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March 6, 2012

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 License Compliance Filing – Article 401(a)(12) – 2011 Pacific Lamprey Management Plan Comprehensive Annual Report

Dear Secretary Bose,

Please find enclosed the 2011 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(5)(b) (Appendix C) for the Priest Rapids Project.

The 2011 PLMP Comprehensive Annual Report summarizes the on-going activities undertaken at the Priest Rapids Project (Project) in 2011, 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 Water Quality Certification Condition requirement, 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 28, 2012, the Public Utility District No. 2 of Grant County, Washington (Grant PUD) prepared and disseminated the draft 2011 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, 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. Consultation comments were received from WDOE on January 31, 2012. A copy of the comments can be found in Appendix A, along with a summary table of Grant PUD's responses were incorporated as Appendix B to the final report. Based on comments received, Grant PUD modified the report to reflect appropriate revisions and edits.

The 2011 PLMP Comprehensive Annual Report is hereby filed with the Federal Energy Regulatory Commission (FERC) for approval. This same report has also been provided to WDOE on March 6, 2012.

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

Sincerely,

Julie Pyper, Manager
License Compliance and Implementation Services
jpyper@gcpud.org

CC: Tom Dresser, Grant PUD
Mike Clement, Grant PUD
Marcie Mangold – WDOE
Priest Rapids Fish Forum

2011
Pacific Lamprey Management Plan
Comprehensive Annual Report

Priest Rapids Hydroelectric Project (FERC No. 2114)

Prepared for:
Public Utility District No. 2 of Grant County
Ephrata, Washington

Prepared by:

Emily Andersen and Bao Le
Long View Associates
Portland, Oregon

Bryan Nass
LGL Limited
Ellensburg, Washington

Mike Clement
Public Utility District No. 2 of Grant County
Ephrata, Washington

March 2012

Executive Summary

In accordance with the Priest Rapid Project's License Order, issued by the Federal Energy Regulatory Commission (FERC) on April 17, 2008 (FERC 2008), and the 401 Water Quality Certification, 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 (Project) in 2011, 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 third year of implementation of Grant PUD's PLMP, an assessment of Pacific lamprey behavior and passage efficiency was conducted at Priest Rapids and Wanapum dams. First, underwater video imagery collected in 2010 at two locations in the Priest Rapids right bank fish ladder was reviewed and analyzed. Cameras captured lamprey approaching and passing weir orifices and the fish count station, and provided a means to assess the use of the aluminum plating and new fish count station crowders by lamprey. Biological assessment of the imagery concluded that the plating was effective in facilitating lamprey passage.

For a second year, the study also evaluated passage success and travel times of lamprey through the fishways using HDX-PIT technology. Due to continued low numbers of returning adult lamprey to the mid-Columbia River basin in 2011, the PRFF decided to continue to implement a passive monitoring approach instead of actively trapping, handling and tagging test fish at the Project. This approach included monitoring for adult lamprey that had originally been tagged at Bonneville Dam on strategic arrays deployed at Priest Rapids and Wanapum dams. For the 2010-2011 monitoring period, a total of 67 and 38 HDX-PIT tagged lamprey were detected at Priest Rapids and Wanapum dams, respectively. Overall, estimated fish passage efficiency for lamprey is 82% at both facilities, and median passage time is approximately 2.2 days. 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 (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. Grant PUD is currently evaluating juvenile salmonid passage and behavior through the Priest Rapids Top-spill bypass which includes modifications to spill bays 19 through 21 to allow near surface route-specific passage. 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, Hanson) drain into the Priest Rapids Reservoir.

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

Over the past decade, Grant PUD has actively participated in the research of 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 2009). More recently, Grant PUD has and continues to participate in and provide support to the U.S. Fish and Wildlife Service (USFWS) Lamprey Conservation Initiative and the Yakama Nation Lamprey Recovery Planning efforts and Columbia River Inter-Tribal Fish Commission's (CRIFC) 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; written fishway fish collection dewatering procedures conducted 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. Now, similar entrances are being installed by the Army Corps of Engineers (ACOE) 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 ¾ - inch gap spacing to accurately enumerate all adult lamprey counts. Significant improvements for downstream passage have been achieved by development of the Wanapum Future Unit Bypass and the Priest Rapids top-spill bulkhead for juvenile salmon which presumably provides a high survival alternative passage route for 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 and; providing upstream and downstream fish passage facilities and support for full-duplex (salmon) and half-duplex (lamprey) passive integrated transponder (PIT) detection systems for the ACOE basin-wide assessments; 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 and the PRFF conducted a study of the effectiveness of these modifications during the summers of 2010 and 2011. While the number of lamprey returning to the Columbia River were not sufficient for tagging at Priest Rapids, the extensive half duplex passive integrated transponder (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 HD-PIT arrays were operated each migration season to track lamprey through the project area (Appendix C). Further, the installation and monitoring of underwater video arrays at strategic locations was conducted in 2010 to evaluate the use of the passage structures by lamprey (Appendix D).

Grant PUD has been 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 demonstrates 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, issued by the Washington Department of Ecology (WDOE) on April 3, 2007 and amended March 6, 2008 (WDOE 2007; FERC 2008), which states:

> *<u>License Order:</u> The licensee shall file annually with the Commission by March 31, beginning 2010, their Annual Pacific Lamprey Management Report. The report shall include the reporting requirements identified under implementation measure 1 of the Biological Objectives and Implementation Measures under Appendix C of the Washington State Department of Ecology 401 Water Quality Certification. Additionally, the licensee's report shall include an updated implementation schedule and identify any variations from the schedule provided in the licensee's filed plan. The licensee shall prepare their report in consultation with the Priest Rapids Fish Forum and allow the Priest Rapids Fish Forum 30 days to review and comment on the report prior to filing with the Commission. The licensee's report shall include any resource agency and Tribe comments and the licensee's response to any comments. The Commission reserves the right to require changes to their plan based upon review of the report.*

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, 2010) 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, 2010 through October 31, 2011) about passage and survival investigations and measures being undertaken throughout the Columbia River Basin.
- Section 3.0: Status report on Pacific lamprey activities underway at the Project, including identification of any variations from the schedule provided in the PLMP (Grant PUD 2009).
- Section 4.0: An evaluation of whether recent activities in the Columbia River Basin should be considered for the Project.
- Section 5.0: A summary of preliminary conclusions regarding Pacific lamprey activities to date, anticipated activities in the Columbia River Basin, and future activities at the Project for the upcoming year.

1.4 Consultation

Pursuant to the reporting requirements, Grant PUD provided a complete draft of the PLMP Comprehensive Annual Report to the PRFF on January 28, 2012 for review. Written comments were received from WDOE on January 31, 2012. A summary of comments by the PRFF as received by Grant PUD on the draft PLMP Comprehensive Annual Report have been compiled along with responses from Grant PUD (Appendix B). The summary is based on written (Appendix A) comments.

2.0 Pacific Lamprey Activities in the Columbia River Basin

2.1 Background and Existing Information

Pacific lamprey (*Lampetra tridentata*) are indigenous to many of the tributaries of the Columbia (Jackson et al. 1997a, Jackson et al. 1997b) and the Snake Rivers (Close et al. 1995). Wydoski and Whitney (1979) reported that the Pacific lamprey is 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, lamprey 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 all Columbia and Snake River 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 U.S. Fish and Wildlife Service (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 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, early implementation by Douglas PUD, and Portland General Electric [PGE]), the USFWS-led Pacific Lamprey Conservation Initiative, continued its activities by making available its Pacific Lamprey Assessment and Template for Conservation Measures document. The assessment and template for conservation measures is the first of a three part process. This first phase of the process identifies critical uncertainties regarding Pacific lamprey life history and improves the scientific understanding of the importance of Pacific lamprey in the ecosystems of the United States. Subsequent to this first phase, conservation agreements and regional implementation plans will also be developed (USFWS 2011).

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[2]									▒	▒	▒	
Entry into saltwater[2]	▒	▒	▒	▒	▒	▒					▒	▒

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

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

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. Activities associated with documenting key habitat related to spawning, rearing, and overwintering habitat as well as nest and escapement surveys are being conducted annually in the Deschutes watershed. Furthermore, a re-introduction evaluation above Pelton Round Butte Dam is also occurring in the Deschutes. In the Yakima watershed, movement patterns, overwintering and spawning areas for adults and juvenile distribution and abundance sampling are occurring. Multi-year juvenile distribution and abundance sampling and larval trend monitoring is occurring in the Klickitat, Wenatchee, Entiat and Methow watersheds. Researchers are studying the physiological ecology and life history of adult lamprey during their freshwater residency in the Willamette River and developing statistical approaches to evaluate patterns of occupancy and distribution and deep water survey methods. In the laboratory setting, researchers are conducting swim performance, behavior, barotrauma impacts, anesthetic efficacy and oxygen consumption experiments as well as assessing the effects of contaminants on lamprey (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 (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. Recently, juvenile lamprey were 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). Researchers are also beginning to evaluate the efficacy of different irrigation diversion screen panels to prevent juvenile lamprey impingement and entrainment at these locations (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 Willamette River. 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, Grande 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). In the upper Columbia River basin, distribution information is being collected in the Wenatchee and Methow rivers while adult translocation activities by the Nez Perce Tribe indicate 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 like Powerdale on the Hood River, and 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.

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. 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).

Table 2 Annual counts of adult Pacific lamprey at select Columbia and Snake River basin dams.[1]

Year	McNary	Priest Rapids	Wells	Ice Harbor	Lower Granite
2000	1,281	1,468	NA	315	28
2001	2,539	1,624	261	203	27
2002	11,282	4,007	338	1,127	128
2003	13,325	4,339	1,408	1,702	282
2004	5,888	2,647	291	805	117
2005	4,158	2,598	212	461	40
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[3]	833	1,114	2	114	15
2011	868	3,868	1	269	48

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 5, 2010.

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. The most recent 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).

