenile salmonid outmigrants, small numbers of lamprey were also observed at monitored locations at both Wanapum (n=31) and Priest Rapids (n=161) dams (Wright et. al., 2010). During the study period (May 12 to July 15, 2010) no negative impacts or screen impingement events were observed at these locations (Mike Clement, Grant PUD, personal communication).

2.2 Updated Information

Pursuant to the requirements of Grant PUD's PLMP (Grant PUD 2009) and specifically for this comprehensive annual report (as described in Section 1.2 above), recent Pacific lamprey passage

and survival investigations and measures undertaken in the Columbia River Basin are summarized in Table 5. For the purposes of this comprehensive annual report, the “updated” information includes activities that are either occurring or are being reported on during the current reporting period of November 1, 2014 through October 31, 2015. Worth noting is that the table only includes activities that have been implemented through the end of the reporting period. Efforts that are proposed or planned for future implementation or are proposed as a potential measure are not identified in this section. Proposed and planned efforts are, however, addressed in Section 4.0 which contains a comprehensive evaluation of all regional activities (implemented, planned and proposed) and assesses their applicability to the Project.

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

Table 5 Pacific lamprey activities in the Columbia River Basin in 2015.

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	General Biology, Ecology, and Population Status					
1.	Monitoring entrance timing, escapement, and movement patterns	No associated hydro project	Fifteenmile Creek	In 2014, adult Pacific lamprey abundance in Fifteenmile Creek was estimated at 3,238 (2,646 – 3,962). From February through October, 256 PIT tagged lamprey were detected at interrogation sites in the Fifteenmile Creek Subbasin. Of those 256 detections, 64 were PIT tagged in 2013 (25%) and six were PIT tagged in 2012 (2%). From the total fish marked by CTWSRO (198), 110 were considered to have backed out of Fifteenmile Creek and fates unknown since going undetected. Eightmile Creek had a total of seven detections, three adults tagged by UI and 4 tagged by CTWSRO. Mill Creek detected one UI fish, on August 4, 2014; in 2013 this antenna detected only two CTWSRO fish tagged. The life-history pattern of lamprey spending two winters before spawning was again documented in 2014 in Fifteenmile Creek. In 2014, distribution of ammocoetes in Fifteenmile, Eightmile, and Mill creeks was similar to 2013. Ammocoete density surveys in Reservation streams indicated a wide range, as in previous years.	CTWSR	Evaluate Status and Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River Subbasins. Confederated Tribes of Warm Springs Reservation of Oregon, Warm Springs. (CTWSR 2014a) Evaluate Status and Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River Subbasins. Confederated Tribes of Warm Springs Reservation of Oregon, Warm Springs (Baker, Wildbill, and Santos 2015).

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
2.	Adult lamprey monitoring and juvenile lamprey density and distribution surveys	No associated hydro project	Deschutes and tributaries	Since 2003, data have been collected in the lower Deschutes River Subbasin to develop population trend data and investigate local lamprey biology and ecology. In 2013, a mark-recapture study was completed to estimate the abundance of adult lamprey at Sherars Falls. In addition, a tribal creel was also completed. Escapement was calculated by subtracting tribal harvest from the abundance estimate. Adult lamprey were collected at night from late July though mid October in the Sherars Falls fish ladder (Deschutes River rkm 70.4) using a long handled dip net. Captured fish received a half duplex tag and a fin clip as a secondary mark. In 2014, adult lamprey escapement at Sherars Falls was estimated at 16,716 (13,877 – 20,122). A total of 955 adult Pacific lamprey were marked at Sherars Falls between June 23 and October 30, 2014. During second-event sampling, 1,922 lamprey were inspected for marks. Of those inspected, 109 were recaptured lamprey (11.4% recapture rate). Four out of the 109 recaptured lamprey lost the Floy tag) but had PIT tags and one PIT tag was ejected but the Floy tag remained. Six lamprey captured at Sherars Falls had PIT tags inserted at Bonneville Dam by University of Idaho; two were tagged in 2013 (334 and 382 days to recapture) and four in 2014 (32 to 97 days to recapture). The pattern of lamprey spending two winters prior to spawning was first documented at Sherars Falls in 2014, in which lamprey tagged at Sherars Falls in 2012 returned. Distribution of ammocoetes in Reservation streams in 2014 varied moderately compared to past data: it was the same in Shitike and Badger creeks, upstream 6 km in Beaver Creek and 7.5 km further downstream in Warm Springs River. However, in	CTWSR	Evaluate Status and Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River Subbasins. Confederated Tribes of Warm Springs Reservation of Oregon, Warm Springs. (CTWSR 2014a) Evaluate Status and Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River Subbasins. Confederated Tribes of Warm Springs Reservation of Oregon, Warm Springs (Baker, Wildbill, and Santos 2015).

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Warm Springs River, a PIT tagged lamprey was detected in upper Warm Springs Meadows, which was 10.7 km upstream of the highest known ammocoete observed. However, in Warm Springs River, a PIT tagged lamprey was detected in upper Warm Springs Meadows, which was 10.7 km upstream of the highest known ammocoete observed.		
3.	Conduct adult lamprey movement study using radio telemetry	BOR projects in Yakima	Yakima	In 2014, the Mid-Columbia River Fishery Resource Office continued a radio telemetry study of Pacific lamprey movements in the Yakima River. Eighty-nine radio-tagged adult Pacific lamprey were released into the Yakima River to assess passage at irrigation diversion dams, movement patterns, overwintering and spawning areas. In 2015, the Mid-Columbia River Fishery Resource Office continued with analysis and report writing for radio and PIT telemetry studies conducted at Roza and Cowiche dams in the Yakima River system. The Phase 3 Annual Report will be available in December 2015	USFWS	Personal communication with RD Nelle, USFWS (10/20/15)
4.	Determining adult escapement and adult harvest monitoring	Willamette Falls	Willamette	Pacific lamprey escapement through the fish ladder at Willamette Falls was 109,372 in 2012 and 55,460 in 2013. Lamprey escapement through the fish ladder at Willamette Falls in 2014 was estimated at 125,778 (99,358 – 159,103). Total abundance present, including escapement and lamprey estimated below the Falls, was 336,305. This was the greatest abundance since the beginning of study in 2010. Lamprey escapement at Willamette Falls continues to be closely associated with day/night counts at Bonneville Dam. While lamprey were relatively abundant, compared to the recent past – not historically,	CTWSR	Willamette Falls Lamprey Study. Annual Report to BPA (CTWSR 2014b) Willamette Falls Lamprey Study. 2014 Annual Report to BPA (Baker and McVay 2015)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				harvest was low, with 3,541collected in 2014, comprising only 1.1% of total abundance. Stage of the Willamette River reached levels low enough for PGE to install riser boards around the crest of the Falls to push water to the turbines on the west side by late June. As they began installing riser boards and lamprey ramps an unexpected heavy rainstorm brought the river up and they had to draw it down July 5th through 9th to complete installation of avian deterrents and preparation of the lamprey ramp approach. Whether the fluctuating water levels or early installation of riser boards, not as many Tribal harvesters participated in 2014 as in prior years of the study. Lamprey passing the ramps and West Side Lamprey Structure in the old fishway accounted for 1.7% of the total escapement. An effort to determine the whereabouts of PIT tagged lamprey that fail to ascend the fish ladder was undertaken in 2014. Out of five tributaries downstream of Willamette Falls, detections of 50 lamprey tagged at Willamette Falls in 2014 were detected near the mouth of Abernethy Creek, near the release location.		
5.	Evaluation of larval Pacific lamprey rearing	John Day, McNary	Columbia River	Larval Pacific lamprey occupancy was evaluated in John Day and McNary pools, shallow water strata within the pools, and tributary mouths occurring within the respective pools including the John Day, Umatilla, Walla Walla, and Yakama River mouths. A generalized random tessellation-stratified approach was used to delineate sample quadrats (30 m X 30 m) in a random, spatially-balanced order. Occupancy of larval lamprey was evaluated within three strata: the pools as whole, shallow-water strata within the pools, and in tributary mouth habitats within the pools. Larval lampreys were found to occupy McNary Pool as a	USFWS	Personal communication with Greg Silver, USFWS (10/6/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				whole, John Day and McNary pool shallow water strata, as well as tributary mouth habitats in the John Day and Umatilla rivers.		
6.	Evaluation of Portland Harbor Superfund Area Restoration: Larval Pacific Lamprey	No associated hydro project	Willamette River	Larval Pacific lamprey occupancy was evaluated in John Day and McNary pools, shallow water strata within the pools, and tributary mouths occurring within the respective pools including the John Day, Umatilla, Walla Walla, and Yakama River mouths. A generalized random tessellation-stratified approach was used to delineate sample quadrats (30 m X 30 m) in a random, spatially-balanced order. Occupancy of larval lamprey was evaluated within three strata: the pools as whole, shallow-water strata within the pools, and in tributary mouth habitats within the pools. Larval lampreys were found to occupy McNary Pool as a whole, John Day and McNary pool shallow water strata, as well as tributary mouth habitats in the John Day and Umatilla rivers.	USFWS	Personal communication with Greg Silver, USFWS (10/6/15)
7.	Evaluating Pacific lamprey occupancy	Condit	White Salmon	Larval Pacific lamprey occupancy was evaluated in the White Salmon River basin above and below the former site of Condit Dam. A generalized random tessellation –stratified approach was used to delineate 50 m sample reaches in a random, spatially-balanced manner throughout the White Salmon River basin. Backpack electrofisher sampling was conducted for larvae in wade-able depth portions of the following six sample units within the White Salmon River basin: (1) the mainstem White Salmon River below the former dam site, (2) the mainstem White Salmon River above the former dam site, (3) Rattlesnake Creek, (4) Buck Creek, (5) Mill Creek, and (6) Trout Lake Creek. In each sample unit, six 50 m sample reaches were surveyed for larvae. Larval Pacific lamprey were detected in each of the six reaches of	USFWS	Personal communication with Greg Silver, USFWS (10/6/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				the White Salmon River mainstem below the former Condit Dam site. Small, unidentifiable larvae were collected in each of the six mainstem White Salmon River reaches above the former dam site, from which tissue clips were collected for genetic identification of species. Genetic analyses of these specimens are pending. Larval western brook lampreys were collected in the White Salmon River above and below the former dam site, as well as within Mill Creek, Rattlesnake Creek, and Trout Lake Creek.		
8.	Lamprey monitoring	No associated hydro project	Hood River	In 2013, 11 sites in Hood River were sampled, including two in the mainstem, two in the Middle and West forks of the Hood River, and three in the East Fork Hood River. Sites sampled in tributaries included two in Neal Creek and one in Odell and Indian creeks. Ammocoetes were present in the Hood River up to the confluence with the East and West Fork Hood River (rkm 0 – 19.3). Ammocoete distribution extended 5.6 km up into East Fork Hood River. Total distribution in the Hood River Subbasin for larval Pacific lamprey was 24.9 rkm. Out of six sites sampled in Hood River and two in East Fork Hood River with ammocoetes present, four sites had ammocoetes large enough to sample. Lamprey captured upstream of the former Powerdale dam site (rkm 6.5) in 2013 were the first large enough to measure, which averaged 53.3 mm (range 39 – 82, n=18). There was no significant difference in mean lengths of ammocoetes upstream or downstream of the former dam site ($t=-1.17$, p- value=0.26, $\alpha=0.05$), 50.9 and 57.1 mm, respectively. Densities in the four sites ranged from 2.1 to 17.8 ammocoetes/m^2. About 100 small (< 20 mm) ammocoetes were	CTWSR	Evaluate Status and Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River Subbasins. Confederated Tribes of Warm Springs Reservation of Oregon, Warm Springs. (CTWSR 2014a) Evaluate Status and Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River Subbasins. Confederated

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				observed at every sample site throughout the mainstem and East Fork Hood River. Range expanded for Pacific lamprey recolonizing Hood River in 2014, where ammocoetes were detected 5.8 km further upstream in East Fork Hood River compared with 2013. In the Hood River sub-basin, there were no fish present in Middle or West forks. Surveys in Odell, Neal and Indian Creek also had no presents of larval lamprey.		Tribes of Warm Springs Reservation of Oregon, Warm Springs (Baker, Wildbill, and Santos 2015).
9.	Adult lamprey monitoring	No associated hydro project	Umatilla	In 2014, the Confederated Tribes of the Umatilla Reservation (CTUIR), continued monitoring of adult lamprey in the Umatilla River via radio-telemetry. The objective of the monitoring is to identify passage bottlenecks within the watershed and passage efficiency at low-elevation dams in the drainage. In total, 30 fish were tagged and monitoring consisted of both fixed stations and mobile surveys. Final reporting of this activity will become available soon. Additional information was not available for inclusion in the 2015 report.	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/5/14)
10.	Re-introduction evaluation	Pelton Round Butte	Deschutes	As part of relicensing the Pelton Round Butte Hydroelectric Project (PRB), the licensees, Portland General Electric and CTWSR, developed a Fish Passage Plan approved by the Federal Energy Regulatory Commission. A component of the Fish Passage Plan is the Pacific Lamprey Passage Evaluation and Mitigation Plan (PLEMP). To re-establish lamprey upstream of PRB, a series of assessments is called for in the PLEMP. The	CTWSR	Personal communication with Cyndi Baker, CTWSR (10/24/14) Synthesis of Pacific lamprey studies conducted by the Confederated

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				first step was to study habitats currently occupied downstream of PRB, then identify potential habitat upstream of PRB. Both juvenile and adult lamprey downstream of PRB were studied to ascertain: 1) timing and locations of spawning and overwintering, 2) spawning and rearing distribution, and 3) habitat associations. The culmination of this assessment was a theoretical abundance estimate of Pacific lamprey ammocoetes (larval lamprey) in habitat that may be re-colonized upstream of PRB. The extent of potential ammocoete rearing habitat upstream of PRB includes the Metolius River from the mouth to Camp Creek (rkm 13.8), the Deschutes River from the head of Lake Billy Chinook (rkm 193) to Big Falls (rkm 213), Whychus Creek from the confluence with the Deschutes River to Alder Springs (rkm 2.4) and the Crooked River from the head of Lake Billy Chinook to Opal Springs (rkm 6.9). Two models; a capture efficiency (CE) model and an ammocoete abundance model (AAM) were developed and used in conjunction with water temperature and habitat data upstream of PRB, which resulted in an estimate of 4.8 million ammocoetes (95% prediction interval = 3.7 to 7.5 million ammocoetes) for the identified habitat. The evaluation to determine whether lamprey can be re-established upstream of the PRB Hydrologic Complex (rkm 161) in the Deschutes River is complete, however a management decision on reintroduction is still pending. No new work on this topic was completed in 2014. A synthesis of lamprey studies undertaken by CTWSRO from 2003 to 2013, which addresses possible avenues for mitigation given the unlikely re-establishment of lamprey upstream of PRB, has		Tribes of Warm Springs Reservation of Oregon, 2003 to 2013 (Baker, Wildbill, and Santos 2015).

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				been completed and will be available in 2016.		
11.	Conduct juvenile distribution and abundance sampling	No associated hydro project	Umatilla	In 2014, index sites were surveyed using backpack electrofishing to assess juvenile lamprey distribution and abundance in the Umatilla watershed. These sites were established in the late 1998 as a research, monitoring and evaluation tool for Tribal translocation activities. Forty sites are surveyed from river mile (RM) 0 to 70. Survey results show that Pacific lamprey are present throughout the Umatilla River and Meacham Creek and juvenile densities remain elevated compared to pre-translocation levels. Final reporting of this activity will become available soon. Additional information was not available for inclusion in the 2015 report.	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/5/14)
12.	Larval lamprey surveys for status and trend, distribution, relative abundance, and habitat availability	No associated hydro project	Yakima, Wenatchee, Methow, White Salmon, and Klickitat	Sampling in 2015 for all subbasins focused on index sites (for long-term status and trend) with a mix of new sites to examine various questions, such as distribution, habitat availability, entrainment rates into irrigation diversion, genetic analysis, and translocation potential or success. In Yakima Subbasin, no larval Pacific lamprey have been found above Roza Dam and very few are found upstream of Naches River confluence consistent with very low recent adult counts at Prosser Dam. Some of the young of the year lamprey captured near supplementation release sites (potential offspring of translocated adults) were preserved for species identification and parentage analysis. In Wenatchee Subbasin, upper distribution of larval Pacific lamprey was pursued as well as relative abundance and habitat availability throughout the subbasin (no Pacific Lamprey were found upstream of Tumwater Dam).	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (12/1/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				In Methow Subbasin, most time was spent assisting the Methow sampling lead by John Crandal (see Activity #15 and 16). In White Salmon Subbasin, Trout Lake Creek and White Salmon River was sampled to document distribution and abundance of lamprey (no Pacific Lamprey were found above the old Condit Dam site). In Klickitat, key sites in lower and mid reaches were surveyed to monitor index sites and collect genetic samples (primarily to see if the genetics are distinct in upper vs. lower reaches) . 2014 Reports are available upon request (2015 Reports available in 2016).		
13.	Mercury study on larval lamprey and fine sediment in Lower Columbia River	No associated hydro project	Lower Columbia & tributaries (including Klickitat, White Salmon, Rock, Wind and Fifteen Mile Creek	In 2013 and 2014, PNNL with assistance from the Yakama Nation and CRIFC collected larval lamprey tissue and fine sediment (rearing habitat) from select locations in Lower Columbia River and its tributaries to compare and contrast the level of mercury concentrations. A manuscript was submitted and accepted for publication in Environmental Toxicology and Chemistry.	PNNL, CRITFC and Yakama Nation	Mercury concentrations in Pacific lamprey (Entosphenus tridentatus) and sediments in the Columbia River Basin (Linley et al. 2015). Personal communication with Robert Mueller, PNNL (12/11/15)
14.	Habitat restoration and effectiveness monitoring	No associated hydro project	Methow (Chewuch River)	A salmonid-based habitat restoration action on the Chewuch River at RM 10 is being assessed to determine its effects on 1) the distribution of larval lamprey rearing habitat, 2) the distribution and relative abundance of ammocoetes. The restoration project was initiated by the Yakama Nation and the monitoring component is being coordinated by John Crandall. Pre-treatment data was collected in 2010 and post-treatment data has been collected in	Methow Salmon Recovery Foundation, and Yakama Nation	Personal communication with John Crandall, Methow Salmon Recovery Foundation (11/30/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				subsequent years including 2013-2015. MSRF continues with larval status and trend monitoring at six sites (3 in Methow and 3 in Chewuch) with field assistance from Yakama Nation. Interim report to be completed spring 2016.		
15.	Distribution and relative abundance monitoring of spawning and larval lamprey	No associated hydro project	Willamette	Spawning surveys of adult lamprey and backpack electrofishing for larval lamprey were conducted throughout the Willamette River Basin, 2011-2013. Lamprey redds were detected in all survey segments visited, including reaches on Ritner Creek (~4m average channel width) and the Santiam River (~70-100m average channel width), but more redds were detected in reaches composed of alluvial underlying sediments. Spawning habitat was similar to that used by salmonids and results suggest that ongoing habitat restoration will be mutually beneficial for these species of concern. The attached manuscript details our findings related to developing monitoring plans for lamprey spawning. Larval lamprey were also collected throughout the Basin, but appeared to be limited by small anthropogenic barriers. In areas with adult access, we did not detect any differences in relative abundance across the basin, but larvae were strongly associated with low velocity burrowing habitats and, in particular, off channel areas (backwaters, side channels). Similar to adults, findings suggest habitat restoration strategies that increase the complexity of stream channels will be beneficial to Pacific lamprey juveniles. Finally, we developed length-based mortality estimation techniques and applied them to Pacific and brook lampreys from the Willamette River Basin. Results indicated that survival was fairly high (21% annual mortality) during the larval	Oregon Cooperative Fish and Wildlife Research Unit at OSU	Personal communication with Luke Schultz, OSU (09/24/15) Using Spatial Resampling to Assess Redd Count Survey Length Requirements for Pacific Lamprey (Mayfield et al. 2014) The distribution and relative abundance of spawning and larval Pacific lamprey in the Willamette River Basin (Schultz et al. 2014)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				portion of the life cycle. These findings have immediate utility in the development of life cycle models to understand Pacific lamprey populations dynamics and may be used in other fishes.		
16.	Spawning ecology and larval distribution	No associated hydro project	Willamette	This report describes the continuation of research in the Willamette Basin, focused on answering questions about freshwater ecology; specifically related to spawning and estimating the effect of passage barriers and geomorphic variables on the distribution of larvae. The various chapters of the report include assessment of redd building behavior and genetic parentage analysis of embryo tissue; spawning assessments of translocated Pacific lamprey to Fall Creek; larval electrofishing surveys to evaluate extent of upstream distribution and support of barrier inferences; and larval surveys using mark-recapture techniques to link capture probability and abundance to habitat variables for the purpose of predicting larval lamprey density across the landscape	Oregon Cooperative Fish and Wildlife Research Unit at OSU	Personal communication with Luke Schultz, OSU (09/24/15) Investigations into Pacific lamprey spawning ecology and larval distribution in the Willamette River Basin, Oregon (Schultz et al. 2015a)
17.	Predicting larval catch rates	No associated hydro project	Willamette	The objective of our study was to estimate the influence of barriers and habitat characteristics on the catch-per-unit effort (CPUE) of larval Pacific lamprey in the Willamette River Basin, Oregon, USA. We sampled lampreys at multiple locations in wadeable streams throughout the basin in 2011–13 and used an information theoretic approach to examine the relative influence of fine- and large-scale predictors of CPUE. Pacific lamprey was observed across the basin, but its relative abundance appeared to be limited by the presence of natural and artificial barriers in some sub-basins. Lower velocity habitats such as off-channel areas and pools contained higher densities of larval	Oregon Cooperative Fish and Wildlife Research Unit at OSU	Role of large- and fine-scale variables in predicting catch rates of larval Pacific lamprey in the Willamette Basin, Oregon (Schultz et al. 2015b)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				lamprey; mean Pacific lamprey CPUE in off-channel habitats was 4 and 32 times greater than in pools and riffles respectively. Restoration and conservation strategies that improve fish passage, enhance natural hydrologic and depositional processes and increase habitat heterogeneity will likely benefit larval Pacific lamprey.		
18.	Lamprey artificial propagation	N/A	N/A	Pacific lamprey artificial propagation research in 2015 focused on improving early survival of larvae and continued assessment of transport effects at various larval stages of development. The work was conducted in close coordination with the Yakama Nation (Ralph Lampman). In 2014 and 2015 we tested the effects of water transfer on Pacific lamprey eggs, prolarvae, and larvae. We observed low mortality (<5%) in fertilized Pacific lamprey eggs during and after water transfer experiments. There was significant mortality (>98%) in prolarvae Pacific lamprey (age 0-45 days post spawning) and in younger larvae (>85%) (45-60+ days post spawning) during water transfer experiments. We also observed that prolarvae transported and kept in source water had higher survival than those transferred to new water upon arrival. There was no mortality in water transfer experiments on slightly older larvae (90+ days post spawning). Also in 2015, we completed a review of pathogen prevalence in Pacific lamprey with data provided by state and federal fish pathologists which is currently in review. Final assessment of PIT-tagging effects on larval lamprey was also completed and lamprey tagged as ammocoetes with 8.5 mm PITs were starting to metamorphose 2 years later.	NOAA Fisheries, CTUIR, Yakama Nation	Personal communication with Mary Moser, NOAA Fisheries (12/4/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
19.	Lamprey artificial propagation	N/A	N/A	The YNPLP have conducted artificial propagation and rearing of Pacific lamprey since 2012. This work was accomplished in close coordination with the CTUIR (Aaron Jackson), NOAA (Mary Moser) and USFWS (Ann Gannam) who are also conducting similar research activities. Over 25,000 larvae were successfully hatched and produced. Rearing experiments, using various tank sizes, density, and feeds are ongoing to learn how to best feed and care for these larvae throughout the year. Maximum threshold density (below which survival and growth was hindered) for prolarvae and larvae was 125 grams / m2. A mixed feed ration of 10-20g / week / fish weight (g), of which ~50% was active dry yeast, resulted in growth rates of 7-12 mm per month between late July and late September for various sizes of larvae, showing the relationship between fish weight and feed requirement. Bottle neck life stage in the hatchery environment appears to be the period between first feeding and 3 month old larvae based on results from YN and partners research. Based on space requirement, survival, and growth calculations, a large scale production of larvae will likely be less efficient for larvae older than 6 months and almost prohibitive for larvae older than one year due to their space requirements. 2014 Report is available upon request.	Yakama Nation, CTUIR, NOAA Fisheries, USFWS	Personal communication with Ralph Lampman, Yakama Nation (12/1/15) Developing Techniques for Artificial Propagation and Early Rearing of Pacific Lamprey (Entosphenus tridentatus) for Species Recovery and Restoration (Lampman et al. in press)
20.	Reservoir fluctuation impacts on larval lamprey	Bonneville	Columbia	A depth averaged numerical hydraulic model (MASS2) which was developed at PNNL was used to quantify the extent of dewatered sediments near the delta regions of four major tributaries in the Bonneville pool. These included the Little White Salmon, Wind, White Salmon, Hood and Klickitat rivers. Inundation changes were examined at four different forebay elevations.	PNNL	Bob Mueller, PNNL, Presentation at AFEP Review, Walla Walla, WA (12/10/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				From the modeled water-surface elevation output we determined that the overall change in affected area is less sensitive to elevation changes during higher river discharges. Changing the forebay elevation at Bonneville Dam and the resulting impact on total dewatered regions was greater at the lowest modeled river flow (97 kcfs) and showed the greatest variation at the White Salmon/Hood River delta regions followed by the Wind, Klickitat, and the Little White Salmon rivers. The unsteady model output showed that water-surface elevation in the reservoir closely follows that of the Bonneville Dam forebay with rapid changes of 1 to 2 ft possible. A 2.5-ft variation in water-surface elevation occurred during a 2-week period in February in 2002 and a 3.7-ft change occurred in the same period in 2014. The durations of these changes were highly variable and generally did not stay constant for more than a 5-hr period.		
21.	Lamprey translocation project including juvenile surveys and radio-telemetry studies.	No associated hydro project	Willamette	In 2015, the CTGR collected 240 adult pacific lamprey from Willamette Falls and translocated them to Fall Creek above the Fall Creek Dam. Electrofishing is also being conducted to determine the presence and distribution of juvenile lamprey both above and below the Fall Creek Dam. The study is ongoing with no formal reports or available at this time.	CTGR	Personal communication with Bryan Fendall, CTGR (9/24/15)
22.	Collection of adult lamprey for translocation, artificial propagation and radio-telemetry studies	No associated hydro project	Umatilla	In 2014, the CTUIR collected adult lamprey from lower Columbia River mainstem dams. In total, 910 adults were captured and transported to the South Fork Walla Walla lamprey holding facility throughout the fall and then moved to Minthorn Springs to over-winter. These fish will be used for translocation programs in the Umatilla and Grande Ronde basins; to support radio-telemetry	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/5/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				assessments (releases in the lower Umatilla River); and to support artificial propagation research occurring at the Walla Walla Community College, Water Environmental Center lab. Final reporting of this activity will become available soon. Additional information was not available for inclusion in the 2015 report.		
23.	Collection of adult lamprey for translocation, artificial propagation and radio-telemetry studies	No associated hydro project	Yakima, Wenatchee, Methow	In 2015, the Yakama Nation collected adult lamprey from Lower Columbia River mainstem dams. In total, 1,068 adults were captured and transported to the Prosser Fish Hatchery (Prosser, WA). These fish will be used for translocation programs in the Yakima and Methow subbasin; to support radio-telemetry and PIT tag assessments (releases in the Yakima, Wenatchee, and Methow rivers); and to support artificial propagation research. Some of the adults were provided to Grant PUD to test passage at Wanapum Dam.	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (12/1/2015)
24.	Pacific lamprey in the Columbia River Estuary	No associated hydro project	Lower Columbia Estuary	Little is known about the basic biology and ecology of most native lampreys, including the use of estuaries by anadromous lampreys. To address this deficiency, we provide the first analysis of anadromous western river (*Lampetra ayresii*) and Pacific (*Entosphenus tridentatus*) lampreys in the Columbia River estuary, using data from 2 fish assemblage studies that span 3 decades (1980–1981 and 2001–2012). Pacific lamprey juveniles and adults in the estuary clearly were separated by size, whereas western river lamprey formed one continuous size distribution. Pacific lamprey juveniles and adults were present in the estuary in winter and spring, and western river lamprey were	NOAA Fisheries	Seasonal abundance, size, and host selection of western river (*Lampetra ayresii*) and Pacific (*Entosphenus tridentatus*) lampreys in the Columbia river estuary (Weitkamp et al. 2015)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				present from spring through early fall. Depth in the water column also differed by lamprey species and age class. During 2008–2012, we documented wounds from lampreys on 8 fish species caught in the estuary. The most frequently wounded fishes were non-native American shad (*Alosa sapidissima*), subyearling Chinook salmon (*Oncorhynchus tshawytscha*), shiner perch (*Cymatogaster aggregata*), and Pacific herring (*Clupea pallasii*). This basic information on western river and Pacific lampreys in the Columbia River estuary adds to the growing body of regional research that should aid conservation efforts for these ancient species.		
25.	Detecting lamprey occupancy	No associated hydro project	N/A	The historical North American range of Pacific Lamprey *Entosphenus tridentatus* extends from the northern Baja California of Mexico to Alaska and inland in suitable habitat as far as there is access to the sea. The population of Pacific Lamprey has declined recently, yet we know little about its actual distribution, and that distribution is changing as the species declines in abundance. We evaluated detection and occupancy probabilities for Pacific Lamprey over a broad region encompassing a wide range of landscapes and drainage sizes. We analyze 110 sites, each representing individual drainages or major subdrainages from the southern border of British Columbia to San Francisco, including over 1,900 km of coastline and the Columbia River basin. Using lamprey-specific electrofishers in suitable habitat low in a drainage we found detection probability of ammocoetes at single sites in occupied drainages was generally high at >90%. If	Western Fishes, USFWS	Detectability of Pacific Lamprey Occupancy in Western Drainages: Implications for Distribution Surveys (Reid and Goodman 2015)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				not initially detected, then two additional sites provided >95% confidence of absence. The four geographic regions (Washington, Oregon coast, Columbia River basin, and northern California coast) had similar detection and occupancy probabilities, making these results broadly applicable and comparable. Results are incorporated into guidance for development of effective surveys over a broad scale and will be crucial to establishing occupancy of Pacific Lamprey for purposes of management, planning and monitoring of its changing distribution.		
26.	Pacific lamprey stress physiology	No associated hydro project	N/A	Great efforts have been put forth to elucidate the mechanisms of the stress response in vertebrates and demonstrate the conserved response across different vertebrate groups, ranging from similarities in the activation of the hypothalamic–pituitary–adrenal axis to the release and role of corticosteroids. There is however, still very little known about stress physiology in the Pacific lamprey (*Entosphenus tridentatus*), descendants of the earliest vertebrate lineage, the agnathans. In this paper we demonstrate that 11-deoxycortisol, a steroid precursor to cortisol in the steroidogenic pathway, may be a functional corticosteroid in Pacific lamprey. We identified the putative hormone in Pacific lamprey plasma by employing an array of methods such as RIA, HPLC and mass spectrometry analysis. We demonstrated that plasma levels of 11-deoxycortisol significantly increased in Pacific lamprey 0.5 and 1 h after stress exposure and that lamprey corticotropin releasing hormone injections increased circulating levels of 11-deoxycortisol, suggesting that the stress response is under the control of the HPA/I axis as it is in higher vertebrates. A comprehensive	UBC	A putative corticosteroid hormone in Pacific lamprey, *Entosphenus tridentatus* (Rai et al. 2015)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				understanding of vertebrate stress physiology may help shed light on the evolution of the corticosteroid signaling system within the vertebrate lineage.		
27.	Larval Pacific lamprey distribution	No associated hydro project	Wenatchee, Entiat, Chelan, Methow, and Okanogan	In 2015, the Mid-Columbia River Fishery Resource Office conducted larval lamprey distribution surveys in several rivers in North Central Washington. Larval lamprey presence/absence was evaluated using APB-2 elec trofishers. Site selection was either randomized (GRTS for occupancy modeling), or targeted (to determine the upstream extent of lamprey in the system). Genetics were collected from lamprey sampled in the Wenatchee and Entiat rivers. The Annual Report for this Project will be available in 2016.	USFWS	Personal communication with RD Nelle, USFWS (10/20/15)
28.	Juvenile lamprey habitat evaluation and presence/absence	Wells	Columbia	In 2015, Douglas PUD surveyed the Wells Reservoir for potential juvenile lamprey habitat and used backpack electrofishing to determine presence/absence of ammocetes in areas with suitable habitat. Eleven sites, 30 m in length, were sampled on four occasions from July to November including one occasion when the Wells Reservoir elevation was reduced to an elevation of 773 ft. Suitable juvenile lamprey habitat was limited in the Wells Reservoir and no Juvenile lamprey were encountered over the course of the entire study.	Douglas PUD	Personal communication with Chas Kyger, Douglas PUD (11/12/15)
29.	Larval Lamprey Identification Guide	No associated hydro project	Columbia, Snake	The 2-page identification guide displays the differences in tail features between Pacific Lamprey and Western Brook Lamprey larvae. The 1-page identification guide displays the differences in tail features between Pacific Lamprey and Western Brook Lamprey larvae at a medium size class (50-90mm). Also, close-up photos of overall body and tail for a large collection of larvae (both Pacific Lamprey and Lampetra species) are	Yakama Nation	Yakama Nation Pacific Lamprey Project, BPA 2014 Annual Report, Project No. 2008-470-00 (Lampman et al. 2015). Personal

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				available to see individual as well as size based difference in tail features.		communication with Ralph Lampman, Yakama Nation (12/1/2015)
	Lamprey Migration in Rivers					
30.	General migration and upstream passage patterns	Bonneville, The Dalles, John Day, McNary	Columbia and Snake	Monitoring adult Pacific lamprey migration in the Columbia River Basin is an important part of understanding how dams and environmental factors affect lamprey behavior, dam passage success, and distribution among spawning areas. Our 2014 adult Pacific lamprey studies assessed Pacific lamprey (*Entosphenus tridentatus*) migration in the Columbia River Hydrosystem at a variety of scales. The results summarized in this report primarily address reach-scale and system-wide migration using detection data from lamprey tagged with either half duplex (HD) passive integrated transponder (PIT) tags or an HD PIT tag and a radio transmitter. The 2005-2014 HD PIT dataset is an important time series for understanding migration-scale questions about adult Pacific lamprey. For this report, we tested the hypothesis that lamprey escapement past dams has increased through the study period. The weight of evidence from logistic regression analyses suggests that upstream escapement has statistically increased during the study period through most single- and multi-dam reaches and for all lamprey size classes. We think it is likely that operational and structural modifications at USACE dams intended to improve lamprey fishway passage efficiency have contributed to an increase in upstream escapement, though other unexplored explanations (i.e.,	University of Idaho Cooperative Fish and Wildlife Research Unit and NOAA Fisheries	Adult Pacific Lamprey Migration in the Columbia and Snake Rivers: 2014 Radiotelemetry and Half Duplex PIT-TAG Studies and Retrospective Summaries (Keefer et al 2015)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				changing ocean productivity) may also have been important.		
31.	Evaluate movement and fate of adult Pacific lamprey in Bonneville Reservoir and Lower Columbia River	Bonneville	Columbia	Between 2011 and 2014, we tagged adult Pacific lamprey with Juvenile Salmon Acoustic Telemetry System (JSATS) transmitters and half-duplex (HD) PIT tags and monitored their upstream migation behavior and final distribution in the Bonneville tailrace and reservoir and upstream of The Dalles Dam to the Deschutes River. Monitoring focused on the Bonneville Dam tailrace and reservoir, two areas with high unaccounted lamprey loss in past telemetry studies. Our objectives were to calculate lamprey travel rates, to estimate survival past the monitored sites, and to estimate final fates and distributions of tagged lamprey. We double-tagged a total of 784 adult Pacific lamprey collected at Bonneville Dam with both JSATS transmitters and HD-PIT tags over three study years (2011-2013). We deployed 15 to 33 JSATS autonomous receivers each year between the Bonneville Dam tailrace and the John Day River. Travel rates for tagged fish were variable among individuals, and were higher in reservoir reaches than in dam reaches. The annual survival estimates varied widely for lampreys released into the Bonneville Dam tailrace past the dam. Final distributions of JSATS-tagged fish was consistent with results from past studies at coarse scales, indicated tributary entry during both fall and spring periods, and revealed substantial proportions last detected in tailraces.	University of Idaho Cooperative Fish and Wildlife Research Unit	Adult Pacific lamprey migration behavior and survival in the Bonneville Reservoir and Lower Columbia River Monitored Using the Juvenile Salmonid Acoustic Telemetry System (JSATS), 2011-2014 (Noyes et al 2015)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Overall, the multi-year study demonstrated: 1) the utility of acoustic technology for tracking adult lamprey in mainstem habitats; 2) rapid migration with high survival through lower and mid-reservoir habitats; 3) substantial numbers of lamprey apparently overwintering in tailrace habitats; and 3) previously undocumented downstream and tributary entry movements by lamprey in spring. The primary remaining uncertainties include the fate of substantial numbers of adult lamprey last detected in tailraces, specifically, the proportions of undetected adults that move into downstream tributaries and spawn, spawn in dam tailraces, or perished in the tailrace or upper reservoir.		
32.	Vulnerability of larval lampreys to hydrosystem operations: Effects of dewatering on movements and survival	No associated hydro project	Columbia	This study evaluated the effects of dewatering on larval lamprey movement and survival. The objective of this controlled laboratory study was to document the response of larval lamprey to dewatering of their habitat, specifically – 1) their movement relative to fish size and ramping rates, and 2) their survival relative to fish size and duration of exposure.	USGS	Vulnerability of Larval Lamprey to Columbia River Hydropower System Operations – Effects of Dewatering on Larval Lamprey Movements and Survival (Liedtke et al.)
33.	Juvenile lamprey outmigration monitoring	No associated hydro project	Umatilla	In 2013-14, the CTUIR continue to operate a rotary screw trap at RM 2.5 of the Umatilla River to document juvenile lamprey outmigration timing. The trap is run from November to May of each year. Status and trend monitoring shows continued increases since initiating translocation. Final reporting of this activity will become available soon. Additional information was not available for	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/5/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				inclusion in the 2015 report.		
34.	Larval / juvenile lamprey surveys in irrigation diversions	No associated hydro project	Yakima, Wenatchee	The Yakama Nation Pacific Lamprey Project has been active in October/November surveying dewatered irrigation canals within the Yakima and Wenatchee subbasins for larval / juvenile lamprey within these diversions. There seems to be a strong correlation between the amount of fine sediment collected in diversions and the number of larvae found at these facilities. Lamprey of various sizes (sometimes in the thousands) were found behind screens. A new report summarizing this sampling from 2014 is available now. Multiple other reports were also made available in 2015, which focused on monitoring 1) Roza Dam reservoir to assess dewatering impacts on larval lamprey, 2) use of VIE mark-release-recapture analysis within diversion and near diversion inlet to estimate abundance and entrainment rates, and 3) PIT tagging of larvae and juvenile in Chandler Diversion to evaluate passage and survival. Also, larval/juvenile lamprey outmigration counts at Chandler Diversion are tallied annually from which movement timing and environmental variables triggering movement is analyzed.	Yakama Nation	Appendices in "Yakama Nation Pacific Lamprey Project, BPA 2014 Annual Report, Project No. 2008-470-00" (Lampman et al. 2015). Appendices in "Evaluation and Coordination of Pacific Lamprey Activities in the Yakima River Subbasin, BOR 2014 Annual Progress Report" (Lampman et al. 2015).
35.	Juvenile lamprey data synthesis	Lower Granite, Little Goose, Lower Monumental, Rock Island, McNary, John Day and Bonneville	Columbia and Snake	We compiled and summarized previous sources of data and research results related to the presence, numbers, and migration timing characteristics of juvenile (eyed macropthalmia) and larval (ammocoetes) Pacific lamprey Entosphenus tridentatus, in the Columbia River basin (CRB). Included were data from various screw trap collections, data from historic fyke net studies, catch records of lampreys at JBS facilities, turbine cooling water strainer collections, and information on the occurrence of lampreys in the diets of avian and piscine predators. We identified key data gaps	USGS	Synthesis of Juvenile Lamprey Migration and Passage Research and Monitoring at Columbia and Snake River Dams (Mesa et al. 2015)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				and uncertainties that should be addressed in a juvenile lamprey passage research program. The goal of this 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 CRB. A common finding in all datasets was the high level of variation observed for CRB lamprey in numbers present, timing and spatial distribution. This will make developing monitoring programs to accurately characterize lamprey migrations and passage more challenging. Primary data gaps centered around our uncertainty on the numbers of juvenile and larval present in the system which affects the ability to assign risk to passage conditions and prioritize management actions. Recommendations include developing standardized monitoring methods, such as at juvenile bypass systems (JBS's), to better document numbers and timing of lamprey migrations at dams, and use biotelemetry tracking techniques to estimate survival potentials for different migration histories.		
36.	Predictive model to prioritize barrier removal	No associated hydro project	Santiam	Mark-recapture population estimates at ~100 sites were conducted throughout wade-able habitats in the Santiam River to assess how reach scale habitat features and segment-scale geomorphic characteristics influence lamprey capture probability and abundance, respectively. This information will be used to develop a predictive map for lamprey abundance that can be combined with a barrier layer within a GIS framework to prioritize barrier removal in stream reaches with the greatest potential to increase availability of	Oregon Cooperative Fish and Wildlife Research Unit at OSU	Personal communication with Luke Schultz, OSU (09/24/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				suitable lamprey habitat. In 2015, we expanded the distribution modeling work by adding mark-recapture study locations in the Luckiamute River drainage on the West side of the Willamette. With this work, we validated predictions from the existing model (based off work conducted in the Santiam River), and found that similar geomorphic patterns were related to lamprey distribution. Furthermore, these data allowed us to expand the spatial scope of predictive models, and examine the expected distribution of larval lamprey across the entire Willamette River.		
37.	Assess lamprey passage success post fishway modifications, raw conversion rates via fishway window counts	Rocky Reach	Columbia	Window Count Conversions Rates - 2015 fishway window counts of adult lampreys at Rock Island Dam (14 April - 7 October) were 2,163 fish; Rocky Reach Dam fishway count were 2,131 adult lamprey for a raw unadjusted window count conversion rate of 98.52% at Rocky Reach. Raw conversions do not account for fall back and re-ascent/re-count of fish at Rock Island or Rocky Reach, or for escapement of fish into the Wenatchee River downstream of Rocky Reach Dam.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/8/15)
38.	Migration behavior and distribution in unimpounded reaches	No associated hydro project	Snake	In this 3-year study, we monitored the movements of 146 adult Pacific Lampreys in the Snake River and its tributaries upstream from Lower Granite Dam, the eighth dam from the Pacific Ocean. Our objectives were to characterize migration and test several hypotheses about adult upstream movement after dam passage. A majority of radio-tagged adults, released above Lower Granite Dam, migrated upstream after release and many moved hundreds of kilometers upstream into Snake River tributaries. Of those with telemetry records after	Columbia River Inter-Tribal Fish Commission	Seasonal Migration Behaviors and Distribution of Adult Pacific Lampyres in Unimpounded Reaches of the Snake River Basin (McIlraith et al 2015)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				release, 59–70% were recorded in the Clearwater River, 16–25% were in the Snake River, and 13–16% were in the Salmon River. Lampreys that passed the Snake River–Clearwater River confluence were significantly more likely, in most years, to enter the lower-discharge Clearwater River. Adults moved primarily at night during the summer–fall migration and did not exhibit a consistent response to changes in water temperature or discharge. These findings highlight the importance of the Clearwater River to Pacific Lampreys in the lower Snake River basin and indicate that adults that successfully pass through the Columbia–Snake hydrosystem can continue upstream migration into many Snake River subbasins. This distribution suggests that improved passage efficiency at dams may increase the number of adult Pacific Lampreys available for spawning within the interior portions of their distribution.		
	Adult Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
39.	Ladder tours	Bonneville, McNary, Lower Monumental, Lower Granite	Columbia and Snake	Completed a tour of fish ladders with regional fish managers and researchers to identify potential minor fishway modification opportunities. Although tours were again offered in 2015, participation has waned. Future tours will only include ladders with new modifications.	ACOE	Personal communication with Sean Tackley, ACOE (09/25/15) and Steve Juhnke, ACOE (09/25/15)
40.	Inspect fishway at Priest Rapids and Wanapum dams and identify areas	Priest Rapids, Wanapum	Columbia	In January 2014, Grant PUD conducted tours during scheduled maintenance outages with the PRFF members to evaluate the modifications to	Grant PUD	Personal communication with Mike Clement,