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. A review of these translocation programs was conducted in 2009 and monitoring is ongoing (see Section 2.2: Updated Information for additional details about the review and monitoring 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, half-duplex Passive Integrated Transponder 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 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 (Nass et al. 2003; Stevenson et al. 2005; LGL Limited and Douglas PUD 2008). The Net Ladder Passage Efficiency (NLPE) at Rocky Reach was 47% (Stevenson et al. 2005). 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 evaluate these modifications, a complex array of HDX-PIT antennas were installed at strategic locations in the Priest Rapids and Wanapum fishways to measure the passage efficiency of adult lamprey. In 2010 and 2011, due to continued low numbers of returning adult lamprey to the mid-Columbia River basin, the PRFF decided to continue to implement a passive monitoring approach instead of actively trapping, handling and tagging test fish at the Project. This approach included monitoring for adult lamprey (that had originally been tagged at Bonneville Dam) on the HDX-PIT arrays deployed at Priest Rapids and Wanapum dams. During the monitoring period, a total of 67 and 38 HDX-PIT tagged lamprey were detected at Priest Rapids and Wanapum dams, respectively. Overall, estimated fish passage efficiency for lamprey was 82% at both facilities, and median passage time was approximately 2.2 days.

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).

Detailed examination of detection histories for radio-tagged lamprey has concluded that there are several potential explanations for relatively low fishway passage success for adult lamprey. In general, these factors are associated with unique physical characteristics of the individual fishways and may include a lack of suitable attachment surfaces, water velocities, and channel configuration (Keefer 2008).

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 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 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 (see Section 2.2: Updated Information for additional details regarding Keefer et al. 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 was 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).

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 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 (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).

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 (see Section 2.2: Updated Information for additional details).

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 (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 to assess juvenile lamprey macrophthalmia outmigration until recently. In 2009, two tagging studies were conducted (and continued in 2010); one on the biological criteria for active tags and the second regarding the development of standard protocols for PIT-tagging 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. 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 3. 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, 2010 through October 31, 2011. 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. Except for the few instances where the Project was one of several dams included in an evaluation, activities regarding the Project are not described herein but rather are detailed in Section 3.0: Status of Pacific Lamprey Activities at the Project.

Table 3 Pacific lamprey activities in the Columbia River basin in 2011.

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
	General Biology, Ecology and Population Status					
1.	Monitoring entrance timing, escapement methodology development, larval distribution surveys, redd surveys, and habitat assessments	No associated hydro project	Fifteen Mile Creek	In its second year, this project focused on escapement estimates (developing techniques), monitoring entrance timing and numbers of HDX tagged fish from ACOE funded projects entering Fifteenmile, larval distribution surveys, redd surveys, and working with Oregon Water Resources (OWR) and Fifteenmile Watershed Council to identify potential habitat-based bottlenecks to the population. In the future the Tribe hope to use the established HDX array to determine if fish that fallback from The Dalles Dam are using Fifteenmile for spawning or potentially as refuge prior to attempting to ascend the dam again. In cooperation with OWR and Fifteenmile Watershed Council, the Tribe is working with landowners to install flow meters on all major irrigation diversion to determine if irrigators are staying within their allocations. A gaging station will also be installed. There is also a fairly extensive water temperature monitoring program in Fifteenmile which is a multi-agency effort. All information collected through flow meters, the gaging station and water temperature monitoring will be correlated with lamprey life history and relative abundance to potentially identify habitat improvements and opportunities to restore flow to the stream. The Tribe will also be investing in dual HDX-FDX monitoring systems with ODFW. After troubleshooting the HDX-FDX system, arrays will be established in tributaries to	CTWSR	Personal communication with Jennifer Graham, CTWSR (11/28/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				Fifteenmile to estimate tributary escapement. Preliminary results not yet available.		
2.	Adult lamprey monitoring	No associated hydro project	Deschutes and tributaries	In 2011, escapement and water temperature monitoring activities continued in the mainstem Deschutes and its tributaries. New work included installation of half duplex antennas in the Warm Springs River and Shitike Creek to monitor tributary entrance timing. Ultimately, the goal is to use the arrays to determine tributary escapement. Entrance timing will be used to determine temporal distribution as well as assist staff in determining when to look for lamprey redds. In 2010, the Tribe attempted to cap lamprey redds but had difficulty identifying them. As a result, in 2011, redd capping occurred again in hopes of being able to correlate emergence timing with multiple variables (e.g., DO, temp) and estimate the number of emergents. Preliminary results not yet available.	CTWSR	Personal communication with Jennifer Graham, CTWSR (11/28/11)
3.	Conduct adult lamprey movement study using radio telemetry	BOR projects in Yakima	Yakima	In 2011, released radio tagged adult Pacific lamprey into Yakima River to assess movement patterns, overwintering and spawning areas.	USFWS	Report-Passage of Radio-tagged Adult Pacific Lamprey at Yakima River Diversions 2011 Annual Report (Johnsen et al. 2011)
4.	Status of Pacific lamprey in Idaho	N/A	Clearwater, Salmon, and Snake rivers	This document summarizes the current available knowledge concerning the status of Pacific lamprey in the state of Idaho. The major river drainages in Idaho that remain accessible to the species are discussed regarding their geology, hydrology, and anthropogenic changes. A number of management actions thought necessary to enhance persistence of the species are also	IDFG	Status of Pacific lamprey in Idaho (IDFG 2011)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				presented.		
5.	Determining adult escapement and adult harvest monitoring	Willamette Falls	Willamette	In 2011, the Tribe worked to establish protocols to determine lamprey escapement upstream of Willamette Falls. This project used a combination of HDX mark-recapture and video cameras within the fish ladder and two lamprey ramps along the falls. This was the second year of the project. The first year was a challenge with all the new technology. Lamprey harvest at two locations downstream of Willamette Falls was also monitored. We anticipate having protocols finalized this year for the MRC and camera portion of the project. We will also be developing protocols to assess what proportion of fish return to the falls after being moved downstream after tagging. Previous RT work suggests a fair amount did not return after being tagged (tagging effects?). Preliminary results not yet available.	CTWSR	Personal communication with Jennifer Graham, CTWSR (11/28/11)
6.	Occurrence, detection and habitat use of larval lamprey	Bonneville Dam	Columbia River	Using a boat-mounted, deepwater electrofisher and a generalized randomized tessellation stratified (GRTS) approach, mainstem areas of the Columbia River associated with Bonneville Dam were sampled to evaluate patterns of occupancy and distribution above and below a major anthropogenic structure which alters natural structure and function of the Columbia River. Quadrats in the Bonneville Reservoir, Tailwater, and at the mouth of the Wind River were sampled. One larval lamprey was detected in the Bonneville Reservoir and one lamprey was detected at the Wind River mouth. No larval lamprey were detected in the tailrace area which suggests these habitats (e.g., increased scouring, suppression of natural flow regime) may be inhospitable to larval lamprey use.	USFWS	Occurrence, Detection, and Habitat Use of Larval Lamprey in Columbia River Mainstem Environments: Bonneville Reservoir and Tailwater. 2010 Annual Report (Jolley et al. 2011a)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				Overall, larval lamprey distribution and habitat usage of mainstem areas in the Columbia River, including above and below hydropower projects, remains largely uninvestigated. In 2011, this work was continued by expanding the Bonneville Tailwater reach examined as well as continuing to investigate occupancy at tributary mouths (Hood, Klickitat, Wind, and White Salmon rivers) within Bonneville Reservoir. A final report will be available in 2012.		
7.	Occurrence, detection and habitat use of larval lamprey	No associated hydro project	Lower Columbia River	Using a boat-mounted, deepwater electrofisher and a generalized randomized tessellation stratified (GRTS) approach, Lower Columbia River mainstem areas were sampled to document the presence of larval lampreys and to examine the influence of salt water on lamprey distribution. A total of 16 quadrats were visited and 15 were sampled. No larval lampreys were detected. To date, only areas that were considered to have a constant freshwater history (i.e., <2%) based on climatological data. Sampling for this project is ongoing.	USFWS	Occurrence, Detection, and Habitat Use of Larval Lamprey in Columbia River Mainstem Environments: Lower Columbia River. 2010 Annual Report (Jolley et al. 2011b)
8.	Occurrence, detection and habitat use of larval lamprey	No associated hydro project	White Salmon, Wind, and Klickitat	In 2011, we estimated occupancy of larval lamprey in the Lower White Salmon, Wind, and Klickitat rivers by adapting an approach used by Peterson and Dunham (2003) and refined by the U.S. Fish and Wildlife Service (USFWS 2008) to evaluate patch occupancy and detection probability for bull trout *Salvelinus confluentus*. Quadrats visited in ranged from 36 to 41 but 34 were ultimately sampled in each river. Feasibility ranged from 83% to 94%. Some were not sampled	USFWS	Occurrence, Detection, and Habitat Use of Larval Lamprey in the White Salmon River Basin: Pre-Condit Dam Removal: 2011 Annual Report - DRAFT (Jolley et al. 2011c)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				because they were not feasible (dewatered conditions or excessive velocity). Larval lampreys occupied all rivers. Pacific lamprey and unidentified lamprey larvae occupied the lower Klickitat River (d=0.27). Pacific lamprey, western brook lamprey, and unidentified lamprey occupied the lower White Salmon River (d = 0.29) and lower Wind River (d = 0.33). Given these levels of detection, the estimated level of quadrat sampling effort to be 80% certain that larval lamprey are absent when not detected was 4 or 5 quadrats. There was no difference in the detection probabilities among river reaches (chi-square=0.28, df=2, P>0.05). A final report will be available in 2012.		
9.	Juvenile lamprey monitoring	No associated hydro project	Hood River	This project is in its infancy but the ultimate goal is to determine if lamprey are naturally recolonizing the Hood Basin. Thermographs have been installed to identify potential locations (based on water temperatures) for natural recolonization and/or assessing if active restoration is appropriate. Prior to the removal of Powerdale Dam, larval distribution surveys were conducted to establish a baseline. No lamprey were found upstream of Powerdale; however, they were collected up to the base of the dam. This fall surveys were re-conducted (last conducted in fall 2009) and determine if lamprey distribution has changed. Preliminary results not yet available.	CTWSR	Personal communication with Jennifer Graham, CTWSR (11/28/11)
10.	Re-introduction evaluation	Pelton Round Butte	Deschutes	An evaluation is underway to determine if lamprey can be re-established upstream of the Pelton-Round Butte Complex (rkm 161) in the Deschutes River since fish passage has been re-established.	CTWSR	Personal communication with Jennifer Graham CTWSR (11/28/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				Preliminary results not yet available.		
11.	Conduct juvenile distribution and abundance sampling	No associated hydro project	Yakima	In 2010, surveys were completed for the main stem Yakima River up to the City of Yakima and in the lower portions of the Naches River, Tieton River, Ahtanum, Wenas, Toppenish and Satus creeks. Although Western Brook lamprey were found throughout much of the basin, Pacific lamprey were also observed. Pacific lamprey were noted in Ahtanum Creek and in the Yakima River near Yakima. Surveys will continue in the Yakima Basin in 2011. Surveys were also conducted in several dewatered diversion ditches in autumn months. Many juveniles were found behind fish screens, consisting of various size classes, but only Western Brook lamprey were noted. Also in 2011, a pilot radio telemetry study in coordination with the USFWS and USBOR will be initiated (see line item #3). The primary objectives will be to evaluate passage over USBOR diversion dams in the lower Yakima River and to obtain information about migration and spawning behavior from tagged adults. In 2011, continuing work was conducted (as described above) but preliminary results are not yet available.	Yakama Nation	Personal communication with Bob Rose, Yakama Nation (2/5/11)
12.	Conduct juvenile lamprey distribution surveys	No associated hydro project	Entiat and Wenatchee	In 2010, juvenile lamprey distribution surveys were conducted in the Entiat and Wenatchee rivers. A draft report is in progress.	USFWS	Personal communication with R. D. Nelle, USFWS (11/29/11)
13.	Conduct status and trend larval monitoring program	No associated hydro project	Methow	In 2011, as part of continuing lamprey activities in the Methow watershed (which began in 2008), on-going status and trend monitoring of larval lamprey continued with surveys of the three sites	Wild Fish Conservancy and USFS	Personal communication with John Crandall,