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	that could represent passage problems for adult Pacific lamprey			the fish ladders to improve adult lamprey passage (i.e., plating installation, adult lamprey collection facilities, newly designed count stations, and ramps downstream of perched orifices) and to identify any potential passage problem areas.		Grant PUD (09/24/15)
41.	Improving adult lamprey passage using lamprey passage structures (LPS) and refuges	Bonneville	Columbia	This project is part of a multi-year effort to understand and improve the passage performance of adult Pacific lamprey at lower Columbia River dams. Efforts to increase adult Pacific lamprey passage in 2014 included structural and operational changes to improve lamprey access to and passage through LPSs at Bonneville Dam. Lamprey use of these structures was assessed with lamprey-activated counters and passive integrated transponder (PIT) detections. Adult Pacific lamprey (n=1,199) were tagged with a PIT tag and released downstream from Bonneville Dam. Movements of PIT tagged lamprey were monitored by antenna arrays at traditional fishways and lamprey passage structures (LPS) at Columbia and Snake River Dams. Adult Pacific lamprey (n=1,327 as of October 1, 2014) were collected from an auxiliary water supply channel that has no outlet to the forebay at Bonneville Dam. These lamprey were transported and released untagged approximately 1 km upstream from the dam. Using PIT detections, we tested whether lamprey use refuge boxes installed along the bottom of the Washington-shore AWS channel placed in an effort to improve lamprey retention in this area.		Adult Pacific Lamprey Passage Structures: Use and Development at Bonneville Dam and John Day Dam South Fishway, 2014 (Corbett et al. 2015)
42.	Design LPS for Westland Diversion	Westland diversions	Umatilla	In 2012, the Umatilla Tribe continued design of the LPS for the Westland Diversion. The diversion	CTUIR	Personal communication with Aaron

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				dam is located in the Umatilla River watershed. Additional information was not available for inclusion in the 2015 report.		Jackson, CTUIR (11/5/14)
43.	Design LPS for Prosser Dam	Prosser, Sunnyside, Wapato, Horn Rapids dams	Yakima	In 2015, a consortium of agencies (e.g. BOR, YN, USFWS) participated in a Project Alternatives Solution Study (PASS) to evaluate and select the best passage improvement projects to improve passage for Pacific Lamprey primarily at Prosser Dam but also for Horn Rapids, Sunnyside, and Wapato dams using the USFWS funding available. This report is available upon request.	Yakama Nation, USFWS, and Bureau of Reclamation	Lamprey Passage, Yakima River Diversion Dams: Project Alternatives Solution Study Report (Bureau of Reclamation 2015). Personal communication with Ralph Lampman, YN (12/1/2015)
44.	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 are being monitored using DIDSON, optical video and HDX PIT-tags. Evaluation is ongoing and is in the second (and final) year. First year (2014) results are available in the cited annual report.	ACOE	Evaluation of Adult Fish Ladder Modifications to Improve Pacific Lamprey Passage at McNary and Ice Harbor Dams, 2014 (Thompson et al. 2015). Personal communication with Steve Juhnke, ACOE (09/25/15)
45.	Installation and/or utilization of 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 (09/24/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
46.	Modify dewatering procedures	All ACOE projects	Columbia and Snake	Modifications to dewatering procedures to reduce stranding and mortalities have occurred over the past several years. These include: managing dewatering to better flush fish down to the tailrace; to keep fish remaining in the ladder in standing water while dewatering to reduce the efforts by lamprey to move through gratings when stranded; and adequate personnel and equipment to ensure timely salvage. This is an ongoing action.	ACOE	Personal communication with Sean Tackley, ACOE (09/25/15)
47.	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 (11/12/15)
48.	Modify dewatering procedures	Rocky Reach, Rock Island	Columbia	Pursuant to the Rocky Reach Unwatering/Waterup 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..	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/8/15)
49.	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 (09/24/15)
50.	Operation of old fishway for lamprey passage	Willamette Falls	Willamette	Based upon past lamprey evaluations conducted at Willamette Falls, activities to restore portions of the existing “old fishway” to operability were completed in 2011 with the completion of a 52m linear curb and an adjustable headgate. The facility began operation in early spring 2012 when flows decrease below a river elevation (upstream of the falls) of 54’. Current information indicated that lamprey congregate in an area of this fishway early in the migration season. Operations of this fishway allow lamprey volitional passage to the forebay of	PGE	Personal communication with Tim Shibahara, PGE (09/24/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				the project. In 2014, Portland General Electric (PGE) continued to operate the "old fishway" and install lamprey ramps to facilitate adult lamprey passage at Willamette Falls Dam. High numbers of lamprey are observed using the facilities and the CTWSR has been evaluating the structures using cameras and PIT tags. Additional information was not available for inclusion in the 2015 report. However, it is likely that the old fishway remained in operation for 2015 similar to past years.		
51.	Passage design elements for new fishway construction	Trail Bridge Dam	McKenzie	As part of the implementation of the Carmen-Smith Project FERC license (currently awaiting issuance), the Eugene Water and Electric Board (EWEB) has included several design elements in the Trail Bridge Dam fish ladder that will assist in the upstream passage of Pacific Lamprey. • The auxiliary water comes into the entrance pool through a wall diffuser rather than a floor diffuser. • A 3"W x 4"H orifice through the dog-leg wall, on the floor and against the side wall. • A rounded instead of square end on the dog-leg • All lips, floor bumps and width changes (e.g. to and from pool and transport channels) have 4" radius corners. • In 2015, engineering design was on hold. All of the above elements remain in place.	EWEB	Personal communication with Andy Talabere, EWEB (10/6/14)
52.	Reduced water velocities at fishway entrances	Bonneville	Columbia	In 2013, continued reduced nighttime flow operations at the Washington Shore Fish Ladder to improve lamprey passage efficiency. Updated information was not available at time of reporting.	ACOE	Personal communication with Sean Tackley, ACOE (09/25/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
53.	Reduced water velocities at fishway entrances	McNary	Columbia	In 2013, continued reduced nighttime flow operations were implemented at the Oregon Shore Fish Ladder entrances, to improve lamprey passage efficiency. In 2014, reduced nighttime flow operation occurred only at SFE1. An adult lamprey passage structure was installed in SFE2, and normal flow operations were maintained. This is an ongoing action.	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/15)
54.	Reduce water velocities at fishway entrances	Wells	Columbia	Water velocities were reduced at the Wells fishway entrances in late 2013 as a component of a passage study.	Douglas PUD	Personal communication with Chas Kyger Douglas PUD (11/12/15)
55.	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 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	ACOE	Personal communication with Sean Tackley, ACOE (09/25/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				record-sized run. Accordingly, ACOE modified the Washington Shore Fish Ladder count station picket leads in winter 2012-13 to improve access to the AWS channel LPS in that fishway. This is now the standard configuration.		
56.	Lift picket leads at count station	The Dalles	Columbia	Lifted picket leads at East and North Fish Ladder count stations by 1.5 inches to provide alternative passage routes for Pacific lamprey. This is now the standard configuration.	ACOE	Personal communication with Sean Tackley, ACOE (09/25/15)
57.	Lift picket leads at count station	John Day	Columbia	Lifted picket leads at South Fish Ladder (already lifted at North) count station by 1.5 inches to provide alternative passage routes for Pacific lamprey. This is now the standard configuration.	ACOE	Personal communication with Sean Tackley, ACOE (09/25/15)
58.	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.	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/15)
59.	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. In 2014, fish passage operations continued with denil extensions to all three Rock Island Dam fishways in response to the Wanapum emergency drawdown. Removal of these denils planned for winter 2016. Final passage counts of Pacific Lamprey at Rock Island Dam (April14-Nov 15, 2014) with fishway denils and lamprey passage structures in place during the Wanapum Reservoir drawdown was 2,451 adult lamprey which volitionally passed count stations at the top of the three Rock Island fishways.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/8/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
60.	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 (09/23/14)
61.	Design, construction, and operation of lamprey collection and counting structure	John Day	Columbia	Modified count station area behind picket leads at John Day South Fish Ladder to facilitate (1) trapping for research or translocation activities; (2) improved escapement estimates. Picket lead spacing was reduced to ¾ inches, except near the bottom, where openings allow lamprey to enter a small flume system leading to a trap and video counting mechanism still in development. When not in collection mode, the system allows lamprey to continue moving up the fishway. Evaluation in 2013-2015 was limited to monitoring the number of lamprey collected in the trap box, along with experimentation with various video configurations. Minor modifications to the system were completed in 2014 and in 2015 to improve functionality.	ACOE	Personal communication with Sean Tackley, ACOE (09/25/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
62.	Design, construction and testing of 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 FERL facility at Bonneville Dam in 2014. Lamprey climbing success was measured against three flow levels and three ways of supplying water to the structure. Lamprey passage was 100% under all experimental conditions for fish that interacted with the structure. The ACOE intends to field test this climbing structure in the Bonneville Dam Washington Shore Ladder in 2017.	NOAA Fisheries	Personal communication with Kinsey Frick, NOAA (11/12/14) and Sean Tackley, ACOE (09/25/15)
63.	Swimming behavior in relation to environmental conditions within large-dam fishways	Bonneville and John Day	Columbia	We used an acoustic camera to make in situ observations on the swimming behaviors of Pacific lamprey at two large Columbia River dams and to develop inferences regarding potential mechanisms influencing passage within lower fishway sections (entrances, collection channels, transition areas). Pacific Lampreys were primarily free-swimming in the middle and upper water column at both the high-velocity entrance (>1 m/s) and the low-velocity transition area (<1 m/s) of Bonneville Dam. In contrast, Pacific Lampreys in the high-velocity fishway channel at John Day Dam were more likely to orient to the fishway floor at the entrance and in the collection channel. Pacific Lampreys exhibited no interaction with diffuser grating along the fishway floor at Bonneville Dam and were observed free-swimming above these structures. Behavior in the Bonneville Dam transition area appeared to be affected by poor attraction flow and the presence of predatory White Sturgeon *Acipenser transmontanus*. Higher Pacific Lamprey tail-beat	University of Idaho Cooperative Fish and Wildlife Research Unit	Characterization of Adult Pacific Lamprey Swimming Behavior in Relation to Environmental Conditions within Large-Dam Fishways (Kirk et al 2015a) Migration Behaviors of Adult Pacific Lamprey at Large Hydropower Dams on the Columbia River (Kirk 2015)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				frequencies and lower ground speeds were observed at the fishway entrances of both dams and in the John Day Dam collection channel, indicating that Pacific Lampreys were exerting greater effort to achieve upstream progress under the high water velocities at these locations. High tail-beat frequencies and low ground speeds support the hypothesis that fishway entrances may act as short-distance, high-velocity barriers for Pacific Lampreys, while passage through the lower John Day Dam fishway may be limited by the endurance requirements for passing a long-distance (»80 m), high-velocity challenge (collection channel). Similar in situ applications offer the potential for understanding and improving the passage of migratory fish at anthropogenic barriers.		
64.	Design of diffuser plating to provide attachment surface in fishways	Bonneville	Columbia	In 2014, ACOE re-designed diffuser plating that is to be installed at the Washington Shore Ladder at Bonneville Dam. The current diffuser design is too large given the abnormally high diffuser velocities in this ladder. Hydraulic analysis suggests that the plating would drive average floor diffuser velocities to over 2 times the NOAA criteria of 0.5 ft/sec and would increase risk of diffuser grating blowouts. An acceptable alternative design was identified and is currently scheduled for installation in Winter 2016-17.	ACOE	Personal communication with Sean Tackley, ACOE (09/25/15)
65.	Design and construction of rounded caps and plating for fishway entrance weirs	Bonneville	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 Basin,	ACOE	Personal communication with Sean Tackley, ACOE (9/25/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				presumably due to the high velocities (> 8 fps) 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 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 South Upstream Entrance (SUE) and South Downstream Entrance (SDE) at the Washington Shore Ladder in Winter 2014-15. The ACOE intends to install similar structures at all applicable entrance weirs at Bonneville, The Dalles, and John Day dams in future years.		

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
66.	Design of 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. 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 are currently scheduled to be installed for initial evaluation at the Bonneville Washington Shore Ladder in Winter 2016-17.	ACOE	Personal communication with Sean Tackley, ACOE (9/25/15)
67.	Design guidelines for lamprey passage structures	Bonneville and John Day	Columbia	The following document includes a compilation of design criteria used in the construction of several LPS systems now operating at Bonneville and John Day dams in support of future LPS system design and construction. Specifically, we report values for available criteria, evaluate the confidence that each criterion has been optimized, determine the range of acceptable values for each criterion, and identify areas of uncertainty in each criterion. A secondary aim is to develop a greater understanding of hydraulic requirements and modeling criteria including estimates of roughness and drag relative to submergence. The report provides a brief description of LPS systems currently in place, present criteria, and then discusses specific criteria and important idiosyncrasies of individual systems.	University of Idaho Center for Ecohydraulics Research and Cooperative Fish and Wildlife Unit and NOAA Fisheries	Design Guidelines for Pacific Lamprey Passage Structures (Zobott et al 2015)
	Project Passage					

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	Effectiveness					
68.	Use of video and sonar technology to monitor adult lamprey use and behavior	McNary, Ice Harbor	Columbia and Snake	Continuation of picketed lead video monitoring in 2014 at McNary and Ice Harbor dams. Additional activities included using a combination of optical video cameras and DIDSON sonar cameras to evaluate the behavior of lamprey in the immediate vicinity of the lamprey prototype entrance structure (LPES) installed in the MCN South Shore Fishway entrance (SFE 2); enumerating adult lamprey entering and exiting the structure; and estimating passage efficiency and passage time using HD-PIT tag technology. Lamprey counts and behavior at the picketed leads were consistent across 2011–2014, and ladder escapement at McNary Dam has increased annually since picketed lead monitoring began. Lamprey passage under the picketed lead gap is highly variable between locations and frequent at the McNary south ladder. Variation in lamprey passage behind picketed leads among locations suggests that variation among ladders' structural features, water velocities, and count slot configurations affect adult lampreys' choice of whether to pass via the count window or picketed leads. The proportion of lamprey counts at the window and in picketed lead video at McNary South fish ladder was consistent across 2011-2014 migration seasons. When monitoring of elevated picket leads is not possible, an index multiplier of 1.469 may be applied to post-season total window counts to estimate picketed lead lamprey counts. From 2011-2014, lamprey passage under the raised picketed section at McNary Dam accounted for a considerable portion (40.9%) of the total count,	UC Davis and University of Idaho	Evaluation of Adult Fish Ladder Modifications to Improve Pacific Lamprey Passage at McNary and Ice Harbor Dams (Thompson et al. 2015) Personal communication with Don Thompson, UC Davis (10/22/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				with most passage occurring at the south ladder. From 2011-2014, lamprey passage under the raised picketed lead section at Ice Harbor Dam accounted for a small portion (3.3%) of the total count, suggesting enumeration at the count station alone does not provide a gross underestimate of escapement past Ice Harbor Dam. During the first year of video monitoring, lampreys utilized the LPES, with 20.9% of lampreys observed in optical and DIDSON video entering the LPES via the upper and lower ports. Most utilized the lower slot, and ports nearest the channel wall. Few HD-PIT tagged lampreys (8) were detected passing through the LPES on internal antennas. These lampreys had a similar dam passage success rate as tagged lampreys not detected within the LPES. Mean LPES baffle passage time was 3 minutes. Using two independent approaches (HD-PIT and video monitoring), very similar proportions of lampreys were observed at the SFE2 LPES, with ~ 5% lampreys detected/observed relative to total ladder counts. No salmonids interacted with the LPES structure or entry ports and exit rack. Continuing the 2014 study at McNary SFE2, adult lamprey behavior and use of the LPES was determined using a combination of optical video and DIDSON, along with HD-PIT telemetry. HD-PIT fish will be limited to those tagged in 2014, as no tagging will occur in 2015. Data collection and analysis is ongoing with results presented in a draft report due Feb 28,		

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				2016.		
69.	Evaluate fishway modifications	Priest Rapids, Wanapum	Columbia	Grant PUD implemented a comprehensive adult passage evaluation study plan, titled "Assessment of Pacific lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams" (Nass et al. 2009). The goal was to collect data in support of determining whether proposed modifications (plating, ramps at perched orifices, and lamprey-specific crowders at fish count stations) improved adult passage. HDX-PIT system were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific lamprey tagged at lower river facilities were passively monitored at PRP facilities as directed by the PRFF. In 2015, Grant PUD, in consultation with the PRFF, collected and tagged 133 adult Pacific lamprey with HDX PIT-tags to continue this multi-year evaluation. Preliminary cumulative data analysis will be completed as part of 2015 activities and included in the 2015 annual report. Final results will be included in Grant PUD's 2016 Comprehensive Annual Report.	Grant PUD	Personal communication with Mike Clement, Grant PUD (9/24/15)
70.	Evaluate passage at LPS structures	Threemile Falls Dam, Maxwell and Feed diversions	Umatilla	In the Umatilla River watershed, lamprey passage structures (LPS) have been completed and are operational at Threemile Falls Dam (July 2009), Feed Diversion (October 2010), and Dillon Diversion (2011). A flat plate was installed to aid upstream lamprey movement at Maxwell Diversion (August 2010). Radio-telemetry monitoring at these structures was conducted in 2012. Preliminary results indicated that 38 lamprey were detected using the LPS while 55 lamprey were detected passing through the traditional ladder at Threemile Dam. A number of fish had undocumented passage at this location so	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/5/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				monitoring of the entire facility is planned for 2013. Information to date indicates no detections higher in the watershed however, complete monitoring results are not yet available. Additional information was not available for inclusion in the 2015 report.		
71.	Project passage evaluation	Clackamas	Clackamas	In 2013, an active/passive tag evaluation using RT and HDX tags to evaluate passage success through the project was implemented. All fish were tagged at the trap in River Mill Fish ladder and released ~1 mile downstream to evaluate re-assent back through this facility and remaining NF ladder upstream. A total of 47 fish were active/HDX tagged and 45 HDX tagged. The evaluation started last spring and is still ongoing. Preliminary results indicate high ladder passage success at River Mill Dam ladder (~86%). No fish were observed passing the NF Ladder. This is confounded by historical fish facility features that prevented migration through this facility. A final report will be available in 2015. Additional information was not available for inclusion in the 2015 report.	PGE	Personal communication with Tim Shibahara, PGE (09/24/14)
72.	Passage structure evaluations	Bonneville, John Day	Columbia River	Lamprey passage structures (LPS) have been installed at Bonneville and John Day Dams in an attempt to improve lamprey passage. Seasonal operation of the four LPS's at Bonneville Dam began as early as April and ended as late as October during 2015. Each LPS at Bonneville Dam operated between 109 and 213 days. The LPS at John Day operated from May through September, but was inoperative from late June to early August due to a pump failure. The number of	ACOE	Darren Gallion, Presentation at AFEP, Walla Walla, WA (12/10/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				lamprey that passed the LPS's were enumerated with mechanical counters or directly during trap and haul operations. Mechanical passage estimates were validated and corrected using video once per week. Results of monitoring will be available in 2016.		
73.	Evaluate migration characteristics of adult lamprey in the Priest Rapids Project	Priest Rapids, Wanapum	Columbia	In 2015, to evaluate passage and travel times through various reaches of the Priest Rapids Project, 100 adult lamprey collected at Priest Rapids Dam were tagged with Vemco acoustic and FDX PIT tags and released at one of three locations; above Priest Rapids Dam (n=30 Desert Aire RM 400.3), or above Wanapum Dam at either the left bank boat launch (n=35 RM 416.0) or at Vantage (n=35 RM 419.9). Fixed receiver arrays were used to monitor lamprey that migrated within the Priest Rapids and Wanapum reservoirs. Detections of FDX PIT tags were queried using PTAGIS. Preliminary results of the study will be available in spring 2016.	Blue Leaf Environmental	Personal communication with Rod O'Connor (9/25/15)
74.	Evaluation of fishway modifications	Rocky Reach	Columbia	Based upon a literature review and site visit conducted in spring of 2010, Chelan PUD made modifications to the Rocky Reach fishway during the 2010-2011 and 2011-2012 fishway maintenance periods to improve adult lamprey passage at the Project. These improvements include installation of plating at diffuser gratings throughout the ladder, plating at orifices in the lower fish ladder sections where overflow weirs are located, ramps at perched orifices in the upper ladder, and an HDX PIT tag detection system at key locations within the fishway and have been evaluated since 2013. In 2014, a total of 288 unique tagged lampreys detected at Rocky Reach in 2014 including 32	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/8/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				FCRPS tagged fish - 27 tagged at BON; 4 at John Day; and 1 Ice Harbor fish. 2014 and 2015 detections of tagged adults passing Rocky Reach indicate an ongoing passage rate of approximately 70%. Net ladder passage efficiency (NLPE) which considers drop back, fall back, and re-ascents of tagged fish is greatly improved. NLPE increased 23% from 2004 estimate of 47% using radio tagged fish at Rocky Reach. 2014 median in-fishway travel times for tagged lamprey from entrance to exit were 0.63 days; mean in-fishway travel times were 3.14 days. Fishway entrance efficiency from a release point 8 km downstream of Rocky Reach was 85.1%.		
75.	Swimming behavior and performance	Bonneville	Columbia	The hydraulic and structural environment within the serpentine weir sections at Bonneville Dam are associated with both high turbulence and relatively long sections of high velocity at individual weirs that may act as a deterrent or barrier for lamprey passage. We assessed lamprey passage rates and behaviors at an experimental weir by varying treatment combinations of velocity, weir length, and turbulence similar to conditions found in the Bonneville Dam serpentine weir sections. We also compared results from the experimental flume to in-situ video observations of lamprey behavior within the serpentine weir sections of Bonneville Dam. We evaluated lamprey success rates and behavior in an experimental flume, which had a vertical slot structure similar in design to a serpentine weir at Bonneville Dam. This slot weir allowed us to manipulate three variables of interest. First, we had three different velocity treatments (1.2 m/s, 1.8 m/s, 2.4 m/s), which captured the range of	University of Idaho, Department of Fish and Wildlife Sciences	Evaluations of Pacific Lamprey Swimming Behavior and Performance in Relation to Velocity, Slot Length, and Turbulence in Vertical Slot Fishway Weirs, 2014 (Kirk et al. 2015b).

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				velocities present within the Bonneville fishways. Second, we had three different slot lengths (0.33 m, 0.66 m, 1.00 m), because slot lengths differ considerably among serpentine weirs at Bonneville Dam. Third, we tested the effect of turbulence using treatments with or without a large deflector wall upstream of the weir, which produced large eddies representative of those in the serpentine weir sections. The overall experimental design consisted of 18 total treatment combinations (3 ×3 × 2) and each combination consisted of three replicates with 5-6 lamprey per replicate. There was no significant overall effect of velocity, turbulence, or slot length on lamprey success rates through the weir. There was however, a turbulence × slot length interaction, in which the lowest success rates (<70%) were observed for the high turbulence × long length treatments. There was no indication of direct body size effects on passage, but adults with larger inter-dorsal fin distance were more likely to pass. Subsequent monitoring of adults during upstream migration post-release provided no evidence of a correlation between passage success in the experimental flume and upstream migration distance, whereby lamprey that did not pass the experiments had similar upstream escapement estimates throughout the hydrosystem as lamprey that did pass the experiments. Detailed results are presented and discussed in the relevant source citation.		
76.	Adult Pacific Lamprey Passage Analysis	Prosser	Yakima	At Prosser Dam on the Yakima River (river km 75.6) between 2002 and 2014, approximately 77% of the run consisted of spring migration, and only approximately 23% were of fall migration. End of June and beginning of July appeared to be the	Yakama Nation	Appendices in "Evaluation and Coordination of Pacific Lamprey Activities in the

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				estimated period when overwintered migrants cease moving and new migrants start their migration, although some overlap likely exists in between. Passage counts were highest (58.1%) in the left ladder for fall migrants whereas passage counts were highest in the right ladder (56.5%) for spring migrants. Passage time was similar across all three fish ladders and was primarily between 8:00 pm and 9:00 am. During the fall migration period, passage was observed in a wide range of flow conditions only in the left ladder. Water temperature appeared to be critical during the fall migration period; majority of lamprey passage took place between water temperatures of 56 and 70°F. During the spring migration period, lamprey appeared to pass the dam at a wide range of flow conditions (800-13,600 cfs) with the exception of extremely low and high flow conditions. Water temperature during spring migrant lamprey passage was mostly between 48 and 61°F. Finally, photos were taken over a 9 month period in 2014 between March and September at Prosser Dam in four locations (left bank, left channel, middle channel, right channel) to document the flow-based changes in water current conditions at these locations, with a focus on the left bank.		Yakima River Subbasin, BOR 2014 Annual Progress Report" (Lampman et al. 2015). Personal communication with Ralph Lampman, Yakama Nation (12/1/15)
	Lamprey Counts at Dams					
77.	Conduct 24-hour lamprey counts	Bonneville, The Dalles, John Day, McNary, Lower Granite	Columbia and Snake	Counts include nighttime video window counts. Nighttime counting was expanded in 2012 to include The Dalles and John Day dams. This is an ongoing operation.	ACOE	Personal communication with Sean Tackley, ACOE (09/25/15)
78.	Conduct 24-hour lamprey counts	Wells	Columbia	On-going 24-hour fishway monitoring since the 1990's.	Douglas PUD	Personal communication with Chas Kyger

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						Douglas PUD (11/12/15)
79.	Conduct 24-hour lamprey counts	Rocky Reach, Rock Island	Columbia	On-going 24-hour fishway monitoring since the late 1980's.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/14/14)
80.	On-going 24-hour fishway monitoring since the mid 1990's.	Grant PUD	Personal communication with Mike Clement, Grant PUD (09/24/15)	On-going 24-hour fishway monitoring since the mid 1990's.	Grant PUD	Personal communication with Mike Clement, Grant PUD (09/24/15)
81.	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.	Yakama Nation	Personal communication with Ralph Lampman, Yakama Nation (12/1/15)
82.	Estimate adult lamprey upstream passage success rates, ladder passage times, entrance slot preference and fallback rates at Snake River dams.	Ice Harbor, Lower Monumental, Little Goose, and Lower Granite	Snake	In 2014, ACOE contracted with Cramer Fish Sciences, to conduct an adult lamprey migration behavior and passage success evaluation in the Lower Snake River. Adult Lamprey were captured at the JDA north ladder LPS, and the JDA South ladder lamprey trap, tagged onsite, and transported for release into Ice Harbor dam tailrace or forebay. Opportunistically, test fish included lamprey previously radio- and/or PIT-tagged for lower Columbia River lamprey modification evaluations, if detected migrating up the Snake River. Specific objectives are: 1. Determine which ladder entrances slots (multiple entrance slots per ladder entrance) attract the majority of migrating	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/15) Peter Stevens, Presentation at AFEP, Walla Walla, WA (12/10/15) Evaluation of Adult Pacific Lamprey Passage at Lower Snake River Dams (Stevens et al., 2015).

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				adult lamprey to aid in developing future entrance design modifications. 2. Estimate adult lamprey upstream passage success rates, relative fishway route use, passage times, turnaround/ladder fallout, and forebay fallback at IHR, LMN, LGO, LGR using radio-telemetry, HDX-PIT technology, and visual counts. 3. Determine conversion rates of migrating adult lamprey between Snake River dams based on a combination of RT and PIT-tag detections. As of 15 October 2015, 243 radio-tagged fish had been detected at Ice Harbor Dam (65%), 66 were detected at Lower Monumental (18%), 30 were detected at Little Goose (8%) and 10 were detected at Lower Granite dams (3%). Preliminary passage ratios by project are 49% for Ice Harbor Dam, 70% for Lower Monumental Dam, 44% for Little Goose Dam and 67% for Lower Granite Dam. Preliminary passage ratio from Ice Harbor tailrace to Lower Granite Dam exits is 3%. These represent minimum estimates which do not account for late-fall 2015 or spring 2016 movement. However, 2015 preliminary estimates are broadly similar to rates observed in 2014 (the first year of the study; Stevens et al. 2015).		
	Predation					
83.	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	ACOE	ACOE Pacific lamprey passage improvements

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				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.		implementation plan, 2008-2018 (ACOE 2009)
	Juvenile Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
84.	Delayed deployment of extended length screen during outmigration	McNary	Columbia	Installation of extended screens was delayed in the spring of 2013 to reduce impacts to juvenile lamprey migrating out early.	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/15)
85.	JBS modifications	McNary	Columbia	Extended the JBS raceway waste water outfall pipe and altered JBS raceway screen mesh size to allow juvenile lamprey to volitionally pass from the raceway back to the river. This is the current configuration and an ongoing action.	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/15)
86.	JBS outfall relocation	McNary, Lower Monumental	Columbia / Snake	JBS outfalls were relocated downriver from existing locations. The outfall relocations were done to improve salmonid survival, but juvenile lamprey will benefit from the new locations as well. This is the current configuration and an ongoing action.	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/15)
87.	Continue salvage activities during ladder maintenance de-watering	All ACOE projects	Columbia / Snake	Modifications to dewatering procedures to reduce stranding and mortalities have occurred over the past several years. These include: managing dewatering to better flush fish down to the tailrace; to keep fish remaining in the ladder in standing water while dewatering to reduce the efforts by lamprey to move through gratings when stranded; and adequate personnel and equipment to ensure timely salvage. This is an ongoing action.	ACOE	Personal communication with Sean Tackley, ACOE (09/25/15) and Steve Juhnke, ACOE (9/25/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
88.	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 Pacific Lamprey Management Plan.	Douglas PUD	Personal communication with Chas Kyger Douglas PUD (11/12/15)
89.	Continue recovery activities during ladder maintenance de-watering	Rocky Reach, Rock Island	Columbia	Pursuant to the Rocky Reach Unwatering/Waterup Job Plan 1402 and Rock Island SOP, fishway dewatering protocols and fish recovery operations for all species are followed during annual winter fishway maintenance and dewatering activities.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/8/15)
90.	Continue salvage activities during ladder maintenance de-watering	Priest Rapids, Wanapum	Columbia	Consistent with its Fishery Operations Plan (Grant PUD 2010), Grant PUD conducts collection operations for all fish species during annual ladder maintenance activities.	Grant PUD	Personal communication with Mike Clement (09/24/15)
91.	Maintain bypass operations criteria	Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island Fish Passage Plan (Chelan PUD 2012), bypass operations criteria are in place.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/8/15)
92.	Maintain bypass operations criteria	Priest Rapids, Wanapum	Columbia	Grant PUD has existing bypass systems, which includes gatewells, spillways, the WFUFB, and Priest Rapids Top-Spill Bypass.	Grant PUD	Personal communication with Mike Clement, Grant PUD (09/23/14)
	Project Passage Effectiveness					
93.	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. Updated information was not available at Columbia River projects at the time of reporting.	ACOE	Personal communication with Sean Tackley, ACOE (09/25/15) and Steve Juhnke, ACOE (09/25/15