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				on both the Chewuch and Methow rivers. Electrofishing was conducted to determine larval presence and relative abundance and all type 1 larval habitat was GIS mapped to determine larval density as well as persistence of larval habitat over time. A project status report that will include all lamprey specific work conducted in the Methow since 2009 will be completed in early 2012.		Wild Fish Conservancy (11/14/11)
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 will be collected in subsequent years.	Wild Fish Conservancy and Yakama Nation	Personal communication with John Crandall, Wild Fish Conservancy (11/14/11)
15.	Relative abundance monitoring of larval lamprey	Willamette Falls (tributaries above and below)	Willamette	Backpack electroshocking surveys were conducted during summer/fall of 2011 to ascertain the distribution and relative abundance of larval lamprey (*Lampetra* and *Entosphenus*). Entire pools and riffles (2 each unit) were shocked using 1 pass survey. Preliminary analyses indicate that lampreys were most abundant in riffles versus pools; Pacific lamprey were most abundant throughout the basin and were increasingly more abundant in the lower portions of the rivers; brook lamprey were relatively more abundant in the upper portions. Unknown *Lampetra* were found in the Clackamas drainage. A report may be available in 2012.	Oregon Cooperative Fish and Wildlife Research Unit at OSU	Personal communication with Ben Clemens, OSU (11/9/11)
16.	Lamprey physiology, behavior, and performance laboratory studies	N/A	N/A	A manuscript on oxygen consumption of adult Pacific lampreys at rest and during swimming is in the final editing stages. The paper may be available 2012.	USGS	Personal communication with Matt Mesa, USGS (10/31/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
17.	Lamprey behavior laboratory studies	N/A	N/A	Using behavioral assays, it was demonstrated that migratory adult Pacific lamprey are attracted to odors emanating from their larval conspecifics. We then identified putative pheromones released by larval Pacific lamprey. Chemical analysis of the conditioned water from larval lamprey using liquid chromatography–mass spectrometry (LC–MS) revealed that the Pacific lamprey can release petromyzonaminedisulfate (PADS), petromyzosteroldisulfate (PSDS), and petromyzonolsulfate (PZS). Electro-olfactogram studies further demonstrated that adult Pacific lamprey can smell those bile acid compounds. The data strongly indicate that the Pacific lamprey employ a chemical communication system mediated by a mixture of bile acids, as evidenced by pheromonal functions of the bile acid compounds in guiding migratory adults a lamprey to the spawning streams. Comprehensive understanding of the chemical communications involved in lamprey migratory behavior may lead to improved scientific approaches for restoration efforts.	Department of Fisheries and Wildlife, Michigan State University	Identification of putative migratory pheromones from Pacific lamprey (*Lampetra tridentata*)(Yun et al. 2011)
18.	The physiological ecology and life history of adult lamprey during freshwater residency	Willamette Falls	Willamette	Adult Pacific lamprey were collected at Willamette Falls and in the Klamath River estuary (baseline comparison) in 2007 and 2008 to ascertain morphology, fat content, stage of maturation, and fecundity. It appears as though relatively recent, sexually immature migrants enter Willamette Falls when river temperatures peak and when river flows are low, whereas the sexually mature fish (fish that had likely already entered freshwater the previous summer) were found during the spring. The warm water itself may prevent imminent sexual maturation during the summer while at the same time helping to expedite the maturation process for both sexes the following	Oregon Cooperative Fish and Wildlife Research Unit at OSU	Life histories of adult Pacific lamprey, National Fish and Wildlife Foundation final programmatic report (Schreck and Clemens 2010) The Physiological Ecology and Run Diversity of Adult Pacific Lamprey, *Entosphenus*

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				spring (Clemens et al. 2009.). Although sexual maturation appears to be unimodal, occurring only during the spring, the substantial variety in all of the measures displayed above suggests that the hypothetical scenario of two cohorts (last year's entrants, this year's spawners and this year's entrants, next year's spawners) may be overly simplistic. In fact, there may be several cohorts whose maturation timing is plastic, dependent upon ambient water temperatures. It is not known whether the ambient temperatures are negatively impacting the spawning population (as might be inferred by the atretic testes), as we do not know what a baseline level for population normalcy is (Schreck and Clemens 2010). A dissertation and publication are now available (Clemens 2011 and Clemens et al. 2011).		*tridentatus*, During the Freshwater Spawning Migration (Clemens 2011) Pre-spawning migration of adult Pacific lamprey, *Entosphenus triedentatus*, in the Willamette River, Oregon, U.S.A (Clemens et al. 2011)
19.	Evaluate effectiveness of the Nez Perce trial translocation program	Lower Granite	Snake	In 2009, adult lamprey salvaged from John Day Dam fishways during the annual winter dewatering period were held through the winter at the Nez Perce Tribal Hatchery. In May they were released into four Snake River tributaries: Asotin Creek in Washington, and Lolo, Newsome, and Orofino creeks in Idaho. During 2007-2010, a total of 480 lamprey have been released for this program of which a sub-sample of 115 fish were outfitted with radio transmitters and released into 3 of the 4 streams. For the most part, radio-tagged lamprey remained in the release streams. Lamprey redds were observed in all release streams where surveys were conducted except for Asotin Creek in 2009. While not conclusive, the indication is that larval lamprey observed in Asotin, Lolo and Newsome creeks were primarily the progeny of the translocated	USFWS	Personal communication with Chris Peery, USFWS (12/1/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				adults. A GIS-based model to characterize usable habitat for adult and juvenile Pacific lamprey in Asotin Creek has been developed. In 2011, the Tribe released lamprey in streams but no additional tracking or juvenile surveys were conducted. A final report is currently being developed.		
20.	Assess Atrazine effects on lamprey	No associated hydro project	Willamette and Siletz rivers	The Confederated Tribes of Siletz Indians are interested in determining potential causes for lamprey population declines. The Oregon Cooperative Fish and Wildlife Research Unit is addressing this interest by determining whether or not herbicides are having a deleterious effect on this threatened species. We have found that atrazine alters' lamprey's behavior in a 2 choice y-maze. We have also found that it causes a hypersensitive reaction in respiration in response to a necromone. Final results expected January 2012.	the Oregon Cooperative Fish and Wildlife Research Unit at OSU Confederated Tribes of the Siletz Indians	Personal communication with April Smith, OSU (12/5/11 Advisor: Dr. Carl Schreck
21.	Assess possible effects contaminated sediment has upon survival, growth and behavior of lamprey ammocoetes	No associated hydro project	Lower Willamette	In summer and fall 2010, Pacific lamprey ammocoetes were exposed to sediments collected from Portland Harbor Superfund site and several reference sites upstream. Individual rearing methods were developed in order to collect survival and growth data on single ammocoetes. Behavioral trials were also conducted to examine ammocoete sediment preference between contaminated and uncontaminated sediments. Results of preliminary burrowing behavior trials demonstrated protracted burrowing in contaminated sediment collected from Portland Harbor Superfund site "Gasco 2" compared with	the Oregon Cooperative Fish and Wildlife Research Unit at OSU Portland Harbor Trustee Council Stratus Consulting	Personal communication with Julia R. Unrein, OSU (12/9/11) Supervisor: Dr. Carl Schreck