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
94.	Juvenile lamprey monitoring	Bonneville, John Day, McNary, Lower Monumental, Little Goose, Lower Granite, and Rock Island	Columbia and Snake	The Fish Passage Center (FPC) continues to monitor juvenile and adult lamprey passage at many Columbia River dams. Adult passage data are from window counts while juvenile passage data are collected as part of the smolt monitoring project. Data is available for query at www.fpc.org	FPC	www.fpc.org
95.	Lower Granite Dam Juvenile Fish Collection Channel Prototype Overflow Weir and Enlarge Orifice Biological Evaluation	Lower Granite	Snake	As part of a study in 2014 to evaluate passage of juvenile fishes through prototype fish passage structures in a gatewell at Lower Granite Dam (LGR), juvenile Pacific lamprey were collected, PIT-tagged, and released. The study was undertaken as part of a broader effort to assess the effectiveness of traditional juvenile bypass systems prescribed by the NOAA Biological Opinion (NOAA 2008, 2010) RPA 54.2. The objectives addressed in the study were: (1) determine how the overflow weir and/or larger orifices affected orifice passage efficiency (OPE) and gatewell residence times compared to current orifice configuration for juvenile lamprey, (2) determine effective collection methods for juvenile lamprey at LGR, Little Goose (LGS), and Lower Monumental (LMN) dams, (3) determine collection efficiency for juvenile lamprey designated for recollection at the Sort by Code (SxC) system at LGR, and (4) evaluate PIT tag retention using two different tagging techniques: surgical methods described by Mesa et al. (2011) and injecting PIT tags with a 16-gauge needle. PIT-tagged lamprey (n=753) were released at night during the period of May 10, 2014 through June 5, 2014. Fish were released into one of four locations. Statistical tests were used to detect	ACOE (prepared by Blue Leaf Environmental)	Lower Granite Dam Juvenile Fish Collection Channel Prototype Overflow Weir and Enlarged Orifice Biological Evaluation (O'Connor et al. 2014) Personal communication with Rod O'Connor, Blue Leaf Environmental (9/25/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				significant differences in travel time between release locations. Collection efficiency, tag retention, and travel times for different release locations were also evaluated. A final report was submitted to ACOE February 16, 2015.		
96.	JSATS Tag Development	No associated hydro project	N/A	With co-funding from the ACOE and DOE, a project has been implemented to design, prototype, and evaluate an acoustic micro transmitter that can be used to study the behavior and survival of juvenile eel and lamprey. Laboratory research will be used to guide the design of the transmitter and provide guidance for field deployment. A new, downsized Juvenile Lamprey Acoustic Transmitter (JLAT) is currently being developed by PNNL which will allow a shift from surgical implantation with an incision and sutures to a simple incision.	PNNL	Daniel Deng, Presentation at AFEP, Portland, OR (12/10/14) Personal communication with Robert Mueller (12/14/15)
	Predation					
97.	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	ACOE Pacific lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009)
98.	Predation control measures and gut sampling	Rocky Reach, Rock Island	Columbia	As part of its HCP obligations, Chelan PUD implements predation control activities. Controlling predators of juvenile salmonids, both fish and birds, is a tool Chelan PUD has used to achieve HCP survival standards for juvenile fish.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/8/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				In 2014, pikeminnow control programs continue in both Rock Island and Reach; Programs utilize long-line and rod-reel angling in tailrace and main reservoirs by Chelan PUD contractors and Chelan PUD fish crews. Chelan PUD's total pikeminnow catch in 2014 from Rock Island and Rocky Reach reservoirs combined was 74,857 fish. 2015 pikeminnow harvest data not complete, but similar to 2014. 2015 pikeminnow gut sampling - qualitative estimate of juvenile lamprey numbers consumed by pikeminnow captured from Rocky Reach tailrace deck. Results in progress.		
99.	Predation control measures	Priest Rapids, Wanapum	Columbia	Grant PUD implements predation control measures (avian and aquatic) to protect outmigrating, anadromous salmonids as a requirement of Grant PUD's NOAA Biological Opinion (NOAA Fisheries 2004). These measures include use of lethal and non-lethal control and monitoring presence and absence of juvenile lamprey through dietary sub sampling. It would be expected that these predation control activities will indirectly benefit outmigrating juvenile lamprey throughout the project.	Grant PUD	Personal communication with Mike Clement, Grant PUD (09/24/15)
	Policy/Recovery Activities					
100.	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 of the region. Activities to	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
				support the objectives identified in the plan were implemented in 2014 (see other categories in Table 4).		
101.	Develop/implement Framework for Pacific Lamprey Supplementation Research in the Columbia River Basin 95% Draft	No associated hydro project	Columbia and Snake	The purpose of this Supplementation Research Framework is to initiate the development of a regionally coordinated and long-term RME and reporting plan (Section 1.4) directed towards the implementation of supplementation and recovery actions for Pacific lamprey within the CRB. Additionally, this Supplementation Research Framework intends to "standardize" key elements of supplementation RME and reporting so that findings associated with status and trends and other important objectives can be reported in a common and consistent format. Finally, the Supplementation Research Framework provides specific guidance for the development of Subbasin Supplementation Research Plans. The development of this regional Supplementation Research Framework is needed to coordinate supplementation RME on both a regional and local level. The Supplementation Research Framework will provide consistency and serve as a communication and management tool for stakeholders to remain focused on the overall goals of the Tribal Pacific Lamprey Restoration Plan and the Lamprey Conservation Agreement.	HDR Engineering, Inc., CRITFC, Yakama Nation, and CTUIR	Personal communication with Ralph Lampman, Yakama Nation (12/1/2015)
102.	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 TPLRP, Lamprey Conservation Agreement (USFWS	HDR Engineering, Inc., CRITFC, Yakama Nation, and CTUIR	Personal communication with Ralph Lampman, Yakama Nation (12/1/2015)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				2012), the Framework for Pacific Lamprey Supplementation research in the CRB (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.		
103.	Implementation of 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 for the Columbia River Basin. A final draft of the Plan was completed in December 2011. The tribes propose the plan for restoration of the species to numbers adequate for tribal use and ecological health of the region. Activities to support the objectives identified in the plan were implemented in 2013 (see other categories in Table 4).	ACOE	ACOE Pacific lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009)
104.	Develop/implement management plan for Pacific lamprey restoration	Wells	Columbia	In 2010, a 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.	Douglas PUD	Personal communication with Chas Kyger, Douglas PUD (11/12/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Implementation of some management plan activities is underway and includes a passage and enumeration study in 2013.		
105.	Develop/implement management plan for Pacific lamprey passage monitoring and improvement	Rocky Reach	Columbia	On-going implementation of the PLMP that was developed and finalized in 2005. In addition to fishway evaluations and activities to improve adult lamprey passage and juvenile passage and survival (when technology exists), management plan activities also include implementation of adult fishway and juvenile bypass operations criteria at the Project, regional data sharing and protocol development, and participation in regional conservation and recovery activities.	Chelan PUD	Rocky Reach Pacific Lamprey Management Plan (Chelan PUD 2005)
106.	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)
107.	Lamprey Technical Work Group • Supplementation Subgroup • Passage Engineering Subgroup • NPCC lamprey synthesis Subgroup	All ACOE projects, Wells, Rocky Reach, Rock Island, Priest Rapids	Columbia and Snake	The purpose of the Columbia River Basin Lamprey Technical Work Group (CRBLTWG) is to provide technical review, guidance, and recommendations for activities related to lamprey conservation and restoration. The CRBLTWG accomplishes this by: 1) identifying and prioritizing critical uncertainties regarding lamprey conservation; 2) providing a forum for discussion regarding lamprey-related concerns; and 3)	USFWS	Personal communication with Christina Wang, USFWS (10/19/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	• FPC smolt monitoring program assistance			disseminating technical information. In 2015, the CRBLTWG met in March and October. The Lamprey Technical Workgroup (LTWG) is now a committee of the Pacific Lamprey Conservation Initiative (PLCI). It was expanded this year outside the Columbia River Basin and now includes Coastal Oregon and Washington, California and Alaska. The Conservation Team, another committee of the PLCI, gives assignments to the LTWG based on needs identified in status assessments, regional implementation plans and guidance from policy representatives. No subgroup meetings were held in 2015 because the LTWG is reorganizing. We expect the same subgroups will continue working and new subgroups will be formed to meet new assignments.		
108.	Pacific Lamprey Conservation Initiative	All ACOE projects	Columbia and Snake	The USFWS with signatories to the Pacific Lamprey Conservation Agreement and other partners continued to work on regional implementation plans for all regional management units in the Columbia and Snake rivers including the mainstem Columbia and Snake. The Conservation Team met 3-16-15, 6-15-15, and 9-21-15. The 6-15-15 meeting was to hear presentations by the Regional Management Unit Groups on their regional implementation plans. The Conservation Team is planning a meeting with the Policy Committee in December of 2015. The purpose of this meeting is to inform Policy level staff of the current needs for Pacific Lamprey and obtain potential funding sources for conservation actions and research. The Conservation Team is proposing Pacific Lamprey as a candidate partnership in the National	USFWS	Personal communication with Christina Wang, USFWS (10/19/15)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Fish Habitat Action Plan (NFHAP). We submitted a candidacy letter in September 2015 to the NFHAP board. We will present the candidate partnership, Pacific Lamprey Fish Habitat Partnership, to the NFHAP board at their meeting October 20, 2015. If candidate status is granted the partnership may be asked to submit an application for full partner status.		
109.	Management Recommendations and Research Needs	No associated hydro project	Willamette	The recovery of Pacific lamprey involves conservation and monitoring actions rangewide as well as locally. Regional implementation planning teams are most effective when conservation partners share similar baseline knowledge about that status of lamprey. However, it is difficult to remain up to date with all of the pertinent monitoring and research information, particularly when the number of research programs is expanding and many studies are published in the gray literature. To address this issue and improve conservation planning in the Willamette River Basin, Oregon we compiled what, to our knowledge, is all the available information on Pacific lamprey from the Basin, organized according to life history stage. We also commented on current management activities and uncertainties. Our review identified information gaps for Pacific lamprey in Willamette River Basin and rangewide, namely estimating annual escapement and outmigration. This synthesis also highlights the Willamette River Basin as both an important conservation area for Pacific lamprey in the Columbia River system, because of its relatively high adult returns, but also as an excellent study area for learning about the basic ecology of the species and improving monitoring programs.	Oregon Cooperative Fish and Wildlife Research Unit at OSU	Pacific lamprey in the Willamette River Basin: management recommendations and research needs (Schultz et al. 2015)

AAM = ammocoete abundance model
ACOE = Army Corps of Engineers
AWS = auxiliary water supply
BOR = U.S. Bureau of Reclamation
BPA = Bonneville Power Administration
CE = capture efficiency
CRBLTWG = Columbia River Basin Lamprey Technical Work Group
CRITFC = Columbia River Inter-Tribal Fish Commission
CTGR= Confederated Tribes of Grand Ronde
CTUIR = Confederated Tribes of the Umatilla Indian Reservation
CTWSR = Confederated Tribes of the Warm Springs Reservation
DDR = design documentation report
DIDSON = Dual-frequency Identification Sonar
EWEB = Eugene Water and Electric Board
FCRPS = Federal Columbia River Power System
FPC = Fish Passage Center
HCP = Habitat Conservation Plan
HDX = half duplex
ISRP = Independent Scientific Review Panel
JSATS = juvenile acoustic telemetry system
LPS = lamprey passage system
mm = millimeters
MRC = mark-recapture methods
MUK = Mukilteo Research Station
N/A = not applicable
NOAA = National Oceanic and Atmospheric Administration
NPCC = Northwest Power and Conservation Council
ODFW = Oregon Department of Fish and Wildlife
OSU = Oregon State University
PGE = Portland General Electric
PIT = Passive Integrated Transponder
PLEMP = Pacific Lamprey Passage Evaluation and Mitigation Plan
PLMP = Pacific Lamprey Management Plan
PNNL = Pacific Northwest National Laboratory, Battelle
PRB = Pelton Round Butte Project
PRFF = Priest Rapids Fish Forum
PUD = Public Utility District
RM = river mile
RRFF = Rocky Reach Fish Forum
SMP = Smolt Monitoring Program
SNP = single nucleotide polymorphism
SOP = Standard Operating Procedure
USDA = U.S. Department of Agriculture
USFWS = U.S. Fish and Wildlife Service
USGS = U.S. Geological Survey
YNPLP = Yakama Nation Pacific Lamprey Project

3.0 Status of Pacific Lamprey Activities at the Priest Rapids

Pursuant to the requirements of Grant PUD's PLMP (Grant PUD 2009) and specifically for this comprehensive annual report (as described in Section 1.2 above), activities at the Project related to Pacific lamprey are described in Table 6. The information is organized by the protection, mitigation and enhancement (PM&E) measures for each of the four objectives set forth in the Project's PLMP. Included for each PM&E is the timeframe for implementation/completion of the measure, the action taken by Grant PUD in 2015, and any variations in schedule. In general, measures are currently on or ahead of schedule.

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

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2015	Variation from Schedule (if applicable)
Objective 1: Identify, address, and fully mitigate Project effects to the extent reasonable and feasible to achieve 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, 2016.	No
Objective 2: Provide safe, effective, and timely volitional passage for adult upstream and downstream migration					
2.	Maintain adult fishways.	Annually for the period 2009-2015	Yes	Grant PUD continues to maintain fishways at the Project in accordance with the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for dewatering and the collection of all fish.	No
3.	Develop adult Pacific lamprey passage criteria.	To be determined by the PRFF Annual passage detection monitoring initiated in July 2010 – 2015.	Yes	Grant PUD installed 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 407 unique PIT tags at Priest Rapids and 374 at Wanapum since 2010. Fish passage efficiency (FPE) and passage times are being calculated. Following the 2015 migration period, the cumulative sample size (2010-2015) should allow for empirical statistical review of the monitoring results.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2015	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 2009-2015	Yes	Grant PUD maintains video stations at the Project to count fish in accordance with the PLMP, NOAA Fisheries Biological Opinion and agreements included in the FERC License. Newly designed and fabricated fish crowder facilities were installed and operated at both Priest Rapids and Wanapum dams prior to April 2010. Fish counts are for all species including adult lamprey are expected to be extremely accurate and are available at www.gcpud.org for review.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2015	Variation from Schedule (if applicable)
5.	Develop and implement a comprehensive evaluation of adult lamprey passage at the Project.	Develop / implement: Within one year of license issuance (2009)	Yes	This annual report includes a comprehensive evaluation on adult lamprey passage in the Project area by addressing each measure in the PLMP. PRFF members conducted an on-site inspection of the Priest Rapids and Wanapum left bank fishway facilities during the 2014-2015 winter fish ladder maintenance outage.	No
		Determination of whether proposed modifications improve adult passage: Within four years of license issuance	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 FLA and included in the FERC License in 2010.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2015	Variation from Schedule (if applicable)
7.	Implement an evaluation program to assess the effectiveness of fishway modifications on adult lamprey.	Within one year of completion of fishway modifications at Priest Rapids Dam (2011)	Yes	Grant PUD implemented an evaluation program in coordination with the PRFF to determine and assess the effectiveness of fish ladder modifications. HDX-PIT system were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific lamprey tagged at lower river facilities were passively monitored at PRP 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 was 74% at Priest Rapids Dam over the 2010-2014 period and 73% at Wanapum Dam over the 2010-2013 period (2014 intentionally omitted). 2015 passage efficiencies were not available in time for this report.	Yes, ahead of schedule. An evaluation program was implemented in 2010 and was continued in 2011.
8.	Implement all modifications identified for adult fishways at the Project as identified in the FLA or as amended by the PRFF.	Within seven years of license issuance (2015)	Yes	Grant PUD has implemented improvements proposed in the FLA and included in the FERC License (see #6 above). Grant PUD will consider additional modifications based on the evaluation of the effectiveness of fishway modifications.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2015	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 WDOE 401 water quality certification.	Every 5th year of the license term (Aug. 2013, 2018, 2023, etc)	Yes	Biological objectives status report update for 2013 was included in the 2014 annual report.	Yes.
11.	Conduct a monitoring and evaluation study of adult Pacific lamprey passage at Project; if based on the 10-year status report, Ecology 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	None	No
12.	Participate in regional studies, forums and measures and cooperate with other entities performing those activities when useful information may be obtained about Project impacts on adult Pacific lamprey. Forums will include (but not limited to) the CRBLTWG.	Annually for the life of the license	Yes	Grant PUD currently participates in regional forums such as the Columbia River Basin Pacific Lamprey Technical Workgroup, the Lamprey Conservation Initiative (USFWS), and the Tribal Restoration Plan activities (CRITFC). Refer to Section 2.2 for specific activities.	No
13.	Continue to operate and maintain the adult PIT-tag detection system (full-duplex) at the Priest Rapids Dam fishway.	Annually for the life of the license	Yes	Grant PUD continues to maintain the adult PIT-tag detection system (full-duplex) at Priest Rapids Dam.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2015	Variation from Schedule (if applicable)
Objective 3: Provide safe, effective and timely volitional passage for juvenile migration					
14.	Identify and mitigate for Project effects on juvenile Pacific lamprey	No later than 10 years following license issuance (2018)	Yes	Currently, options for measuring Project effects on juvenile Pacific lamprey are under consideration by the PRFF. At this time, technology does not exist to measure juvenile Pacific lamprey passage.	No
15.	Develop juvenile Pacific lamprey passage criteria	No later than 10 years following license issuance (2018)	No	None. At this time, technology does not exist to measure juvenile Pacific lamprey passage.	No
16.	Participate in regional studies, forums and measures and cooperate with other entities performing those activities when useful information may be obtained about Project impacts on juvenile Pacific lamprey. Forums will include (but not limited to) the CRBLTWG.	Annually for the life of the license	Yes	Grant PUD currently participates in regional forums such as the Columbia River Basin Pacific Lamprey Technical Workgroup, the Lamprey Conservation Initiative (USFWS), and the Tribal Restoration Plan activities (CRITFC). Refer to Section 2.2 for specific activities.	No

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

ACOE = Army Corps of Engineers
BOR = Bureau of Reclamation
CRBLTWG = Columbia River Basin Lamprey Technical Work Group
CRITFC = Columbia River Inter-Tribal Fish Commission
FERC = Federal Energy Regulatory Commission
FPE = Fish Passage Efficiency
HDX-PIT = Half-duplex Passive Integrated Transponder
LPS = lamprey passage system
N/A = Not applicable
NOAA = National Oceanic and Atmospheric Administration
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

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

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

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

1). "Consistent with similar measures taken at other projects" is "Yes" for an activity that has been implemented by a hydroelectric facility operator in a hydroelectric project area other than Grant PUD's Priest Rapids Project.

2). "Appropriate to implement at the Priest Rapids Project" is "Yes" for an activity that is a requirement of Grant PUD's PLMP (Grant PUD 2009) or is an activity subsequently agreed to by Grant PUD as a result of implementation of the PLMP.

3). "Cost-effective to implement at the Priest Rapids Project" is "Yes" for an activity where resource benefits are commensurate with the level of effort and cost to implement, and in a manner not inconsistent with anadromous fish passage criteria and habitat requirements. If a measure is "appropriate to implement", then it is also considered cost effective and the specific action being taken by Grant PUD is described. If a measure is not "appropriate to implement," then cost effectiveness is considered not applicable.