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				non-contaminated "Reference" sediment. Each sediment type was tested with an individual ammocoete. While all ammocoetes eventually buried completely, out of 14 trials, 8 ammocoetes were discovered unburied after 24 hours in contaminated Gasco 2 sediment.		
22.	Develop methods to survey juvenile lamprey in deep water habitats	No associated hydro project	Lower Snake	Researchers developed a means to survey for the presence of juvenile lamprey ammocoetes in deep water habitats. A lowered sled outfitted with electroshocker (modified ABP-2 backpack unit) and video cameras was positioned over suitable rearing habitats and electric charge applied while recording. Sampling system has the capability to document lamprey presence over a wide range of habitats and can determine physical habitats (grain size, water velocity, depth, water temperature, GPS locations). Lab tests using juvenile brook lamprey indicated a sampling efficiency of 60%. No lamprey were found during the initial surveys in the summer and fall of 2011.	PNNL	Personal communication with Robert Mueller, PNNL (11/1/11)
23.	Anesthetic efficacy trials and post-tagging prophylactic treatment tests	N/A	N/A	In 2011, anesthetic efficacy trials and post-tagging prophylactic treatment tests were conducted on juvenile lampreys at the USGS laboratory in Cook, Washington. For the anesthetic efficacy trials, "time to handleable" and "time to recovery" were measured for three concentrations of four anesthetics [MS-222, BENZOAK (20% benzocaine), AQUI-S 20E (10% eugenol), and Aquacalm (metomidate hydrochloride)] with fifteen fish per concentration. MS-222 and BENZOAK were effective anesthetics for juvenile lampreys at concentrations of 100 mg/L and 60 mg/L. Fish were highly agitated by exposure to AQUI-S 20E and were sedated slowly even at high concentrations (100–200 mg/L). Aquacalm was ineffective as an anesthetic for juvenile lampreys.	USGS	Personal communication with Matt Mesa, USGS (10/31/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				Once optimal anesthetic concentrations were determined, an additional 45 fish were anesthetized with MS-222, BENZOAK, or AQUI-S 20E and then held at 12°C for 30 days and monitored for health and survival. Fish anesthetized with BENZOAK presented with the fewest fungal infections and had the best survival, suggesting that it may be a good alternative anesthetic for juvenile lampreys. To test the ability of short-term post-tagging prophylactic tests to reduce freshwater fungal infections, fish were anesthetized with MS-222 or BENZOAK; PIT tagged with 9 × 2 mm tags, and then treated for 30 min with Stress Coat, hydrogen peroxide, salt, or left in plain water. Twelve fish were used per treatment with three treatment replicates per anesthetic. All fish were held at 12°C, and fish health and survival were monitored for 27 days. Survival was generally high for all groups including controls, and few fungal infections were observed. More work is needed to determine the efficacy of prophylactic treatments or if they are needed at all.		
24.	Collect pacific lamprey genetic samples for CRITFC basin-wide assessment	No associated hydro project	Entiat and Wenatchee	Collection of juvenile Pacific lamprey genetic samples in Entiat and Wenatchee rivers. Analysis conducted by Jon Hess, CRITFC, Hagerman, ID.	USFWS	Personal communication with R. D. Nelle, USFWS (11/29/11)
25.	Genetic characterization of Pacific Lamprey	No associated hydro project	Willamette (Agendy Creek)	In 2010 and 2011 the Confederated Tribes of Grand Ronde collected tissue samples from ammocoete lamprey caught in the juvenile smolt trap located on Agency Creek, a tributary to the South Yamhill. Samples were sent to Denise Hawkins with the USFWS Abernathy Fish Technology Conservation Genetics lab in Washington State. As of December 2011, CTGR is waiting for the final report.	The Confederated Tribes of Grand Ronde and USFWS Abernathy Fish Technology Center	Personal communication with Rebecca McCoun, CTGR (12/12/11)
26.	Population genetics of Pacific	N/A	N/A	The project used 9 newly developed microsatellite	Dr. Margaret	Microsatellite

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
	lamprey			markers to determine if there is broad-scale population structure in Pacific lamprey populations. A total of 965 Pacific lamprey were genotyped from 21 sites along the west coast of North America (British Columbia, Washington, Oregon, and California). Levels of genetic differentiation among locations were low, providing support for a lack of natal homing in Pacific lampreys. The vast majority (93%) of Fst values above 0.05 (high degree of genetic differentiation) involved comparisons among only 5 of the 21 sites. One possible explanation for the high degree of genetic differentiation between these sites and many of the other sites is a small number of spawning adults at these sites or water level fluctuations that wipe out all by a localized and potentially related number of ammocoetes. In these cases, differences in allele frequencies between locations would be due to sampling effects, not reproductive isolation. It appears that Pacific lampreys from most of the sites examined in this study can be managed as one unit; hopefully, future investigations will indicate whether this is true for all sites.	Docker. Dept. of Biological Sciences. University of Manitoba	Analysis on Pacific Lamprey along the West Coast of North America (Docker 2010)
	<u>Lamprey Migration in Rivers</u>					
27.	Estimating upstream passage metrics and performance in Pacific lamprey from the Columbia River hydrosystem	Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, Priest Rapids, Wanapum	Columbia and Snake	In 2011, adult lamprey were collected at Bonneville Dam and tagged with HDX-PIT tags. Passage was monitored at multiple projects in the Columbia and Snake rivers. A second group of lampreys was tagged with both HDX-PIT and acoustic transmitters (JSATS) and was monitored in reservoirs and at some tributary sites. The primary objectives of the evaluation were to estimate lamprey escapement past the monitored sites, to assess the final known distribution of	ACOE (prepared by the University of Idaho Cooperative Fish and Wildlife Research Unit)	Chris Caudill, University of Idaho, Presentation at AFEP Review, Walla Walla, WA (11/28/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				tagged fish, and to integrate 2011 results with those from HDX, JSATs, and radio-tagged lampreys from previous years. A total of 929 adult lamprey were HDX-PIT tagged and 85 were double tagged (HDX and JSAT). Data is still being processed but preliminary results show high attrition rates occurred as the lamprey run progressed upstream, consistent with findings in previous years. The multi-year comparative analysis indicates that lamprey passage at dams is sensitive to environmental and operational conditions, but also that major behavioral patterns repeat across years.		
28.	Evaluate adult lamprey migration through Bonneville Reservoir	Bonneville Dam reservoir	Columbia	In 2010, a pilot study was conducted to evaluate the use of acoustic telemetry to monitor migration behavior and fates in the Bonneville Dam reservoir. 30 adult lamprey collected at Bonneville Dam were outfitted with transmitters fashioned on the juvenile salmon acoustic telemetry system (JSATS) and released 7.6 km upstream of the dam. Autonomous JSATS receiver nodes stationed at Stevenson, WA (release area, all 30 detected) and Klickitat, WA (50 km upstream of dam; 23 detected) successfully recorded the tagged fish during the summer but a third site at Wind Mountain (11 km upstream of the dam) malfunctioned. A mobile-tracking JSATS receiver placed on a boat was able to detect deployed test transmitters effectively at distances less than 60 m.	ACOE (prepared by University of Idaho Cooperative Fish and Wildlife Research Unit)	Evaluation of the juvenile acoustic telemetry system (JSATS) for monitoring adult Pacific lamprey in the Bonneville reservoir and at Bonneville Dam, 2010 (Naughton et al. 2011)
29.	Evaluate adult lamprey migration through the lower Columbia and Snake rivers	Bonneville, The Dalles, John Day, McNary, Ice Harbor, Priest	Columbia and Snake	In 2010, 312 lamprey were tagged with radio-transmitters and HDX-PIT. 13 lampreys received HD-PIT tags only. The 2010 escapement estimate from release below Bonneville Dam to top-of-ladder antennas was 41% for radio-tagged fish, the	ACOE (prepared by University of Idaho Cooperative	Adult Pacific lamprey migration in the lower Columbia River: 2010

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
		Rapids		highest estimate among the 2007-2010 radiotelemetry studies. Escapement from the top of Bonneville Dam to top-of-ladder antennas at The Dalles Dam (55%) and from the top of The Dalles Dam to the top of John Day Dam (49%) was also higher than in recent years. Large lampreys were significantly more likely than small lampreys to pass through most dam to-dam reaches, and early migrants were more likely than late migrants to escape upstream. Median reservoir passage times were 2.7 d (Bonneville) and 1.8 d (The Dalles). Lampreys generally migrated faster later in the summer through most reaches, coincident with increasing river temperatures and decreasing river discharge. Twenty-five percent of the lampreys that passed Bonneville Dam eventually entered tributaries, including the Snake River, or passed the uppermost monitoring sites at Priest Rapids Dam. The largest group in this category was recorded in the Deschutes River. Lampreys that returned to the Deschutes and John Day River were collected at Bonneville Dam relatively early in the run. In addition, most lampreys that returned to the upper basin were in the largest size classes, indicating probable size and migration timing effects on lamprey distribution in the basin. Almost all of the remaining 75% of the sample was last detected at main stem dams or in dam tailraces.	Fish and Wildlife Research Unit and NOAA Fisheries)	radiotelemetry and half-duplex PIT tag studies. (Keefer et al. 2011a)
30.	Upstream migration of Pacific lamprey in the Willamette Basin	No associated hydro project	Willamette	In 2008 The Confederated Tribes of Grand Ronde (CTGR) conducted a radio telemetry study on adult Pacific Lamprey to determine the following: the timing and movement patterns during their upstream migration; to identify over-wintering locations; to determining relative use of primary	The Confederated Tribes of Grand Ronde (in collaboration	Migration characteristics and habitat use of the imperiled adult Pacific lamprey in the Willamette

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				tributaries for spawning and with the information gained assist with formulating management recommendations for Pacific Lamprey. In, 2009 and in 2010 the Grand Ronde Tribe started working collaboratively with Cramer Fish Sciences and the Oregon Cooperative Fish and Wildlife Research Unit at OSU (CRITFC Study) to increase research efforts. The collaborative effort increased the number of lamprey being tracked as well as increased the number of fixed tracking stations. Fixed stations were monitored by CTGR and Cramer. Boat tracking was conducted by CTGR and Oregon Cooperative Fish and Wildlife Unit at OSU. Additional aerial tracking was conducted by Oregon Cooperative Fish and Wildlife Unit at OSU. In 2008, 111 fish were radio tagged, 206 in 2009, and 219 in 2010. In 2011 the CTGR tagged 120 adult lampreys. All the tributaries being monitored were used by tagged lamprey. The Santiam, Molalla and the Yamhill had the most use. The majority of the tagged lampreys were found in the main stem after one year of tracking. A range of behavior has been observed. Tagged lamprey were observed entering tributaries throughout the winter months. Some of the tagged fish moved quickly into tributaries shortly after being released above the Falls. Others overwintered in the main stem and then entered tributaries the following spring. The CTGR will continue tracking the 2011 tagged fish into the summer of 2012.	with Cramer Fish Sciences and the Oregon Cooperative Fish and Wildlife Research Unit at OSU	Basin: Prelude to estimating requirements for persistence (Clemens et al. 2010) Personal communication with Rebecca McCoun, CTGR (12/12/11)
31.	(1) Evaluate adult lamprey migration through Winchester Dam (2) Assess adult lamprey habitat at Winchester Dam in relation	Winchester Dam (not a hydroelectric project)	North Umpqua (outside of Columbia River Basin)	In 2009, 25 lamprey were radio-tagged with Lotek NTC-6-2. In 2010, 45 lamprey were radio-tagged: Lotek NTC-6-2 (6 tags), NTC-3-2 (10 tags), and MST-820T (29 tags). Fixed stations were set up at Winchester Dam as well as near major tributary	Oregon Cooperative Fish and Wildlife Research Unit	Personal communication with Ralph Lampman, OSU (12/9/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
	to temperature (3) Analyze upstream migration behavior (effects of river environment and morphology) (4) Assess adult lamprey habitat use (holding, overwintering and spawning)			junctions (Little River, Rock Creek, and Steamboat Creek). Manual tracking was conducted semiweekly (summer) and biweekly (winter) both along riverside roads and on and along the river. Passage efficiency was low in both years (8% and 19%, respectively), and all tagged lamprey that successfully passed the dam used routes other than the fish ladder. Lamprey that migrated early within the run and those with relatively small tags had higher passage rates and traveled further compared to the other groups of lamprey. Lamprey released above the dam or those that passed the dam on their own distributed themselves widely in the upstream environment, suggesting that the dam deterred their upstream migration. Most tagged lamprey that did not pass the dam remained at the base of the dam at the end of the summer season (63% in 2009 and 67% in 2010). Types of habitat most frequently used by lamprey downstream from the dam included the dam surface (wooden structures with crevices), interface zones between fast and slow water, and highway bridge pilings. Tagged lamprey were detected using thermal refuges immediately downstream from the dam that were 0.4 to 2.8 C° colder than the mean river temperature at the dam, and this temperature differential increased as the season progressed. Ninety-one percent of the overall upstream migration took place during the first spring/summer period, and only small-scale upstream movements were observed during the winter and second spring/summer (4% and 5%, respectively). During winter, 71% of the lamprey remained in the same location where they initiated holding. Multiple regression analysis indicated that the total upstream distance traveled by individual lamprey was most strongly related to presence/absence of Winchester Dam, relative tag	at OSU Partnership for Umpqua Rivers ODFW	 Advisor: Dr. Carl Schreck

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				size, and water temperature / photoperiod conditions at release. This specific project is completed, but future research is being developed by the core partners (a new lamprey passage ramp at Winchester Dam will be built in spring, 2012).		
32.	Evaluate movement and fate of adult Pacific lamprey in Columbia River reservoirs	Bonneville	Columbia	In 2011, 85 adult lampreys were tagged (60 day tags n=20; 400 day tags n=65) and released into Bonneville reservoir at Stevenson, WA or below Bonneville Dam to evaluate the effectiveness of a Juvenile Salmon Acoustic Telemetry System (JSATS) for monitoring migration. A preliminary evaluation of JSATS tag detection efficiency in fishway environments at Bonneville Day was also conducted. To date, 23 adults released into Bonneville Dam tailrace have been undetected (n=9; 39%), or last detected in the Bonneville tailrace (n=8; 35%), in the Bonneville reservoir (n=2; 9%), or in The Dalles tailrace (n=4; 17%). Mean travel time from release to the first detection in The Dalles tailrace was 7.3 d (median 7.1, range 2.8-13.4 d). Mean migration rate from release to first detection in The Dalles tailrace was 15.2 km/d (median 10.6 km/d, range 5.4-32.3 km/d). All 62 fish released at Stevenson were detected on at least one receiver in the array and 58 (94%) were first detected on the Stevenson receivers. In the Bradford Island fishway, we detected the test transmitters at all seven locations tested, though detection range was limited in some locations. Continued monitoring of the 400-day tags through winter and spring 2011-2012 will provide important information on the final distribution of	ACOE (prepared by the University of Idaho Cooperative Fish and Wildlife Research Unit)	Chris Caudill, University of Idaho, Presentation at AFEP Review, Walla Walla, WA (11/28/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				adult lamprey and help determine to what degree adult lamprey overwinter in reservoirs prior to spawning in reservoir tributaries.		
33.	Evaluate irrigation diversion screen panels and juvenile entrainment	N/A	N/A	In 2010, studies were done evaluating the efficacy of different irrigation diversion screen panels to prevent ammocoetes from becoming entrained. Phase I of this research was completed in 2011 and the development of a journal article is in process.	USGS	Personal communication with Matt Mesa, USGS (10/31/11)
	Adult Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
34.	Evaluate effectiveness of fishway modification to improve adult lamprey passage at Bonneville Dam	Bonneville	Columbia	The entrance to the Cascades island fishway at Bonneville Dam was modified by adding a variable width weir to improve performance and reduce maintenance costs. As part of the modification, bollards were added to the floor area to improve entrance success for Pacific lamprey. Radio-tagged and HD PIT-tagged lamprey were monitored during 2010 to evaluate the effectiveness of the modified entrance. In 2010, entrance efficiency was significantly higher (61.1%) than that observed in 2008 (33.3%) and 2007 (50%) prior to the modifications while entrance efficiencies at the unmodified Bradford Island fishway did not differ significantly between the two time periods. However, other passage metrics (i.e. exit ratios, passage times, etc.) did not show an improvement between pre- and post construction.	ACOE (prepared by the University of Idaho Cooperative Fish and Wildlife Research Unit)	Evaluation of adult Pacific lamprey passage at the Cascades Island fishway after entrance modification, 2010 (Clabough et al. 2011a)
35.	Evaluate passage at Bonneville, The Dalles and John Day dams	Bonneville, The Dalles, John Day	Columbia	312 adult lamprey were collected at Bonneville Dam, radio-tagged and released downstream of the dam. Of the 312 lampreys tagged, 275 (88%)	ACOE (prepared by the University	General Passage and fishway use summaries for adult

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				approached a Bonneville Dam fishway, 236 (76%) entered a Bonneville fishway, and 126 (40%) volitionally passed the dam. Three lampreys (1%) were recaptured at Bonneville Dam during the field season. At upstream dams, 96 (31%) lampreys were recorded at The Dalles Dam, 32 (10%) were recorded at John Day Dam, and 10 (3%) were recorded at McNary Dam. Lampreys approached Bonneville fishway openings 8.2 times per fish, entered fishways 2.5 times per fish, and of those that entered, lampreys exited fishways into the tailrace 2.7 times per fish, on average. Means at The Dalles Dam were 2.4 approaches, 1.7 entry, and 2.1 exits per fish that entered. Thirty-four lampreys entered John Day Dam and 32 were recorded passing on radio telemetry sites. Ten of the 32 lampreys passing John Day Dam were recorded at McNary and six passed McNary Dam. Median full-dam passage times from first tailrace record to exit from the top of a ladder were 13.0 d at Bonneville Dam, 4.9 d at The Dalles Dam, and 1.5 d at John Day Dam. Median fishway passage times from first fishway entrance to exit from the top of a ladder were 7.3 d at Bonneville Dam, and 2.0 d at The Dalles dams. Fish that exited a fishway into the tailrace had substantially longer full-dam and full-fishway passage times than those that did not exit. Overall passage improved by 8% at the Washington-shore ladder in 2010 compared to 2009 when the picket lead gate to the auxiliary water channel was raised.	of Idaho Cooperative Fish and Wildlife Research Unit and NOAA Fisheries)	Pacific lamprey at Bonneville, The Dalles and John Day dams, 2010 (Clabough et al. 2011b)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
36.	Ladder tours	Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite	Columbia and Snake	Completed a tour of fish ladders with regional fish managers and researchers to identify potential minor fishway modification opportunities.	ACOE	Personal communication with Sean Tackley, ACOE (11/4/11) and Steve Juhnke, ACOE (11/21/11)
37.	Inspect fishway at Priest Rapids and Wanapum dams and identify cases that could represent passage problems for adult Pacific lamprey	Priest Rapids, Wanapum	Columbia	In 2011, Grant PUD conducted tours during scheduled maintenance outages with the PRFF members to evaluate the modifications to the fish ladders to improve adult lamprey passage (i.e., plating installation, adult lamprey collection facilities, newly designed count stations, and ramps downstream of perched orifices) and to identify any potential passage problem areas.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/31/11)
38.	Evaluate the performance of lamprey passage structure (LPS) and collector	Bonneville	Columbia	In 2011, picketed leads at both auxiliary water supply (AWS) channels were raised by at least 3.8 cm to allow access to LPSs located in channels. During this period, lamprey collection efficiency at each LPS was significantly higher (WA-shore LPS = 49.0%, Bradford Island LPS = 125.8%) than the following month when pickets were lowered to protect salmonids (WA-shore LPS = 20.8%, Bradford Island LPS = 40.2%). Lamprey use of refuge boxes was also tested. Refuge boxes were installed along the bottom of the WA-shore AWS channel, thereby improving lamprey retention in this area. Twenty (of 929) lamprey implanted with PIT tags and released downstream from Bonneville Dam were detected in the refuge boxes. Most of these fish entered during the night and resided in the refuge box for a mean of 9.1 h (range = 0 - 23 h). Finally, at the Cascades Island LPS, tests were conducted to determine whether reducing water volume through the lower part of this structure would improve collection efficiency	ACOE (prepared by NOAA Fisheries)	Personal communication with Mary Moser, NOAA Fisheries (10/31/11).

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				and/or passage success. Lamprey use of this structure in 2011 was the highest of any previous year of operation (n = 485), and 7 PIT-tagged lamprey were detected at antennas integrated into this LPS. However, experiments to determine passage rates and passage success indicated that only 38% of PIT-tagged fish released into the structure successfully ascended to the trap at its terminus on their first attempt (mean passage time = 3.8 h, range = 1.4 – 6.2 h). These data suggest that improvements to the exit area and rest boxes are needed to retain lamprey and improve passage success at this site.		
39.	Install LPS at Dillon Diversion and design LPS for Westland Diversion	Dillon and Westland diversions	Umatilla	In 2011, the Umatilla Tribe installed an LPS at the Dillon Diversion and began design of an LPS for the Westland Diversion. Both diversion dams are located in the Umatilla River watershed.	CTUIR	Adult Lamprey Passage Improvement Report for the Umatilla River, Oregon (Jackson 2011).