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

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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 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	BOR projects in Yakima (I)	Yakima	#3	Yes.	No. This activity is not required by Grant PUD's PLMP. Radio-telemetry studies conducted in 2001-2002 did not show use of any tributaries in the PRPA (Nass et al. 2003).	N/A
		No associated hydro project (I)	Willamette	#16			
2.	Develop measures to protect spawning habitat	Wells (P)	Columbia	N/A[2]	No.	No. This activity is not required by Grant PUD's PLMP.	N/A
		Rocky Reach (P)	Columbia	N/A[3]			
3.	Monitor adult population status and trends (unrelated to counting at hydroelectric projects)	BOR projects in Yakima (I)	Yakima	#3	No.	No. This activity is not required by Grant PUD's PLMP.	N/A
		Willamette Falls (I)	Willamette	#4			
		No associated hydro project (I)	Fifteenmile Creek,	#1			
			Deschutes, and tributaries	#2			
			Hood	#8			
			Umatilla	#9			
			Lower Columbia Estuary	#24			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 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	The Dalles (I)	Columbia	#5	Yes.	Yes. PLMP Objective 4 requires quantification of lamprey habitat in the Project area.	Yes. Stratified sampling habitat surveys were implemented in 2012, 2013, and again in 2014 (under abnormally low reservoir elevations) to detect presence/absence of juvenile lamprey within the Project operational zone. Required to be conducted within the PRPA within 10 years of license issuance. This activity is complete.
		No associated hydro project (I)	Fifteenmile Creek	#1			
			Deschutes and tributaries	#2			
			Willamette	#17			
		Wells (P)	Columbia	N/A[2]			
5.	Develop measures to protect juvenile rearing habitat	No associated hydro project (I)	Fifteenmile Creek	#1	No.	No. This activity is not required by Grant PUD's PLMP.	N/A
			Columbia	#32			
		Wells (P)	Columbia	N/A[2]			
		Rocky Reach (P)	Columbia	N/A[3]			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
6.	Monitor juvenile population status and trends (unrelated to counting at hydroelectric projects)	Wells (P)	Columbia	#28	No.	Yes. PLMP Objective 4 requires the assessment of juvenile presence / absence and relative abundance.	Yes. Stratified sampling habitat surveys were implemented in 2012 to detect presence/absence and Project operational zone. Required to be conducted within the PRPA within 10 years of license issuance.
		Condit (I)	White Salmon	#7			
		No associated hydro project (I)	N/A	#25			
			Willamette	#6, 15			
			Deschutes and other tributaries	#2			
			Hood	#8			
			Umatilla	#11			
			Yakima, Entiat, Methow, and Klickitat	#12			
			Lower Columbia & tributaries (including Klickitat, White Salmon, Rock, Wind)	#13			
			Methow (Chewuch)	#14			
			Willamette	#15, 17			
			Wenatchee, Entiat, Chelan, Methow, and Okanogan	#27			
			Yakima	#34			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
7.	Evaluate lamprey physiology, energy use, swimming performance	No associated hydro project	N/A (I)	#26	No.	No. This activity is not required by the PLMP. Evaluating lamprey physiology, energy use, and swimming performance are not objectives, goals, or measures outlined in the PLMP.	N/A
			Columbia/ Snake	#29			
8.	Evaluate, implement and/or monitor translocation, supplementation, and artificial propagation programs	No associated hydro project (I)	Umatilla	#22	Yes.	No. This activity is not required by Grant PUD's PLMP. However, trap and transport is being evaluated by the PRFF as a potential implementation measure in fulfillment of an ongoing conceptual NNI agreement. Grant PUD successfully trapped and transported 2,269 adult Pacific lamprey above Rock Island Dam during 2014 as a result of fish passage activities in support of the Wanapum Dam fracture.	N/A
			Yakima	#23			
			Wenatchee	#23			
			Methow	#23			
			N/A	#19, 20			
			Columbia and Snake	#101			
			Columbia (Mid and Upper)	#102			
		Pelton Round Butte (I)	Deschutes	#10			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
9.	Develop and test new technologies / methodologies / protocols for lamprey	John Day(I)	Columbia	#5	No.	No. This activity is not required by the PLMP. Developing technologies for sampling juvenile lamprey in deep water are not objectives, goals, or measures outlined in the PLMP. However, Grant PUD will determine juvenile lamprey presence / absence, habitat use, and relative abundance in the Project area, in coordination with the PRFF no later than 10 years following license issuance.	N/A
		McNary (I)	Columbia	#5			
		No associated hydro project (I)	Willamette River	#6, 21			
			N/A	#18, 19			
10.	Determine genetic structure and maintain genetic integrity	No associated hydro project (I)	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
			Santiam	#36			
		Condit	White Salmon	#7			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
11.	Determine water quality impacts of hydropower projects on lamprey and implement actions to mitigate these impacts	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No.	No. This activity is not required by the PLMP. Grant PUD monitors and maintains water quality in compliance with freshwater designated uses and criteria for the Project as required by the Ecology 401 Certification; therefore, no further actions are required.	N/A
12.	Evaluate the need for a lamprey aquaculture facility based upon a limiting factor analysis	No associated hydro project	Columbia (Mid and Upper)	#102	No.	No. This activity is not required by the PLMP. However, lamprey aquaculture is being evaluated by the PRFF as a potential implementation measure in fulfillment of an ongoing conceptual NNI agreement.	N/A
13.	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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Lamprey Migration in Rivers						
14.	Evaluate adult migration in rivers and reservoirs	Bonneville (I)	Columbia	#30, 31, 35	Yes.	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD has committed to collect and evaluate data on the passage of adult lamprey through the Project reservoirs as part of a telemetry evaluation (Objective 2). Grant PUD conducted this activity as part of its 2001-2002 radio-telemetry studies on adult lamprey (Nass et al. 2003).	Yes. Monitoring of lamprey through the Project reservoirs was conducted using HDX-PIT tags in 2010 through 2015 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 2015, Grant PUD tagged 100 adult lamprey with both acoustic tags (Vemco V7) and FDX-PIT tags. These fish were released in either the Priest Rapids Forebay at Desert Aire (RM 400.4; n=30) or in the Wanapum Forebay at either RM 415.8, (n=35) or RM 419.9, (n=35). 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 trends in reservoir and upstream tributary passage.
		The Dalles (I)	Columbia	#30			
		John Day (I)	Columbia	#30, 35			
		McNary (I)	Columbia	#30			
		Ice Harbor (I)	Snake	#30			
		Lower Monumental (I)	Snake	#30, 35			
		Little Goose (I)	Snake	#30, 35			
		Lower Granite (I)	Snake	#30, 52			
		Priest Rapids and Wanapum (I)	Columbia	#30, 73			
		Rock Island (I)	Columbia	#30, 35			
		Rocky Reach (I)	Columbia	#30			
		McNary (I)	Columbia	#35			
		No associated hydro project	Snake	#38			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
15.	Assess impacts of irrigation water withdrawal structures on juvenile passage/habitat	No associated hydro project (I)	Yakima	#34	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
			Wenatchee	#34			
16.	Assessing juvenile lamprey outmigration	No associated hydro project (I)	Umatilla	#33	No.	No. This activity is not required by the PLMP. Assessing the impacts of irrigation water withdrawal are not objectives, goals, or measures outlined in the PLMP.	N/A
			Yakima, Wenatchee	#34			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Adult Passage at Hydroelectric Facilities						
	Structural and Operational Fishway Modifications						
17.	Inspect / inventory / document / assess structural improvements for fishway	Bonneville (I)	Columbia	#39	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 2015 migration period, the 2010 – 2015 cumulative passage dataset will be empirically and statistically evaluated. Results will be presented to the PRFF for review in spring 2016.
		McNary (I)	Columbia	#39			
		Lower Monumental(I)	Snake	#39			
		Lower Granite (I)	Snake	#39			
		Priest Rapids and Wanapum	Columbia	#40			
		Prosser, Sunnyside, Wapato, Horn Rapids dams (P)	Yakima	#43			
		Rocky Reach (I)	Columbia	#74			
		Wells (P)	Columbia	N/A[2]			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
18.	Conduct a literature review of upstream passage improvements	Wells (I)	Columbia	#107	Yes.	Yes. PLMP Objective 1 requires compilation of measures taken in the Columbia River basin and an assessment of their applicability to the Project.	Yes. This activity is documented in this PLMP Comprehensive Annual Report (see Section 2.2: Updated Information).
19.	Design / install / evaluate lamprey passage system (LPS) and entrance structures	Bonneville (I)	Columbia	#41, 63, 66, 67	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
		John Day (I)	Columbia	#67			
		McNary (I)	Columbia	#44			
		Westland diversions (I)	Umatilla	#42			
		Prosser, Sunnyside, Wapato, Horn Rapids dams (P)	Yakima	#43			
20.	Install / evaluate / operate slotted “keyhole” fishway entrances	Priest Rapids and Wanapum (I)	Columbia	#45	Yes.	Yes. Keyhole entrances are currently utilized at both Wanapum and Priest Rapids dams.	Yes. See adjacent response.
		John Day (P)	Columbia	N/A[5]			
		McNary (P)	Columbia	N/A[6]			
21.	Develop / implement / evaluate ladder dewatering procedures	No associated hydro project (I)	Yakima, Wenatchee	#34	Yes.	Yes. Dewatering procedures were identified as existing at the Project in the PLMP.	Yes. Grant PUD operates its fishways according to the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for dewatering and the recovery of all fish.
		All ACOE projects[7] (I)	Columbia / Snake	#46			
		Wells (I)	Columbia	#47			
		Rocky Reach (I)	Columbia	#48			
		Rock Island (I)	Columbia	#48			
		Priest Rapids and Wanapum (I)	Columbia	#49			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
22.	Rehabilitate and/or operate old or existing fishway for lamprey passage	Willamette Falls (I)	Willamette	#50	No.	Yes. Subsequent to fishway modifications completed in 2009-2010 outage at Priest Rapids and Wanapum dams, Grant PUD and the PRFF will continue to assess the applicability, feasibility, and appropriateness of other potential modifications.	Yes, as determined appropriate by Grant PUD and the PRFF.
23.	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., track rack cleaning system and grating support system)	John Day (I)	Columbia	#61	No.	No. These issues have not been identified in the Project fishways. Members of the PRFF toured the fish ladders at Priest Rapids and Wanapum dams and did not identify that these issues existed at either dam. However, Grant PUD replaced the fish count stations at both dams in 2010 with picket-lead gratings that is 11/16-inch gap to ensure accurate adult counts.	N/A
		Other ACOE projects (exact ones unspecified) (P)	Columbia / Snake	N/A[5]			
		Wells (P)	Columbia	N/A[2]			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
24.	Install/evaluate plates over diffuser along the bases of walls and weir	Bonneville (I)	Columbia	#61, 65	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 aluminum plating on diffuser grates at Priest Rapids during the 2009-2010 winter fish ladder maintenance outage. The effectiveness of the plating was evaluated through the use of underwater video as part of the 2010 assessment of Pacific lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams (Nass et al. 2009). This study showed that lamprey effectively used the plating to move through a weir orifice or past the counting station.
25.	Round sharp corners	Trail Bridge Dam (I)	McKenzie	#51	Yes.	No. Sharp corners have not been identified in the Project fishways. Members of the PRFF toured the fish ladders at Priest Rapids and Wanapum dams and did not identify that sharp corners were an issue at either dam.	N/A
		Ice Harbor (P)	Snake	N/A[6]			
26.	Design / install water supply or auxillary water supply systems	Trail Bridge Dam (I)	McKenzie	#52	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 or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
27.	Reduce/evaluate ladder entrance flow velocities at night	Bonneville (I)	Columbia	#52	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. 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).
		McNary (I)	Columbia	#53			
		Wells (I)	Columbia	#54			
		Priest Rapids (P)	Columbia	N/A[8]			
		Ice Harbor (P)	Snake	N/A[5]			
28.	Modify/evaluate weir head differentials	Bonneville (I)	Columbia	#65, 75	No.	No. Fishway operational procedures were identified as existing at the Project in the PLMP.	N/A. Grant PUD operates its fishways according to the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for weir head differentials.
29.	Manage flows to a peaking hydrograph	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No.	No. Grant PUD operates its facilities as part of a seven dam coordination schedule of flows. The proposed activity is not consistent with operations for power generation, flood control and recreational activities.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
30.	Establish protocol for formal inspection of passage facilities	Priest Rapids and Wanapum (I)	Columbia	#107	No.	Yes. PLMP Objective 2 requires inspection of passage facilities by PRFF members.	Yes. Inspection by the PRFF is coordinated with annual winter fish ladder maintenance outages.
31.	Establish protocol for annual lamprey passage reporting	Priest Rapids and Wanapum (I)	Columbia	#107	No.	Yes. PLMP Objective 1 requires an annual report summarizing all PLMP activities.	Yes. Lamprey activities at the Project are documented in this PLMP Comprehensive Annual Report.
32.	Develop and/or maintain fishway operations criteria	Bonneville (I)	Columbia	#55	Yes.	Yes. PLMP Objective 2 requires Grant PUD to maintain its fishways in a manner that is consistent with the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). In 2011, Grant PUD implemented a Standard Operating Procedure (SOP) for operation of the OLAFT vertical orifice gate to remain open when the OLAFT is not operating.	Yes. Specific operations criteria are presented in Grant PUD's Project Adult Fishways Operational Plan (Grant PUD 2008).
		The Dalles (I)	Columbia	#56			
		John Day (I)	Columbia	#57			
		McNary (I)	Columbia	#58			
		Ice Harbor (I)	Snake	#58			
		Lower Monumental (I)	Snake	#58			
		Little Goose (I)	Snake	#58			
		Lower Granite (I)	Snake	#58			
		Wells (I)	Columbia	#107			
		Rocky Reach (I)	Columbia	#107			
		Rock Island (I)	Columbia	#59			
		Priest Rapids and Wanapum (I)	Columbia	#60			
	Project Passage Effectiveness						
33.	Develop adult lamprey passage criteria	Rocky Reach (P)	Columbia	N/A[3]	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.
		Priest Rapids and Wanapum (P)	Columbia	N/A[4]			
		Bonneville and John Day	Columbia	#67			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
34.	Evaluate effectiveness of dam passage	Bonneville (I)	Columbia	#31, 72, 75	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 PRP 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, although the sample size is insufficient for statistical comparisons. Through 2015, Grant PUD has tracked a total of 407 unique PIT tags at Priest Rapids and 374 at Wanapum since 2010. Estimated FPE for 2010-2014 for Priest Rapids Dam is 74% and estimated FPE for 2010-2013 Wanapum Dam is 73%. Median passage times at Priest Rapids Dam are 70 h at the left bank and 5 h at the right bank. Median passage times at Wanapum Dam are 23 h at the left bank and 21 h at the right bank.
		Rocky Reach (I)	Columbia	#37			
		John Day (I)	Columbia	#72			
		McNary (I)	Columbia	#68			
		Ice Harbor (I)	Snake	#82			
		Lower Monumental (I)	Snake	#82			
		Little Goose (I)	Snake	#82			
		Lower Granite (I)	Snake	#82			
		Priest Rapids (I)	Columbia	#69, #73			
		Wanapum (I)	Columbia	#69, #73			
		Threemile Falls Dam, Maxwell and Feed diversions (I)	Umatilla	#70			
		Clackamas	Clackamas	#71			
		Prosser	Yakima	#76			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
35.	Evaluate upstream passage modifications	Priest Rapids and Wanapum(I) [Note: evaluations performed on existing structural / operational improvements at ACOE dams are identified earlier in this table, under the heading, Structual and Operational Fishway Modifications.]	Columbia	#69	No.	Yes. PLMP Objective 2 requires a comprehensive passage evaluation of modifications to fishways as required per the 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 PRP 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. Estimated FPE for 2010-2014 for Priest Rapids Dam is 74% and estimated FPE for 2010-2013 Wanapum Dam is 73%. Median passage times at Priest Rapids Dam are 70 h at the left bank and 5 h at the right bank. Median passage times at Wanapum Dam are 23 h at the left bank and 21 h at the right bank.
		Rocky Reach (P)	Columbia	#37			
		Bonneville	Columbia	#75			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Lamprey Counts at Dams						
36.	Develop feasibility, techniques, and protocols to improve 24-hour counting / conduct counts	McNary (I)	Columbia	#77	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.
		Lower Granite (I)	Snake	#77			
		Bonneville (I)	Columbia	#63			
		Wells (I)	Columbia	#78			
		Rocky Reach (I)	Columbia	#79			
		Rock Island (I)	Columbia	#79			
		Prosser and Roza	Yakima	#81			
37.	Develop/evaluate passage alternatives related to count facilities	Bonneville (I)	Columbia	#72	Yes.	Yes. PLMP Objective 2 requires maintenance and feasible improvements to adult fish counting systems.	Yes. Grant PUD installed newly designed, lamprey-specific fish crowder structures for all count stations at Priest Rapids and Wanapum dams during the 2009-2010 winter fish ladder maintenance outage. Based on design criteria for the new video fish count crowders (picketed lead gap of 11/16 inches). Grant PUD expects fish count accuracy to be at or near 100% for adult lamprey and other fishes passing through all count stations.
		John Day	Columbia	#72			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Predation						
38.	Establish predation control measures (sea lions)	Bonneville (I)	Columbia	#83	Yes.	No. Sea lions are not present in the PRPA.	N/A
	Juvenile Passage at Hydroelectric Facilities						
	Structural and Operational Fishway Modifications						
39.	Conduct a literature review of juvenile Pacific lamprey passage and survival	Priest Rapids and Wanapum (I)	Columbia	N/A	No.	Yes. PLMP Objective 1 requires compilation of measures taken in the Columbia River basin and an assessment of their applicability to the Project.	Yes. This activity is documented in this PLMP Comprehensive Annual Report.
		Wells (P)	Columbia	N/A[2]			
40.	Replace turbine intake screens with smaller spacing	All ACOE projects (P)	Columbia / Snake	N/A[6]	No.	No. Grant PUD dams are not equipped with turbine intake or diversion screens.	N/A
41.	Lift/remove extended length screens during outmigration	McNary (I)	Columbia	#84	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
42.	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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
43.	JBS modifications	McNary (I)	Columbia	#84, 85, 86	Yes.	No. Grant PUD has existing bypass systems, which includes gatewells, spillways, the WFUFB, and Priest Rapids Top-Spill Bypass. The WFUFB and experimental Priest Rapids Top-Spill Bypass are operated to achieve safe passage of out-migrating salmonids. It would be expected that juvenile lamprey would also benefit as a result of these operations.	N/A
		Lower Monumental (I)	Snake	#86			
44.	Establish/continue salvage activities during ladder maintenance de-watering	All ACOE projects (I)	Columbia / Snake	#87	Yes.	Yes. Dewatering procedures were identified as existing at the Project in the PLMP.	Yes. Grant PUD operates its fishways according to the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for dewatering and the recovery of all fish during all maintenance activities.
		Wells (I)	Columbia	#88			
		Rocky Reach (I)	Columbia	#89			
		Rock Island (I)	Columbia	#89, 91			
		Priest Rapids and Wanapum (I)	Columbia	#90			
45.	Develop and/or maintain bypass operations criteria	Wells (I)	Columbia	#88	Yes.	Yes. Grant PUD has existing bypass systems, which includes gatewells, spillways, the WFUFB, and Priest Rapids Top-Spill Bypass.	Yes. The WFUFB and experimental Priest Rapids Top-Spill Bypass are operated to achieve safe passage of out-migrating salmonids. It would be expected that juvenile lamprey would also benefit as a result of these structural modifications and spill operations.
		Rocky Reach (I)	Columbia	#89			
		Rock Island (I)	Columbia	#89, 91			
		Priest Rapids and Wanapum (I)	Columbia	#90, 92			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Project Passage Effectiveness						
46.	Evaluate tagging and development of miniature tags	No associated hydro project (I)	N/A	N/A	No.	No. This activity is not required by the PLMP. Evaluation and development of tags are not objectives, goals, or measures outlined in the PLMP.	N/A
47.	Develop juvenile lamprey passage criteria	Priest Rapids and Wanapum (P)	Columbia	N/A[4]	No.	Yes. PLMP Objective 3 requires the development of juvenile lamprey passage criteria.	Yes. Grant PUD and the PRFF will include consideration of success achieved at other Columbia River basin projects and site specific conditions when the technology exists to measure juvenile lamprey passage.
48.	Evaluate downstream passage and survival when technology available	Wells (P)	Columbia	N/A[2]	No.	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD has committed to providing safe, effective and timely passage which could be evaluated when adequate technology exists.	Yes.
		Rocky Reach (P)	Columbia	N/A[3]			
		Priest Rapids and Wanapum (P)	Columbia	N/A[4]			
		No associated hydro project (I)	N/A	#99			
49.	Laboratory passage evaluation	No associated hydro project (I)	N/A	N/A	No.	No. This activity is not required by the PLMP. Lab passage evaluations are not objectives, goals, or measures outlined in the PLMP.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
50.	Monitor passage timing, number, and mortalities of juvenile lamprey collected at projects with juvenile fish bypass facilities	Bonneville (I)	Columbia	#93, 94	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
		John Day (I)	Columbia	#94			
		McNary (I)	Columbia	#93, 94			
		Rock Island (I)	Columbia	#94			
		Lower Monumental (I)	Snake	#93, 94			
		Little Goose (I)	Snake	#93, 94			
		Lower Granite (I)	Snake	#93, 94, 89			
51.	Monitor and report on juvenile impingement	Rocky Reach (I)	Columbia	#107	Yes.	No. Priest Rapids and Wanapum dams are not equipped with turbine intake or diversion screens.	N/A
	Predation						
52.	Continue predation control measures (Northern pikeminnow and birds)	<u>Pikeminnow only</u> All ACOE projects (I)	Columbia / Snake	#97	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.
		<u>Pikeminnow and birds</u> Rocky Reach (I)	Columbia	#98			
		<u>Pikeminnow and birds</u> Rock Island (I)	Columbia	#98			
		<u>Pikeminnow and birds</u> Priest Rapids and Wanapum (I)	Columbia	#99			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Policy and Recovery Activities						
53.	Develop/implement Pacific Lamprey Management Plans	All ACOE projects (I)	Columbia / Snake	#100, , 103, 107, 108	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.
		Wells (I)	Columbia	#104			
		Rocky Reach (I)	Columbia	#105			
		Priest Rapids and Wanapum (I)	Columbia	#106			
		No associated hydro project (I)	Willamette	#109			
54.	Establish regional data protocols for collection, storage and analysis; develop means to widely access and share information	All ACOE projects (I)	Columbia / Snake	#100, 103, 104, 107, 108	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 CRBLTWG the USFWS Lamprey Conservation Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.
		Wells (I)	Columbia	#104			
		Rocky Reach (I)	Columbia	#105			
		Priest Rapids and Wanapum (I)	Columbia	#106			
55.	Establish coordinated public education and other outreach programs	Priest Rapids and Wanapum (I)	Columbia	#106	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.
56.	Participate in regional lamprey activities	All ACOE projects (I)	Columbia / Snake	#100, 103, 107, 108	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 CRBLTWG the USFWS Lamprey Conservation Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.
		Wells (I)	Columbia	#104			
		Rocky Reach (I)	Columbia	#105			
		Priest Rapids and Wanapum (I)	Columbia	#106			
		No associated hydro project (I)	Willamette	#109			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
57.	Environmental analysis and feasibility investigations	All ACOE projects (I)	Columbia / Snake	#107, 108	No.	No. This activity is not required by the PLMP. Environmental analysis and feasibility investigations related to public transportation and lamprey propagation are not objectives, goals, or measures outlined in the PLMP.	N/A

Notes:

1. Defined as a measure identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River (Nez Perce, Umatilla, Yakama, and Warm Springs Tribes 2009), that has not already been implemented or planned by the ACOE or mid-Columbia PUDs.
2. Per requirement in Wells Project PLMP (Douglas PUD 2009).
3 Per requirement in Rocky Reach PLMP (Chelan PUD 2005).
4 Per requirement in Priest Rapids PLMP (Grant PUD 2009), wee Table 5 for status.
5 Per commitment in ACOE's 10 year implementation plan (ACOE 2009).
6 Per personal communications with David Clugston, ACOE (11/9/09, 11/10/09, and 12/11/09).
7 "All ACOE projects" including Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite.
8 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 PRFF0 as returning numbers were sufficient.