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
40.	Passage improvement design	John Day	Columbia	Completed design work and awarded contracts for extensive salmonid and lamprey passage improvements to North Fish Ladder lower ladder and entrance areas. Entrance and transition pool modifications include lamprey-friendly features, such as a variable-width fixed weir, a bollard array to slow lamprey-level velocities at the fishway invert, rounded corners, ¾-inch diffuser grating, less confusing flows, diffuser plating ("lamprey sidewalks"), removal of lower ladder weirs, and a planned entrance area LPS. Construction to be completed in Winter 2011-12 and Winter 2012-13.	ACOE	Personal communication with Sean Tackley, ACOE (11/4/11)
41.	Passage improvement design	McNary	Columbia	Ongoing design refinement of an adult lamprey structure to be installed in the entrance slot of Oregon shore adult fishway (SFE1). Alternate designs were modeled and tested at Engineer Research and Development Center (ERDC) in Vicksburg, MS during 2011. Through regional collaboration a preferred design was selected, and pending addition velocity testing, design will move to construction. Passage structure to be installed in winter 2013-14.	ACOE	Personal communication with Steve Juhnke, ACOE (11/21/11)
42.	Install slotted "keyhole" fishway entrance at Project	Priest Rapids, Wanapum	Columbia	Grant PUD currently utilizes the "keyhole" fishway entrance at Priest Rapids and Wanapum dams.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/31/11)
43.	Modify dewatering procedures	All ACOE projects	Columbia and Snake	Modifications to dewatering procedures to reduce stranding and mortalities have occurred over the past several years. These include: managing dewatering to better flush fish down to the tailrace; to keep fish remaining in the ladder in standing water while dewatering to reduce the efforts by lamprey to move through gratings when stranded; and adequate personnel and equipment to ensure timely salvage. Procedures are in place and ongoing.	ACOE	Personal communication with Sean Tackley, ACOE (11/23/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
44.	Modify dewatering procedures	Wells	Columbia	Pursuant to the Wells Habitat Conservation Plan (HCP; Douglas PUD 2002), a dewatering protocol is in place.	Douglas PUD	Personal communication with Beau Patterson, Douglas PUD (11/29/11)
45.	Modify dewatering procedures	Rocky Reach, Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island HCPs (Chelan PUD 2002a and 2002b), dewatering protocols are in place.	Chelan PUD	Personal communication with Jeff Osborn, Chelan PUD (10/28/11)
46.	Modify dewatering procedures	Priest Rapids, Wanapum	Columbia	Pursuant to the Project Fishway Operation Plan, dewatering protocols are followed annually during winter maintenance and dewatering activities.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/31/11)
47.	Rehabilitate 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 will be in operation in early spring 2012 when flows decrease below a river elevation (upstream of the falls) below 54'. Current information indicated that lamprey congregate in an area of this fishway early in the migration season. Operations of this fishway will allow lamprey volitional passage to the forebay of the project.	PGE	Personal communication with Tim Shibahara, PGE (11/30/11)
48.	Initiated design work for fishway modifications	Ice Harbor, Lower Monumental	Snake	Initiated design work and awarded contract for minor modifications to fishway. Lamprey orifices in control section weir walls and diffuser grating landing plates will be installed during the winter outage period (Jan-Feb 2012).	ACOE	Personal communication with Steve Juhnke, ACOE (11/21/11)
49.	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	Chelan PUD	Pacific lamprey upstream passage modifications

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				the 2010-2011 fishway maintenance period to improve adult lamprey passage at the Project. These improvements include installation of plating at diffuser gratings throughout the ladder, ramps at perched orifices in the upper ladder, and an HDX-PIT tag detection system at key locations within the fishway.		literature review and analysis and recommendations for passage improvements in the Rocky Reach Fishway (Andersen et al. 2010) Personal communication with Jeff Osborn, Chelan PUD (10/28/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
50.	Initiated design of alternative water supply system	Bonneville	Columbia	Initiated design of alternative water supply system for the prototype Bonneville Washington Shore Fish Ladder, North Downstream Entrance (NDE) Lamprey Flume System, now to be installed in Winter 2012-13. The gravity water supply system will replace the screened pump system included in the original design. This will save on O&M costs, may provide a cost break up for initial construction, and eliminates noise concerns associated with having a 53 cfs pump in the Powerhouse 2 tailrace. The gravity flow system is currently at the 60% Plans & Specifications phase, and USACE plans to award a construction contract for the flume system in July 2012.	ACOE	Personal communication with Sean Tackley, ACOE (11/4/11)
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 auxillary 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.	EWEB	Personal communication with Andy Talabere, EWEB (11/2/11)
52.	Passage evaluation	McNary	Columbia	During 2005-2010, radiotelemetry was used to evaluate passage success for adult Pacific lamprey at McNary Dam. A total of 276 adult lamprey (ranged 18 to 84 per year) were collected at McNary Dam, outfitted with radio transmitters (and half-duplex PIT) and released downstream of	ACOE (prepared by the University of Idaho Cooperative Fish and	Adult Pacific lamprey migration and behavior at McNary Dam 2005-2010 (Keefer et al. 2011b)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				the project. An average of 58% of fish were detected again at the dam and 37% of released fish passed the dam. More lamprey first approached (43%) and first entered (50%) the south-shore fishway. Fishway passage efficiencies averaged 64% from fishway approach to ladder exit and 84% from fishway entry to ladder exit. Year-to-year variability in passage efficiency metrics was high from release through the tailrace and relatively low through the fishways. The likelihood of lamprey return to McNary Dam, lamprey passage of McNary Dam, and lamprey detection at Snake River or upper Columbia River sites was highest for larger and earlier-timed migrants. Similar patterns were observed using independent datasets from lamprey counts at dams and lampreys PIT tagged at Bonneville Dam. The combined size and timing results indicate likely environmental and/or physiological factors strongly influence migration distance in adult Pacific lamprey. Apparent difficult passage areas (locations where unsuccessful fish stopped progress) were at fishway entrances and in transition pools. Of 102 lampreys that passed McNary Dam, 34 (33%) were subsequently detected at Priest Rapids or Wanapum dams and 9 (9%) were detected at one or more Snake River dams. Fish that returned to the Snake and upper Columbia migrated at similar times (relatively early) and were among the largest in the tagged samples. A two-year fishway velocity experiment (2009-2010), where night-time velocity was reduced at Oregon shore fishway entrances, proved	Wildlife Research Unit and NOAA Fisheries)	

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				inconclusive because low run sizes and sample sizes limited statistical power in the experiment. However, the weight of evidence from this and studies at other dams and in experimental fishway experiments suggests that reduced fishway entrance velocity likely provided a benefit to lamprey passage.		
53.	Reduced water velocities at fishway entrances	Bonneville	Columbia	In 2011, continued reduced nighttime flow operations at the Washington Shore Fish Ladder to improve lamprey passage efficiency.	ACOE	Personal communication with Sean Tackley, ACOE (11/4/11)
54.	Reduced water velocities at fishway entrances	McNary	Columbia	In 2011, Continued reduced nighttime flow operations at the Oregon Shore Fish Ladder to improve lamprey passage efficiency.	ACOE	Personal communication with Steve Juhnke, ACOE (11/21/11)
55.	Assess the effects of temporary velocity reductions at fishway entrances on the (a) attraction and (b) relative entrance success of adult lampreys at Wells Dam	Wells	Columbia	DIDSON units were deployed at Wells Dam fishway entrances during the peak of historic Pacific lamprey migration in 2009 and 2010. Combining both years, a total of seven lamprey observations were recorded where lamprey were observed to encounter the entrance sill heading upstream (n=5 in 2009; and n=2 in 2010). Overall, five of the seven observations showed successful entry into the fishways (71%). During reduced head differential treatments, five observations were recorded with four of the five resulting in successful entry (80% efficiency). Pooling observations that occurred during reduced head differential treatments shows 80% (4 of 5) entrance efficiency compared to 50% (1 of 2) under the current operating condition. Despite the low numbers of lamprey observed during the two years of study, results suggest that reduced head differentials show promise in providing an environment conducive to upstream passage of lamprey.	Douglas PUD	Assessment of adult Pacific lamprey response to velocity reductions at Wells Dam fishway entrances (P.N. Johnson et al. 2011)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
56.	Lift picket leads at count station	Bonneville	Columbia	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). USACE and partners at NOAA (Mary Moser) will be looking at ways to allow the picket lead lifts without impacting sockeye or other migrants.	ACOE	Personal communication with Sean Tackley, ACOE (11/4/11)
57.	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.	ACOE	Personal communication with Sean Tackley, ACOE (11/4/11)
58.	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.	ACOE	Personal communication with Sean Tackley, ACOE (11/4/11)
59.	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.	ACOE	Personal communication with Steve Juhnke, ACOE (11/21/11)
60.	Maintain fishway operations criteria	Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island Fish Passage Plan (Chelan PUD 2010), fishway operations criteria are in place.	Chelan PUD	Personal communication with Jeff Osborn, Chelan PUD (10/28/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
61.	Maintain fishway operations criteria	Priest Rapids, Wanapum	Columbia	Pursuant to the Project Fishway Operation Plan (Grant PUD 2009), fishway operations criteria are routinely maintained.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/31/11)
	Project Passage Effectiveness					
62.	Using models to prioritize sites for fishway passage improvements	Federal projects	Columbia and Snake	Two sets of models were developed: 1) A series of lamprey escapement and distribution models were developed that were parameterized using historic data from radio- and HDX-PIT tagged fish. The models were used to assess how increased passage efficiency at an FCRPS dam will affect lamprey escapement to upriver sites, and the relative upriver escapement benefits of the improvement at single versus combinations of dams. 2) Models that were designed to improve in-season predictions of adult run timing and size (previous temperature-based model). The escapement models provide several insights into how to best prioritize lamprey passage improvements among dams. As an example, a 10% increase in passage efficiency at Bonneville increased predicted escapement to upriver sites by 15-60% over baseline values, whereas a 10% increase at The Dalles Dam had a relatively modest effect at upstream sites and had no effects at downstream sites. Simulation models that reduced lamprey passage times at individual dams had much smaller positive effects on escapement than models that increased dam passage efficiency. However, results also suggest that slow lamprey	ACOE (prepared by the University of Idaho Cooperative Fish and Wildlife Research Unit)	Matthew Keefer, University of Idaho, Presentation at AFEP Review, Walla Walla, WA (11/28/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				passage at dams may significantly constrain upstream migration distances for adult migrants when considered independently from dam passage efficiency. The revised in-season run timing/run size models improve upon the temperature based model used in recent years. In test applications using previous years' data, the new models have greater precision and narrower confidence intervals than the temperature-only model.		
63.	Video monitoring to determine adult lamprey ladder escapement	McNary and Ice Harbor	Columbia and Snake	In 2011, low light video cameras and other non-invasive technology (DIDSON) were used at McNary and Ice Harbor dams to establish lamprey passage behavior and performance at ladder structures and work towards providing accurate enumeration of lamprey ladder escapement. Results suggest monitoring of alternative lamprey passage routes or monitoring additional locations will be essential to obtaining accurate escapement estimates. A report is not yet available. As part of this study, automated visual event detection and classification software (AVEDac) was used to process underwater video data. On average, the use of the software reduced processing time (on average, 24 hours of video was condensed to 8 hours) and results indicate that with continued modification, the software shows promise by substantially reducing time spent by human annotators to review video.	ACOE (prepared by UC Davis)	Frank Loge, UC Davis, Two presentations at AFEP Review, Walla Walla, WA (11/28/11)
64.	Passage bottlenecks meta-analysis	Bonneville, The Dalles	Columbia	This project is a part of a multi-year effort to understand and improve the passage performance of adult Pacific lamprey at Lower Columbia River	ACOE (prepared by the University	Matthew Keefer, University of Idaho, Presentation