ACOE = Army Corps of Engineers
BOR = Bureau of Reclamation
CRBLTWG = Columbia River Basin Lamprey Technical Work Group
CRITFC = Columbia River Inter-Tribal Fish Commission
FERC = Federal Energy Regulatory Commission
FPE = Fish Passage Efficiency
HDX-PIT = Half-duplex Passive Integrated Transponder
LPS = lamprey passage system
N/A = Not applicable
NOAA = National Oceanic and Atmospheric Administration
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 sixth year of PLMP implementation, several planned activities were conducted on schedule. Grant PUD continued to conduct components of a PRFF-approved study plan titled, "Assessment of Pacific Lamprey Behavior and Passage Efficiency at Priest Rapids and Wanapum Dams" (Nass et al. 2009). The study was conducted to evaluate the effectiveness of structural modifications to Priest Rapids Project fishways that are intended to facilitate lamprey passage.

The study plan objectives were to:

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

In 2015, Grant PUD, in consultation with the PRFF, continued to passively monitor Pacific lamprey tagged at downstream facilities and added valuable information to the cumulative Project data set. The intent of the PIT data collection program is to provide sufficient sample size over time to calculate relevant passage metrics. Analysis of the data available from 2010 – 2015 was completed as part of 2015 reporting activities. During this time period, data available indicates that fishway passage efficiency for lamprey at Priest Rapids Dam during the 2010-2014 period was 74% and at Wanapum Dam during the 2010-2013 period was73%. Note that 2014 data for Wanapum Dam was intentionally omitted due to anomalous conditions associated with the Wanapum fracture. 2015 passage efficiencies were not available at the time of reporting and l be included in the 2016 annual report. Interpretation of fishway passage efficiency should include consideration of fish that overwintered during migration (fish tagged in the previous study year). Such fish made up 6.1% of detected tags during the 2010-2015 period. These detections indicate the complexity of adult lamprey migration behavior. 010 through 2015 showed a continuing trend of increased median travel time for adult lamprey ascending the upper fishway on Priest Rapids left bank compared to the other fishways at Priest Rapids and Wanapum dams (median passage time of 43.2 hours for the Priest Rapids left bank upper fishway versus 3.5 hours for the other upper fishways at Priest Rapids and Wanapum dams). The only feature in the Priest Rapids left bank upper fishway that is unique compared with the other fishways is the OLAFT.

In 2015, two new HDX-PIT stations installed during the 2014-2015 fishway maintenance period in the vicinity of the OLAFT were used increase detection resolution in the Priest Rapids left bank upper fishway. A small sample (n=6) of run-of-river HDX-PIT tagged fish had a median passage time of 36.0 hours through the Priest Rapids left bank upper fishway, which is an improvement over the median passage time of 76.6 hours for all tagged fish monitored in 2010-2014. However,133 fish captured from the Priest Rapids Dam lower fishways, tagged with HDX-PIT tags, and released into the lower left bank fishway in July and August 2015 had a median passage time of 6.0 hours through the upper left bank fishway. As such, it appears that the slower passage times at the Priest Rapids left bank upper fishway observed in previous years is not a consistent phenomenon.

Initial results of the voluntary study initiated by Grant PUD in 2015 to assess passage of adult lamprey through the PRP reservoirs suggests the large majority of tagged lamprey (75 of 100) reached the upstream Project boundary at the tailrace of Rock Island Dam by October 2015. One hundred adult lamprey captured with mechanical traps from the Priest Rapids Dam lower fishways during the peak migration period in July and August were implanted with both acoustic tags (Vemco V7) and FDX-PIT tags. These fish were released in either the Priest Rapids Forebay at Desert Aire (RM 400.4; n=30) or in the Wanapum Forebay at either RM 415.8 (n=35) or at RM 419.9 (n=35). An array of fixed acoustic receivers deployed throughout the Project area was used to monitor the tagged fish after release. Additionally, mobile tracking was employed to locate tagged individuals in the study area during the remainder of the migration period. The median travel time to reach Rock Island Tailrace was 3.6 days for fish released in the Wanapum Reservoir and 5.5 days for fish released in the Priest Rapids Reservoir. Travel rates to reach the Rock Island Tailrace ranged from 1.9-28.2 km/d for fish released in the Wanapum Reservoir and from 1.9-12.7 km/d for fish released in the Priest Rapids Reservoir. Eight fish had not been detected after release and were assumed to have either been mortalities or have failed acoustic tags. Complete results will be summarized in the 2016 annual report.

In 2015, Grant PUD also continued its regional approach to monitoring lamprey by coordinating among utilities, participating in forums, and the sharing of PIT data with other researchers.

In 2016, 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 2015-2016 winter fish ladder maintenance outage.
2. Pre-season testing and calibration of HDX-PIT arrays, and maintenance of arrays during the migration season. Continue to operate HDX-PIT arrays to assess passage metrics (passage efficiency, etc.) and coordinate detection of tagged fish with regional monitoring efforts to evaluate Pacific lamprey passage; both downstream and upstream of the Priest Rapids Project.
3. Tracking lamprey enumeration statistics for the Priest Rapids Project and lower Columbia River dams.
4. Summarizing results from field surveys completed in 2012 through 2014 to assess the distribution and relative abundance of juvenile lamprey in the operational zone of the PRPA.
5. A second year of evaluation to assess passage in the Priest Rapids Dam left bank fishway and OLAFT using HDX-PIT tags.
6. A second year of evaluation to assess migration characteristics through the Priest Rapids Project area using acoustic and FDX-PIT tags.

Given three years of sampling at varying reservoir elevations (2012-2014) have indicated that juvenile lamprey do not commonly occur within the Project operational zone, no additional assessments were conducted in 2015 or are currently planned in the future.

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
A Monitoring Study to Assess Passage of adult Pacific Lamprey in the Priest Rapids Dam Left Bank Fishway and past the Off Ladder Adult Fish Trap (OLAFT)

A Monitoring Study to Assess Passage of adult Pacific Lamprey in the Priest Rapids Dam Left bank Fishway and past the Off Ladder Fish Trap (OLAFT), 2015

SUBMITTED TO:
Public Utility District No. 2 of Grant County. Washington
30 C Street South West
Ephrata, WA 98823

SUBMITTED BY:
Rod O'Connor, Blue Leaf Environmental
2301 West Dolarway Road, Suite 3
Ellensburg, Washington, 98926

PRINCIPAL PROPONENTS:
Mark Timko, Blue Leaf Environmental
Bao Le, HDR, Inc.

HDR

BLUE LEAF ENVIRONMENTAL

June 18, 2015

Executive Summary

Federal Energy Regulatory Commission (FERC) operating license for the Priest Rapids Hydroelectric Project (Project) (FERC 2008). As required by FERC License Article 401(a)(12) and Clean Water Act 401 Water Quality Certification Section 6.2 (5)(b), Grant PUD, in consultation with the Priest Rapids Fish Forum (PRFF), developed and submitted to FERC for approval a Pacific Lamprey Management Plan (PLMP) on February 19, 2009. On May 1, 2009, FERC issued an order modifying and approving the PLMP.

The goals and objectives of the PLMP are to be achieved through a series of Protection, Mitigation, and Enhancement (PME) measures. Grant PUD proposes to implement a monitoring study to augment existing efforts to monitor adult Pacific lamprey passage at Priest Rapids and Wanapum dams, in support of the following PME measure as identified in the PLMP:

PME 4.2.1-Maintain Adult Fishways: Grant PUD will continue to maintain adult fishways to support adult Pacific lamprey passage. These fishways shall be maintained in a manner not inconsistent with anadromous fish passage criteria described in the annual Fishway Operations Plan and those criteria specified in the Anadromous Salmonid Passage Facility Guidelines and Criteria Plan (NOAA Fisheries) including future updates.

Half-duplex passive integrated transponder tag (HDX-PIT) arrays have been used to monitor tagged adult Pacific lamprey at Priest Rapids and Wanapum dams since 2009. Lamprey passage data from 2010 through 2013 showed a trend of increased median travel time for adult lamprey ascending the upper fishway on Priest Rapids left bank compared to the other fishways at Priest Rapids and Wanapum dams (median passage time of 32.3 hours for the Priest Rapids left bank upper fishway versus 3.5 hours for the other upper fishway sections at Priest Rapids and Wanapum dams). The only physical feature in the Priest Rapids left bank upper fishway that is unique compared with the other fishways is the off-ladder fish trap (OLAFT). In order to investigate the possibility that the OLAFT in the Priest Rapids left bank fishway was associated with increased median passage time, two new HDX-PIT stations were installed, with Priest Rapids Fish Forum (PRFF) approval, in the vicinity of the OLAFT during the 2014-2015 fishway maintenance period. The new stations (2) were installed downstream and upstream of the OLAFT to provide insight into lamprey behavior in the Priest Rapids left bank upper fishway and increase the detection resolution in the vicinity of the trap.

Up to 125 adult Pacific lamprey collected from Priest Rapids Dam fishways during the 2015 peak migration period will be implanted with HDX-PIT tags and released into the left bank lower fishway at Priest Rapids Dam. The existing arrays of HDX-PIT antennas will be used to monitor the passage behavior of tagged individuals and determine whether previously observed increases in median passage time continue to occur in the vicinity of the off-ladder fish trap (OLAFT) in the left bank upper fishway at Priest Rapids Dam. Downstream movements and fallback will be reported.

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List of Figures

1.0 Introduction

On April 17, 2008, Public Utility District No. 2 of Grant County (Grant PUD) received a new Federal Energy Regulatory Commission (FERC) operating license for the Priest Rapids Hydroelectric Project (Project) (FERC 2008). As required by FERC License Article 401(a)(12) and Clean Water Act 401 Water Quality Certification Section 6.2 (5)(b), Grant PUD, in consultation with the Priest Rapids Fish Forum (PRFF), developed and submitted to FERC for approval a Pacific Lamprey Management Plan (PLMP) on February 19, 2009. On May 1, 2009, FERC issued an "order modifying and approving" the PLMP.

The goals and objectives of the PLMP are to be achieved through a series of Protection, Mitigation, and Enhancement (PME) measures. Grant PUD proposes to implement a monitoring study to augment existing efforts to monitor adult Pacific lamprey passage at Priest Rapids and Wanapum dams, in support of the following PME measure as identified in the PLMP:

PME 4.2.1-Maintain Adult Fishways: Grant PUD will continue to maintain adult fishways to support adult Pacific lamprey passage. These fishways shall be maintained in a manner not inconsistent with anadromous fish passage criteria described in the annual Fishway Operations Plan and those criteria specified in the Anadromous Salmonid Passage Facility Guidelines and Criteria Plan (NOAA Fisheries) including future updates.

1.1 Adult Lamprey Passage

Pacific Lamprey (*Entosphenus tridentatus*) numbers have generally declined since the 1940's as a result of spawning habitat loss, impediments to migration, changing ocean conditions, and decreased water quality (Close et al. 1995, 2002). Much focus over the past 10 years has been placed on studying migrating adults. Modifications have been made to many dam operations and structures to improve lamprey passage.

At Priest Rapids and Wanapum dams, several modifications have been implemented to improve adult lamprey passage. 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 and improved 24- hour video fish counting stations to collect reliable and accurate count data. The slotted entrances were installed prior to the 2001 and have provided effective fishway entrance efficiency. 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 passing adult lamprey. Design enhancements (plating and ramps at Priest Rapids Dam) installed during the 2009-2010 winter fish ladder maintenance outage, were intended to improve volitional passage efficiency.

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

counting chute. Of 123 events, 79% of lamprey were successfully guided by the structure to the chute and 40% of these used the plated ramp to stage below the chute.

The half-duplex passive integrated transponder (HDX-PIT) antenna stations in the fishways at Priest Rapids and Wanapum dams used for monitoring upstream passage of adult lamprey were installed in 2009. For the 2010 through 2014 migrations, Grant PUD monitored a total of 380 and 258 HDX-PIT tagged lamprey at Priest Rapids and Wanapum dams, respectively (Le et al. 2015). Lamprey passage data from 2010 through 2013 showed a trend of increased median travel time for adult lamprey ascending the upper fishway on Priest Rapids left bank compared to the other fishways at Priest Rapids and Wanapum dams (median passage time of 32.3 hours for the Priest Rapids left bank upper fishway versus 3.5 hours for the other upper fishway sections at Priest Rapids and Wanapum dams). The only physical feature in the Priest Rapids left bank upper fishway that is unique compared with the other fishways is the off-ladder fish trap (OLAFT). Another potential factor may be the presence of adult white sturgeon (*Acipenser transmontanus*), which are predators of adult Pacific lamprey and have been observed in the Priest Rapids left bank upper fishway in the vicinity of the OLAFT during the adult lamprey migration period (M. Clement, pers. comm.). The presence of adult sturgeon may deter lamprey from ascending the fishway.

In order to investigate the possibility that the OLAFT in the Priest Rapids left bank fishway was associated with increased median passage time, two new HDX-PIT stations were installed, with Priest Rapids Fish Forum (PRFF) approval, in the vicinity of the OLAFT during the 2014-2015 fishway maintenance period. The new stations (2) were installed downstream and upstream of the OLAFT to provide insight into lamprey behavior in the Priest Rapids left bank upper fishway and increase the detection resolution in the vicinity of the trap.

During the 2015 Pacific lamprey migration season, the US Army Corps of Engineers will not be supporting HDX-PIT tagging efforts at locations downstream of the Project, as was common in previous years. Though other groups may release some HDX-PIT tagged lamprey, it is not expected that the level of effort will be commensurate with past years (approximately 2% of the run). In order to determine whether increased median passage time continues to occur in the left bank upper fishway at Priest Rapids Dam, 125 adult Pacific lamprey will be implanted with HDX-PIT tags during the peak migration period in 2015. Tagged fish will be released immediately upstream of the fish count station in the Priest Rapids left bank lower fishway and monitored as part of Grant PUD's ongoing Pacific lamprey monitoring program.

1.2 Study Area

The study area is defined by the adult fishways at Priest Rapids Dam. Detection stations for HDX-PIT tags allow monitoring of passage behavior in each fishway (left bank n=6; right bank n=4). Of particular interest in this study is the left bank upper fishway at Priest Rapids Dam where the OLAFT may increase passage time for tagged adult Pacific lamprey. Because individual HDX-PIT tagged Pacific lamprey are commonly detected in both left and right bank fishways prior to passing Priest Rapids Dam, all HDX-PIT detections stations will be monitored during the study period.

2.0 Adult Pacific Lamprey Collection, Tagging, Release, and Monitoring Schedule

2.1 Tag and Monitoring Equipment

This study will employ HDX-PIT tags (32mm HDX+ PIT tags; length 32 mm, diameter 3.65 mm, weight 0.8 g in air) and antenna arrays deployed at strategic locations within the Priest Rapids left bank fishway to determine whether increased median passage times through the upper fishway continue to occur during the 2015 Pacific lamprey migration season. Existing antenna arrays (installed in 2009) were augmented by installation of two additional stations in the vicinity of the OLAFT during the 2014-2015 maintenance period (see section 2.5 below).

2.2 Collection

All lamprey will be collected using existing mechanical fish traps located in the lower fishways at Priest Rapids Dam. The traps will be operated and maintained by Grant PUD Fisheries staff. Protocols for fish handling are described in Grant PUD (2014).

All trapped fish will be scanned for existing HDX and FDX PIT tags. Previously tagged fish will be released upstream of Priest Rapids Dam. Up to 50 unmarked fish per day will be transported to holding facilities at Priest Rapids Dam left bank.

Up to 125 lamprey will be tagged and released for this study. The collection schedule will be complementary to trap and transport efforts planned to occur during the peak of the lamprey migration in summer 2015, beginning in August.

2.3 Tagging and Recovery

All lamprey will be tagged by Blue Leaf Environmental (BLE) staff with a HDX-PIT tag using methods described below.

All surgical tools and tags will be disinfected in a Nolvasan (Chlorhexidine diacetate) solution for ten minutes and then held in trays filled with distilled water. Surgical tools will be disinfected and rinsed between each fish.

One lamprey at a time will be transferred from a holding tank by hand, using water soaked cotton gloves, to a heavy anesthetic bin. It will remain in the bin until the fish loses equilibrium and swimming motion ceases (approximately 5 minutes). Start and end time (i.e., surgery start time) will be recorded.

Once the lamprey is fully anesthetized, length and girth to the nearest mm, and weight in grams, will be measured and recorded.

The lamprey will then be transferred to a surgical trough, inspected for general health and condition, and positioned ventral side up so the gills are submerged in a light anesthetic bath.

A < 10 mm incision will be made approximately 1 cm above the ventral midline, in the softer, thinner part of the abdomen between the ventral midline and the muscular “rib cage”. The midpoint of the incision will be in line with the anterior insertion of the first dorsal fin.

The HDX-PIT tag will be inserted into the body cavity through the incision. The skin above the tag will be rubbed with a finger to ensure it lies flat and will not come back out the incision, then one suture will be placed at the midpoint of the incision using 5-0 coated VICRYL (absorbable) suture with a taper point needle. Surgery end time will be recorded.

The lamprey will then be transferred to a recovery tank and monitored until it regains equilibrium (5-10 minutes).

Lamprey will be held in transport/holding tanks on flow-through water until fully recovered before release.

2.4 Releases

After recovery, fish will be transported in aerated coolers filled with river water and released immediately upstream of the adult fish count station in the Priest Rapids left lower fishway.

2.5 Monitoring

Tagged fish will be monitored by an array of HDX-PIT detection stations deployed throughout the left and right bank fishways at Priest Rapids Dams (Figure 1).

All antenna stations will be downloaded at regular intervals, typically every two weeks during the Pacific lamprey migration period.

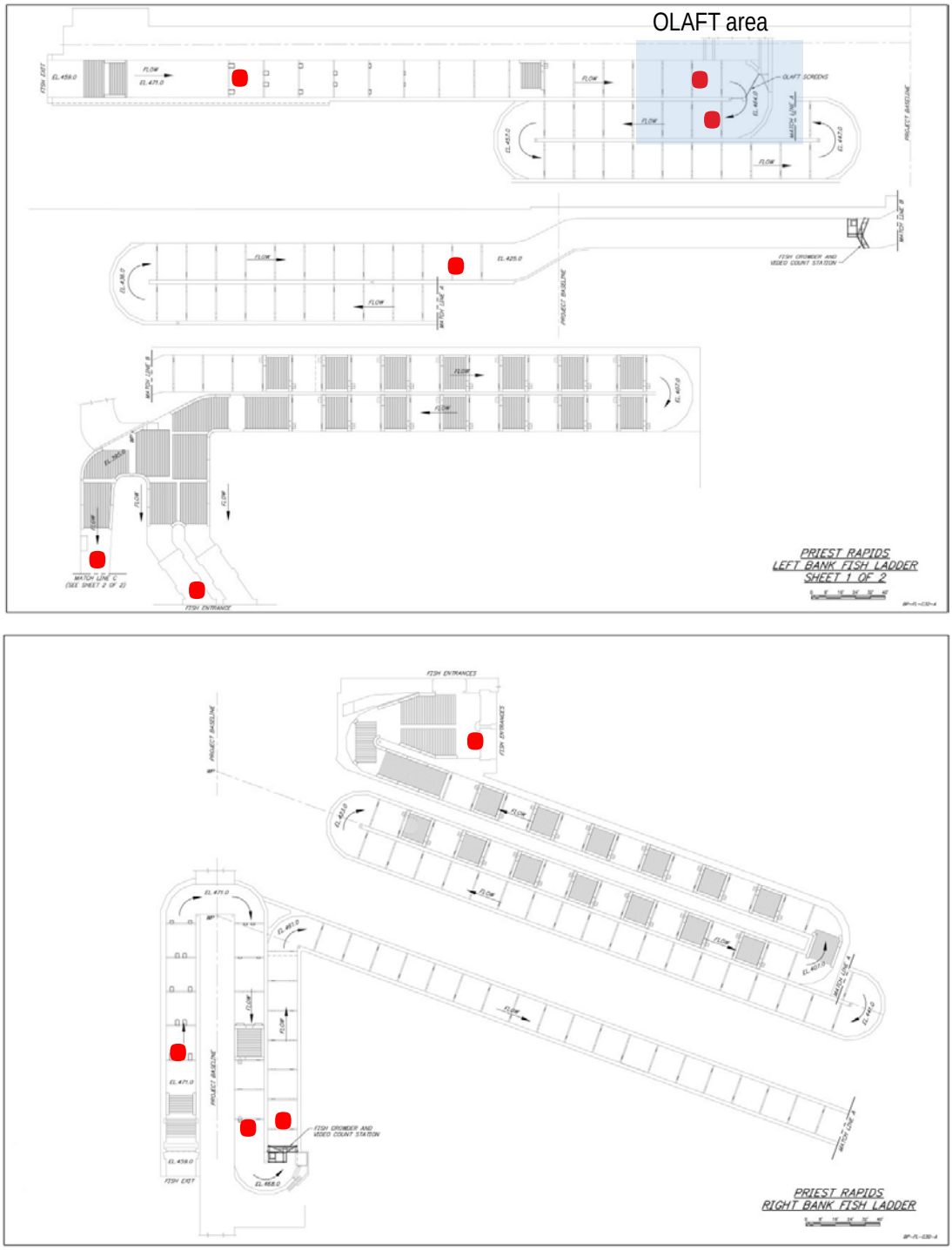

Figure 1 **Locations of half-duplex (HDX-PIT) detection antenna arrays in Priest Rapids Dam left and right fishways. The shaded area in upper figure (left bank) indicates the off-ladder fish trap (OLAFT) where two HDX-PIT detection stations were installed during the 2014-2015 fishway maintenance period.**

3.0 Analysis

Detection records from all HDX-PIT detection stations at Priest Rapids Dam will be compiled in a relational database maintained by BLE staff.

A detection history will be generated for each tag.

Detection records will be used to determine fishway passage characteristics of tagged lamprey.

The key metric will be median passage time from release to the exit in the Priest Rapids left bank fishway, with emphasis placed on quantifying any increased median passage time observed in the OLAFT area, compared to other upper fishway sections.

Median passage time from release to the detection station below the OLAFT will be compared with median passage time from the station below the OLAFT to the fishway exit. Differences in passage time through these two sections will provide information on the location of ongoing increased passage time.

Downstream movements within a fishway and fallback (fish that are detected at a fishway exit then detected at a fishway entrance of the same dam) will be reported.

Summary statistics on fishway passage will be reported in a format that will allow comparisons with previous year's data.

Environmental covariates such as river flow and temperature as well as OLAFT operations will be considered, as appropriate, when analyzing detection records.

Unexpected results will be identified as quickly as possible and discussed with Grant PUD staff. If necessary, an adaptive approach will be adopted to address additional analyses.

Detections of study fish on receivers in other Grant PUD dam fishways (Priest Rapids right bank, Wanapum left and right bank) will be evaluated to assess passage at those locations, should they be detected. Detections outside of the Priest Rapids left upper fishway will be supplemental data, not related to this study, and will add to Grant PUD's ongoing multi-year passage monitoring program.

Detections of study fish at HDX-PIT systems located upstream of the Project (i.e. systems in the Rock Island and Rocky Reach dam fishways, installed and maintained under direction of Chelan PUD) will be evaluated if they become available and used, in part, to determine conversion rates between Grant PUD and Chelan PUD dams.

4.0 Reporting

BLE staff will provide bimonthly progress updates during monitoring activities. The first bimonthly update will be delivered approximately 2 weeks after onset of collection and tagging activities beginning in August 2015. The delivery schedule of progress updates may be modified per request from Grant PUD.

Progress updates will include details regarding collection, tagging, monitoring, preliminary results, and any accounts of problems encountered during the study, as appropriate.

Complete results from this study will be included in Grant PUD's 2016 PLMP Comprehensive Annual Report.

An oral presentation will be provided to Grant PUD's license implementation committee (i.e. Priest Rapids Fish Forum) in spring of 2016.

References

Close, D. A., M. S. Fitzpatrick and H. W. Li. 2002. The ecological and cultural importance of a species at risk of extinction, Pacific lamprey. Fisheries. 27: 19-25.

Close, D.A., M.S. Fitzpatrick, H.W. Li., B.L. Parker, D.R. Hatch and G.A. James. 1995. Status report of the Pacific Lamprey (Lampetra tridentata) in the Columbia River Basin. Bonneville Power Administration, Portland, Oregon.

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Le, B., S. Twitchell, R. O'Connor, and M. Clement. 2015. 2014 Pacific Lamprey Management Plan comprehensive annual report. Prepared for Public Utility No. 2 of Grant County, Ephrata, WA.

Appendix B
A Monitoring Study to Quantify Migration Characteristics of adult Pacific Lamprey in the Priest Rapids Project Area

A Monitoring Study to Quantify Migration Characteristics of adult Pacific Lamprey in the Priest Rapids Project Area

SUBMITTED TO:
Public Utility District No. 2 of Grant County. Washington
30 C Street South West
Ephrata, WA 98823

SUBMITTED BY:
Rod O'Connor, Blue Leaf Environmental
2301 West Dolarway Road, Suite 3
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PRINCIPAL PROPONENTS:
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HDR

BLUE LEAF ENVIRONMENTAL

June 12, 2015

Executive Summary

On April 17, 2008, Public Utility District No. 2 of Grant County (Grant PUD) received a new Federal Energy Regulatory Commission (FERC) operating license for the Priest Rapids Hydroelectric Project (Project) (FERC 2008). As required by FERC License Article 401(a)(12) and Clean Water Act 401 Water Quality Certification Section 6.2 (5)(b), Grant PUD , in consultation with the Priest Rapids Fish Forum (PRFF), developed and submitted to FERC for approval a Pacific Lamprey Management Plan (PLMP) on February 19, 2009. On May 1, 2009, FERC issued an "order modifying and approving" the PLMP.

The goals and objectives of the PLMP are to be achieved through a series of Protection, Mitigation, and Enhancement (PME) measures. In support of these PME's, this document proposes to implement a voluntary monitoring study to better inform decisions regarding future required evaluations.

The objectives of this study are to estimate the proportion of tagged lamprey that:

1). Migrate upstream to the tailrace of Rock Island Dam.
2). Overwinter in the study area and resume migration in spring 2016.
3). Experience pre-spawn or predation mortality in the study area.
4). May engage in undetected spawning in reservoir tributaries
5). May engage in spawning in the tailrace of Wanapum and/or Rock Island dams.

One hundred adult Pacific lamprey collected from Priest Rapids Dam fishways during the 2015 peak migration period will be implanted with acoustic tags and released either above Priest Rapids (n=30) or Wanapum dams (n=70). Acoustic receivers deployed at fixed locations throughout the Project area will be used to monitor the migration behavior of tagged individuals in the study area. In the event that not all individuals are detected at fixed location receivers, mobile tracking will be employed to locate individuals within the project area. Fixed location receivers will be downloaded at regular intervals to collect detection records. A detection history will be created for each tagged lamprey and used to calculate metrics related to the study objectives.

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1.0 Introduction

On April 17, 2008, Public Utility District No. 2 of Grant County (Grant PUD) received a new Federal Energy Regulatory Commission (FERC) operating license for the Priest Rapids Hydroelectric Project (Project) (FERC 2008). As required by FERC License Article 401(a)(12) and Clean Water Act 401 Water Quality Certification Section 6.2 (5)(b), Grant PUD , in consultation with the Priest Rapids Fish Forum (PRFF), developed and submitted to FERC for approval a Pacific Lamprey Management Plan (PLMP) on February 19, 2009. On May 1, 2009, FERC issued an "order modifying and approving" the PLMP.

The goals and objectives of the PLMP are to be achieved through a series of Protection, Mitigation, and Enhancement (PME) measures. In support of these PME's, this document proposes to implement a voluntary monitoring study to better inform decisions regarding future required evaluations.RPT_heading2

1.1 Adult Lamprey Passage

Pacific Lamprey (*Entosphenus tridentatus*) numbers have declined since the 1940's as a result of spawning habitat loss, impediments to migration, changing ocean conditions, and decreased water quality (Close et al. 1995, 2002). Much focus over the past 10 years has been placed on studying migrating adults. Modifications have been made to many dam operations and structures to improve lamprey passage. Passive tags, such as half duplex passive integrated transponder tags (HDX- PIT), and active tags, such as radio tags (RT) or acoustic tags (i.e. Juvenile Salmonid Acoustic Transmitter System [JSATS]) have been employed to monitor adult lamprey passage at dams in the Federal Columbia River Hydropower System (FCRPS), primarily in the lower Columbia River (Keefer et al. 2009a, Keefer et al. 2009b, Keefer et al. 2009c, Noyes et al. 2014). While much work has been done to improve dam passage, comparatively little effort has been devoted to investigating lamprey migration characteristics between dams in the Columbia River basin.

Determining the fate and migration characteristics of adult lamprey in Columbia River basin reservoirs can be achieved with either passive or active tags. These technologies allow identification of individual fish but have notable strengths and weaknesses. The use of HDX-PIT likely provides the best estimate of dam passage and conversion rates between dams due to the smaller tag effects than observed with RT (Noyes et al. 2014). However, reservoir passage and fate are best determined with active tags. Studies have shown that potential fates of tagged Pacific lamprey that are not detected at mainstem dams include 1) overwintering in the reservoir and resuming upstream migration the following spring; 2) pre-spawn mortality or predation mortality; 3) undetected spawning in reservoir tributaries; or 4) spawning in the tailrace of a dam or elsewhere in the reservoir (Noyes et al. 2014). Among active tag technology, acoustic tags have the advantage of allowing detections in water >10 m deep (RT do not have this ability), which is common in many mainstem Columbia River reservoirs. This greater detection ability allows the opportunity to monitor the locations of tagged lamprey that remain in the tailrace or reservoir by using an array of autonomous receivers deployed in fixed locations. Additionally, mobile tracking can be employed to detect tags that may be in locations outside the detection range of fixed receivers.

In the Project area, HDX- PIT tag detection systems were installed in the fishways at Priest Rapids and Wanapum dams in 2009 and have been used to monitor passage of tagged Pacific

lamprey. For the 2010 through 2014 migrations, Grant PUD monitored a total of 380 and 258 HDX-PIT tagged lamprey at Priest Rapids and Wanapum dams, respectively (Le et al. 2015). However, because of detection limitations, it is unknown how many of those fish reached the upstream boundary of Project waters and approached the fishway entrances at the tailrace of Rock Island Dam.

In order to estimate successful approach to the Rock Island Dam tailrace, 100 adult Pacific lamprey will be implanted with active acoustic tags during the peak migration period in 2015. Tagged fish will be released either above Priest Rapids (n=30) or Wanapum (n=70) dams and monitored within the Project for a period of approximately 10 months.

The objectives of this study are to estimate the proportion of tagged lamprey that:

1). Migrate upstream to the tailrace of Rock Island Dam.
2). Overwinter in the study area and resume migration in spring 2016.
3). Experience pre-spawn or predation mortality in the study area.
4). May engage in undetected spawning in reservoir tributaries
5). May engage in spawning in the tailrace of Wanapum and/or Rock Island dams.

1.2 Study Area

The study area is defined by the FERC licensed project area which includes Wanapum and Priest Rapids dams and their respective tailrace areas and reservoirs. The project area is known collectively as the Priest Rapids Project (PRP). The PRP spans approximately 58 miles of the Columbia River. The Wanapum Reservoir is 38 miles long and has a surface area of approximately 14,680 acres. The Priest Rapids Reservoir is 18 miles long and has a surface area of approximately 7,725 acres.

2.0 Adult Pacific Lamprey Collection, Tagging, Release, and Monitoring Methods

2.1 Tag and Monitoring Equipment

This study will employ active acoustic tags and receivers deployed at fixed locations (Vemco V7 tags and VR2 receivers), augmented with mobile tracking, to determine migration characteristics of adult Pacific lamprey in the Priest Rapids and Wanapum reservoirs and verify approach to Rock Island Dam. Vemco equipment for this study will take advantage of efficiencies created by an existing array of Vemco acoustic receivers deployed throughout the Project in support of white sturgeon monitoring (see section 2.5 below). Two additional VR2 acoustic receivers will be deployed near the entrances of the left and right bank fishways in the tailrace of Rock Island Dam to improve detection capabilities of the array. The dimensions of V7 tags (length 22 mm, diameter 7mm, weight 1.8 g in air) are nearly identical to the JSATS tags used by Noyes et al. (2014).

2.2 Collection

All lamprey will be collected using existing mechanical fish traps located in the lower fishways at Priest Rapids Dam. The traps will be operated and maintained by Grant PUD Fisheries staff. Protocols for fish handling are described in Grant PUD 2014.

All trapped fish will be scanned for existing PIT tags. Previously tagged fish will be released upstream of Priest Rapids Dam. Up to 50 unmarked fish per day will be transported to holding facilities at Priest Rapids Dam left bank.

Up to 100 lamprey will be tagged and released for this study. The collection schedule will be complementary to trap and transport efforts planned to occur during the peak of the lamprey migration in summer 2015, beginning in August.

2.3 Tagging and Recovery

All lamprey will be double tagged by Blue Leaf Environmental (BLE) staff with Vemco V7 tags and a full duplex PIT tag (FDX-PIT) using methods described below.

All surgical tools and tags will be disinfected in a Nolvasan (Chlorhexidine diacetate) solution for ten minutes and then held in trays filled with distilled water. Surgical tools will be disinfected and rinsed between each fish.

One lamprey at a time will be transferred from a holding tank by hand, using water soaked cotton gloves, to a heavy anesthetic bin. It will remain in the bin until the fish loses equilibrium and swimming motion ceases (approximately 5 minutes). Start and end time (i.e., surgery start time) will be recorded.

Once the lamprey is fully anesthetized, length and girth to the nearest mm, and weight in grams, will be measured and recorded.

The lamprey will then be transferred to a surgical trough, inspected for general health and condition, and positioned ventral side up so the gills are submerged in a light anesthetic bath.

A < 10 mm incision will be made approximately 1 cm above the ventral midline, in the softer, thinner part of the abdomen between the ventral midline and the muscular “rib cage”. The midpoint of the incision will be in line with the anterior insertion of the first dorsal fin.

First the PIT tag will be inserted into the body cavity through the incision, followed by the Vemco V7 tag. The skin above the tags will be rubbed with a finger to ensure they are laying flat and will not come back out the incision, then one suture will be placed at the midpoint of the incision using 5-0 coated VICRYL (absorbable) suture with a taper point needle. Surgery end time will be recorded.

The lamprey will then be transferred to a recovery tank and monitored until it regains equilibrium (5-10 minutes).

Lamprey will be held in transport/holding tanks on flow-through water until fully recovered from the anesthetic, and released later the same day.

2.4 Releases

After recovery, fish will be transported in aerated coolers filled with river water and released from either Desert Aire (Priest Rapids Reservoir; n=30) or in the Wanapum Reservoir at either Vantage (n=35) or the boat launch immediately upstream of Wanapum Dam left bank (n=35).

2.5 Monitoring

Tagged fish will be monitored by an array of fixed location Vemco VR2 acoustic receivers deployed throughout the Project reservoirs (Figure 1 and 2). Suggested locations for two additional receivers in the immediate tailrace of Rock Island Dam are illustrated in Figure 3.

All receiver will be downloaded at regular intervals. The receivers located in the Rock Island Dam tailrace will be downloaded every two weeks for the first six weeks after all releases are complete and then at 6 week intervals for the duration of the life of the tags (approximately 299 d

at 120 s burst rate). The remaining receivers in the study area will be downloaded in coordination with scheduled downloads associated with the white sturgeon monitoring program.

In the event that not all individual are detected on fixed receivers, mobile tracking will be used to locate fish that remain at-large. If tagged fish remain at-large, mobile tracking will commence after the first download of the receivers in the Rock Island tailrace (approximately two weeks after the final release). Mobile tracking will be completed from a boat by drifting or slowly motoring downstream with an omnidirectional hydrophone placed 1-2 m beneath the surface of the water. Detections will be logged with a GPS location. BLE will provide a boat and operator for mobile tracking activities.

Figure 1 **Locations of current Vemco VR2 acoustic receivers in Wanapum Reservoir deployed for the sturgeon monitoring program. The last four digits of each label (VRRMXXX.X represent the river mile at the deployed location.**

Figure 2 **Location of current Vemco VR2 acoustic receivers in Priest Rapids Reservoir deployed for the sturgeon monitoring program. The last four digits of each label (VRRMXXX.X) represent the river mile at the deployed location.**

Figure 3 Proposed locations for the placement of two additional Vemco VR2 acoustic receivers in the tailrace of Rock Island Dam.

3.0 Analysis

Detection records from Vemco VR2 acoustic receivers will be compiled in a relational database maintained by BLE staff.

A detection history will be generated for each tag.

Detection records will be used to determine migration characteristics of tagged lamprey in the study area.

> Key metrics will include proportion of tagged fish that reach the Rock Island Dam tailrace, estimated migration rate between detection sites, and downstream movements out of the study area below Priest Rapids Dam. Additionally, the proportion of fish that overwinter in the study area, experience mortality in the study area, or engage in spawning behavior either in tributaries or the tailrace of Wanapum and/or Rock Island dams will be estimated.

For example, fish released at Desert Aire that continue migrating upstream will potentially be detected approaching Wanapum Dam, ascending the Wanapum fishways (via FDX-PIT tag) and continuing on to the Rock Island Dam tailrace.

Detection records of lamprey collected during mobile tracking will be plotted using GPS locations. These detection records will be used to augment detections from fixed receivers.

Environmental covariates such as river flow and temperature will be considered, as appropriate, when analyzing detection records.

Unexpected results will be identified as quickly as possible and discussed with Grant PUD staff. If necessary, an adaptive approach will be adopted to address additional analyses.

4.0 Reporting

BLE staff will provide monthly progress updates during monitoring activities. The first monthly update will be delivered approximately 30 days after onset of collection and tagging activities beginning in August 2015. The delivery schedule of progress updates may be modified per request from Grant PUD.

Progress updates will include details regarding collection, tagging, and monitoring, including preliminary results and accounts of problems encountered during the study as appropriate.

A final technical report will be produced by BLE and HDR staff following the completion of monitoring and analysis.

A draft report will be submitted to Grant PUD in electronic format no later than August 30, 2016.

A final report incorporating edits and comments from Grant PUD will be submitted in electronic format no later than November 30, 2016

References

Close, D. A., M. S. Fitzpatrick and H. W. Li. 2002. The ecological and cultural importance of a species at risk of extinction, Pacific lamprey. Fisheries. 27: 19-25.

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Noyes, C.J., C.C. Caudill, T.S. Clabough, D.C. Joosten, and M.L. Keefer. 2014. Adult Pacific lamprey migration behavior and escapement in the Bonneville Reservoir and lower Columbia River monitored using the Juvenile Salmonid Acoustic Telemetry System (JSATS), 2013. Technical Report #2014-7. Prepared for the U.S. Army Corps of Engineers Portland District, Portland, OR.

Appendix C
WDOE February 11, 2016 Approval Letter

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
4601 N Monroe Street • Spokane, Washington 99205-1295 • (509)329-3400

February 11, 2016

Mr. Mike Clement
Senior Biologist
Grant County PUD
PO Box 878
Ephrata, WA 98823

RE: Request for Ecology Review and Comment –*2015 Pacific Lamprey Management Plan Comprehensive Annual Report.* Priest Rapids Hydroelectric Project No. 2114

Dear Mr. Clement:

Ecology has reviewed the *2015 Pacific Lamprey Management Plan Comprehensive Annual Report* that was e-mailed to Ecology on January 22, 2016.

Ecology has no comments on the *2015 Pacific Lamprey Management Plan Comprehensive Annual Report* as submitted. The report is a requirement of Section 6.2(5)(c) for the *Pacific Lamprey Management Plan* and Section 6.2(5)(d) of the 401 Certification.

If you have any questions for Ecology, please contact me at (509) 329-3567, or pmcg461@ecy.wa.gov.

Sincerely,

Pat McGuire

Patrick McGuire
Eastern Region FERC License Coordinator
Water Quality Program

PDM:jab