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				dams. Data from 3,250 adult lamprey collected and radio-tagged at Bonneville Dam over ten years (1997-2002, 2007-2010) was compiled to identify fishway bottlenecks at these projects. Results overall indicated that a variety of factors affected lamprey passage performance at each dam. Most important were passage route, tailwater elevation, and water temperature. There were also likely local effects such as high fishway water velocity at serpentine weirs that restricted passage. Priority sites for relieving passage bottlenecks at Bonneville Dam and the Dalles were also presented. A final report is not yet available.	of Idaho Cooperative Fish and Wildlife Research Unit)	at AFEP Review, Walla Walla, WA (11/28/11)
65.	DIDSON monitoring	Bonneville	Columbia	In the summer of 2011, a DIDSON pilot study was completed at Bonneville Dam to evaluate potential applications of this technology for evaluating lamprey behavior and passage. Overall, approximately 1400 hours of DIDSON imagery was collected. Qualitative preliminary findings indicate that we can 1) develop repeatable protocols for lamprey identification, 2) infer lamprey swimming direction, including entrance and exit behavior, 3) quantify differences in day- versus night-time activity, 4) identify lamprey depth distributions at the monitoring sites, and 5) enumerate sturgeon activity in the junction pool. A final report is not yet available.	ACOE (prepared by the University of Idaho Cooperative Fish and Wildlife Research Unit)	Chris Caudill, University of Idaho, and Peter Johnson, LGL, Presentation at AFEP Review, Walla Walla, WA (11/28/11)
66.	Evaluate fishway modifications	Priest Rapids, Wanapum	Columbia	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	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/31/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				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. Data analysis will be completed as part of 2011 activities and preliminary information included in the 2011 annual report (see Table 4, Line #7).		
67.	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) and Feed Diversion (October 2010). A flat plate was installed to aid upstream lamprey movement at Maxwell Diversion (August 2010). In fall of 2011, an LPS was installed at the Dillon Diversion Dam. In 2011, 138 adult lamprey were enumerated returning over Threemile Dam on the lower Umatilla River. Of those, 113 used the LPS to pass. No lamprey were counted at the Feed Diversion LPS in 2011. The Tribe plan to install another LPS at Westland diversion dam in FY12.	CTUIR	Personal communication with Aaron Jackson, CTUIR (12/21/11)
	Lamprey Counts at Dams					
68.	Conduct 24-hour lamprey counts	McNary, Lower Granite	Columbia and Snake	Counts include nighttime video window counts.	ACOE	Personal communication with Sean Tackley, ACOE (11/23/11)
69.	Conduct 24-hour lamprey counts	Wells	Columbia	On-going 24-hour fishway monitoring since the 1990's.	Douglas PUD	Personal communication with Beau

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
						Patterson, Douglas PUD (11/28/11)
70.	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 Jeff Osborn, Chelan PUD (10/28/11)
71.	Conduct 24-hour lamprey counts	Priest Rapids, Wanapum	Columbia	On-going 24-hour fishway monitoring since the mid 1990's.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/31/11)
72.	Non-invasive methods to evaluate Pacific Lamprey counts and passage behavior	The Dalles, John Day	Columbia	In 2011, use underwater video in fishways and 24 hr counts at fish count stations to estimate total number of adult lamprey passing dams. Data currently being processed. Report expected March 2012.	ACOE (prepared by the USFWS)	Personal communication with Chris Peery USFWS (11/30/11)
73.	Structural modifications to count station	Bonneville Dam	Columbia	In 2010, LPS structures at Bonneville Dam were fitted with web-linked counters and motion-activated counters to allow real-time updates to LPS count records. This new technology was operational in LPS systems at the facility in 2011.	ACOE	Personal communication with Mary Moser, NOAA Fisheries (10/31/11).
	Predation					
74.	Establish predation control measures (sea lions)	Bonneville	Columbia	Ongoing implementation of predation control measures such as sea lion removal efforts, although planned for salmon, are also expected to benefit adult Pacific lamprey. Efforts are being made to be sure to include concerns for lamprey and adequate monitoring of lamprey predation in future efforts.	ACOE	ACOE Pacific lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
	Juvenile Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
75.	Delayed deployment of extended length screen during outmigration	McNary	Columbia	Installation of extended screens were delayed in the spring of 2011 to reduce impacts to juvenile lamprey migrating out early.	ACOE	Personal communication with Sean Tackley, ACOE (11/23/11)
76.	JBS modifications	Little Goose	Snake	Modified JBS raceway screens mesh size to allow juvenile lamprey to volitionally pass from the raceway back to the river.	ACOE	Personal communication with Steve Juhnke, ACOE (11/21/11)
77.	JBS modifications	Lower Granite	Snake	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.	ACOE	Personal communication with Steve Juhnke, ACOE (11/21/11)
78.	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.	ACOE	Personal communication with Sean Tackley, ACOE (11/23/11)
79.	Continue salvage activities during ladder maintenance de-watering	Wells	Columbia	Pursuant to the Wells Habitat Conservation Plan (HCP; Douglas PUD 2002), a dewatering protocol is in place. Any adult lamprey captured during salvage activities are released upstream of Wells Dam, juveniles downstream per the Wells Pacific Lamprey Management Plan.	Douglas PUD	Personal communication with Beau Patterson, Douglas PUD (11/28/11)
80.	Continue salvage activities during ladder maintenance de-watering	Rocky Reach, Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island HCPs (Chelan PUD 2002a and 2002b), dewatering protocols are in place.	Chelan PUD	Personal communication with Jeff Osborn,

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
						Chelan PUD (10/28/11)
81.	Continue salvage activities during ladder maintenance de-watering	Priest Rapids, Wanapum	Columbia	Consistent with its Fishery Operations Plan (Grant PUD 2010), Grant PUD conducts salvage operations for all species during annual ladder maintenance activities.	Grant PUD	Personal communication with Mike Clement (10/31/11)
82.	Maintain bypass operations criteria	Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island Fish Passage Plan (Chelan PUD 2010), bypass operations criteria are in place.	Chelan PUD	Personal communication with Jeff Osborn, Chelan PUD (10/28/11)
83.	Maintain bypass operations criteria	Priest Rapids, Wanapum	Columbia	Grant PUD has existing bypass systems, which includes gatewells, spillways, the Wanapum Future Unit Fish Bypass (WFUFB), and Priest Rapids Top-Spill Bypass (currently under construction).	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/31/11)
	Project Passage Effectiveness					
84.	Develop PIT-tagging protocols for juvenile lamprey	N/A	N/A	In 2009-2010, fish ranging from about 100 – 190 mm in length were collected in June from the John Day Dam, transferred to the USGS laboratory, and groups of fish were subjected to one of three experiments: (1) identification of an optimal incision site for PIT tagging; (2) effect of temperature on survival of PIT-tagged juvenile lamprey in freshwater; and (3) long term survival of PIT-tagged juvenile lampreys in seawater. Experiment 1: After 33 days, no tags were lost in either the mid-ventral or lateral tag insertion groups, even though incisions were not sutured. Total mortality for control, mid-ventral and lateral insertion groups was 28.3%, 27.9%, and 21.7 % (no significant difference between groups). Most of the fish that died had fungal, parasitic, or bacterial infections. Survival was significantly	USGS	Development of standard protocols for tagging juvenile lampreys with Passive Integrated Transponder (PIT) tags. (Mesa et al. 2011)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				influenced by initial fish length but not treatment, and the odds of survival increased with fish length. Experiment 2: Survival was best (ca. 98%) at 9°C, lowest at 12°C (28%) and intermediate (64%) at 15°Cover 40 d. Experiment 3: During the first week in sweater, three fish died. No further mortality occurred until Day 94. Total mortality was about 43% for each group and did not differ significantly. Fish length at tagging significantly influenced survival and increased length improved the odds of survival. About 58% of PIT-tagged fish that survived over 180 d appeared to have fed since they increased in mass from 1 to 1,149%. The remaining fish lost 2-40% of their body weight and apparently did not feed.		
85.	Evaluation of barotrauma during hydroturbine passage	N/A	N/A	Juvenile brook and Pacific lamprey were exposed to rapid and prolonged decompression in hyper/hypobaric chambers. The conditions (e.g., acclimation pressure, nadir pressure, total dissolved gas) and procedures were similar to those used in previous tests examining the rates of injury and mortality for juvenile Chinook salmon exposed to simulated turbine passage. Generally, no mortalities or barotraumas were observed for lamprey exposed to these decompression scenarios. In contrast, previous research demonstrates mortality and barotraumas in juvenile Chinook salmon exposed to the similar conditions.	PNNL	Personal communication with Alison Colotelo, PNNL (11/4/11)
86.	Monitor passage timing, number, and mortalities of	Bonneville, McNary,	Columbia and Snake	Monitoring is occurring at all of the identified projects.	ACOE	Personal communication

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
	juvenile lamprey collected at projects with juvenile fish bypass facilities	Lower Monumental, Little Goose, Lower Granite				with Sean Tackley, ACOE (11/23/11)
87.	Juvenile lamprey monitoring	Bonneville, John Day, McNary, Lower Monumental, Little Goose, Lower Granite, and Rock Island	Columbia and Snake	The Fish Passage Center (FPC), in collaboration with Smolt Monitoring Program (SMP) staff, monitored juvenile lamprey at smolt monitoring facilities at Bonneville, John Day, McNary, Lower Monumental, Little Goose, Lower Granite, and Rock Island dams. Information collected as part of the 2011 program included lamprey identification, counts, passage timing, mortality, and condition monitoring. The SMP has requested guidance from the Lamprey Technical Work Group with regard to potential changes to the lamprey monitoring component for the 2012 sampling season.	Fish Passage Center (FPC)	Memo: Results of 2011 lamprey monitoring and request for guidance for 2012 (FPC 2011)
88.	Evaluation of prototype turbine intake emergency gatewell exclusion screens	Priest Rapids, Wanapum	Columbia	During the 2010 juvenile salmon outmigration period, turbine intake emergency wheelgate exclusion screens were monitored at the Project using DIDSON. Although the study was primarily focused on juvenile salmonid outmigrants, small numbers of lamprey were observed in the monitored locations of both dams. In total, 31 and 161 lamprey were observed at Wanapum and Priest Rapids dams, respectively. Over the entire study period, no negative impacts or screen impingement events were observed. A final report was filed with FERC on January 14, 2011.	Grant PUD	Priest Rapids Hydroelectric Project (P-2114) Gatewell Exclusion Screen Study (Grant PUD 2011)
	Predation					
89.	Establish predation control measures (pike minnows and	All ACOE projects	Columbia	Ongoing implementation of predation control measures such as harassment, avian lines, avian	BPA	ACOE Pacific lamprey passage

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
	birds)			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.		improvements implementation plan, 2008-2018 (ACOE 2009)
90.	Avian array lines	The Dalles	Columbia	Expanded avian line array to provide additional coverage in the powerhouse tailrace area, where gull predation on juvenile lamprey appeared significant in recent years. This was part of a larger effort, completed in March 2011, to revise the avian line array at The Dalles Dam.	ACOE	Personal communication with Sean Tackley, ACOE (11/4/11)
91.	Predation control measures	Wells	Columbia	As part of their HCP obligations, Douglas PUD implements predation control activities. The northern pikeminnow control program to protect outmigrating juvenile anadromous salmonids removes approximately 20,000 northern pikeminnow annually. Nonlethal avian control actions include maintenance of a wire array over the tailrace to hinder avian predators, and hazing with foot patrols, motorized vehicles (boats and pickups) and pyrotechnics. These activities are also expected to directly benefit outmigrating juvenile lamprey at the project.	Douglas PUD	Personal communication with Beau Patterson, Douglas PUD (11/28/11)
92.	Predation control measures	Rocky Reach, Rock Island	Columbia	Controlling predators of juvenile salmonids, both fish and birds, is another tool Chelan PUD is using to contribute to achieving HCP survival standards for juvenile fish. Chelan PUD's predator control program for Northern pikeminnow has reduced the number of pikeminnow known to consume large numbers of outmigrating juveniles. The program includes a sport fishing derby, a U.S. Department of Agriculture (USDA) catch-and-remove program, and a Chelan PUD funded long-lining program. Chelan PUD will also continue working with the USDA and other parties to identify and implement the best methods for deterring	Chelan PUD	Personal communication with Jeff Osborn, Chelan PUD (10/28/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				predatory birds. Since 2003, Chelan PUD has removed an average of 61,215 Northern pikeminnow annually from Rocky Reach and Rock Island Project areas combined, and a total of 428,505 Northern pikeminnow from 2003 to 2009.		
93.	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 BiOp. 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 at the project.	Grant PUD	Personal communication with Mike Clement, Grant PUD (10/31/11)
	Policy/Recovery Activities					
94.	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") finalized a lamprey restoration plan for the Columbia River basin. 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 2011 (see other categories in Table 3).	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 2009)
95.	Develop/implement implementation plan for Pacific lamprey restoration	All ACOE projects	Columbia and Snake	In July 2009, ACOE finalized its 10-year (2008-2018) passage improvements implementation plan. Pursuant to a May 2008 MOA between the Action Agencies (ACOE and USFWS), the Accord Treaty Tribes (Umatilla, Warm Springs, and Yakama) and the Columbia River Inter-Tribal Fish Commission, the ACOE collaborated with the tribes and the USFWS to develop a 10-year lamprey plan that	ACOE	ACOE Pacific lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				provides a proposed funding stream and total cost of implementing improvements, and identifies specific actions to be considered to improve lamprey passage and survival.		
96.	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 and protocol development, and participation in regional conservation and recovery activities. Early implementation of some management plan activities is underway.	Douglas PUD	Personal communication with Beau Patterson, Douglas PUD (11/28/11)
97.	Develop/implement management plan for Pacific lamprey restoration	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)
98.	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),	Grant PUD	Priest Rapids PLMP (Grant PUD 2009)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				management plan activities also include, regional data sharing and protocol development, and participation in regional conservation and recovery activities.		
99.	Assessment and template for conservation measures	N/A	N/A	In 2011, the FWS made available its Pacific Lamprey Assessment and Template for Conservation Measures document in support of its Pacific Lamprey Conservation Initiative. The conservation initiative is a three part process: assessment and template for conservation measures; conservation agreement; and regional implementation plans. The first phase of the process identifies critical uncertainties regarding Pacific lamprey life history and improves the scientific understanding of the importance of Pacific lamprey in the ecosystems of the United States.	USFWS	Pacific Lamprey Assessment and Template for Conservation Measures (USFWS 2011)
100.	Pacific lamprey and the Columbia River Crossing Project	No associated hydro project	Columbia	In 2011, an analysis of potential project effects to and minimization/mitigation measures for Pacific Lamprey resulting from the implementation of the Columbia River Crossing Project was conducted. The project is a multi-modal transportation project focused on improving safety, reducing congestion, and increasing mobility of motorists, freight, bicyclists, and pedestrians along a 5 mile section of the I-5 corridor connecting Vancouver, WA and Portland, OR.	Parametrix	Interstate 5 Columbia River Crossing. Pacific Lamprey and the Columbia River Crossing Project: A White Paper (Parametrix 2011)
101.	Pacific lamprey artificial propagation and rearing investigations	Rocky Reach	Columbia	The Rocky Reach Fish Forum (RRFF) commissioned developing a report to investigate reliable and technically feasible techniques for culturing Pacific lamprey, and identify potential facilities associated with culture techniques.	Chelan PUD	Pacific Lamprey Artificial Propagation and Rearing Investigations: Rocky Reach Pacific Lamprey Management Plan (GeoEngineers, Inc. et al. 2011)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
102.	Lamprey Technical Work Group • Passage Subgroup • Translocation 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) disseminating technical information. In 2011, the CRBLTWG met twice (5/3/11, 11/29/11). Additional subgroup meetings were convened during the year to discuss lamprey passage metrics, translocation, smolt monitoring program, NPCC synthesis reporting, and critical uncertainties revision and progress report. The Passage Standards subgroup worked on Phase 3 in 2011. Preliminary results of phase 3 will be presented in 2012. In 2011, the Translocation subgroup submitted the Translocation Review Paper to the journal Fisheries. In 2011, the CRBLTWG assisted the Fish Passage Center with including lamprey as a target species in the smolt monitoring program at FCRPS dams. Lampreys were identified, counted and at John Day dam condition was recorded. In 2011, the CRBLTWG worked on a synthesis report for NPCC that includes a synopsis of Fish and Wildlife Program projects and answers to status questions posed by the ISRP. In 2011 the CRBLTWG worked on revising the Critical Uncertainties document (2005) as well as a	USFWS	Personal communication with Christina Luzier, USFWS (11/30/11)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				progress report on the original 2005 version. This revision is currently in progress.		
103.	Pacific Lamprey Conservation Initiative	All ACOE projects, Wells, Rocky Reach, Rock Island, Priest Rapids	Columbia and Snake	The Pacific Lamprey Conservation Initiative, developed in 2007, is an effort led by the USFWS to facilitate communication and coordination for the conservation of Pacific lampreys throughout their range. The primary goal of the initiative is to develop a Pacific Lamprey Conservation Plan (Plan) which will initiate the implementation of conservation actions and research to restore and sustain habitat and Pacific lamprey populations throughout their range. In 2011, the Conservation Initiative Team released the Pacific Lamprey Assessment and Template for Conservation Measures which completes Phase 1 of the Pacific Lamprey Conservation Initiative. The USFWS is now working on Phases 2 and 3 which are a multistate, tribal and Federal Conservation Agreement and Regional Implementation Plans, respectively.	USFWS	Personal communication with Christina Luzier, USFWS (11/30/11)

Notes:

ACOE = Army Corps of Engineers
AWS = auxiliary water supply
BPA = Bonneville Power Administration
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
DIDSON = Dual-frequency Identification Sonar
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
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
PLMP = Pacific Lamprey Management Plan
PNNL = Pacific Northwest National Laboratory, Battelle

PRFF = Priest Rapids Fish Forum
PUD = Public Utility District
RM = river mile
RRFF = Rocky Reach Fish Forum
USBOR = U.S. Bureau of Reclamation
USFWS = U.S. Fish and Wildlife Service
USGS = U.S. Geological Survey

3.0 Status of Pacific Lamprey Activities at the Priest Rapids Project

Pursuant to the requirements of Grant PUD's PLMP (Grant PUD 2009) and specifically for this comprehensive annual report (as described in Section 1.2 above), activities at the Project related to Pacific lamprey are described in Table 4. 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 2011, and any variations in schedule. In general, measures are currently on or ahead of schedule.

Table 4 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 2011	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, 2012.	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 recovery 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.	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 67 PIT tags at Priest Rapids and 38 at Wanapum. Fish passage efficiency (FPE) and passage times are being calculated, although the sample size is insufficient for statistical comparisons.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2011	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 fish video count stations at the Project 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 2011	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 left and right bank fishways and the Wanapum left bank fishway facilities during the 2010-2011 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 is 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. Fish passage efficiency (FPE) and passage times are being calculated, although the sample size is insufficient for statistical comparisons. Data analyses are conducted yearly.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2011	Variation from Schedule (if applicable)
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)	Yes	Grant PUD completed improvements proposed in the FLA and included in the FERC License. Modifications at Priest Rapids Dam include plating at edges of diffusion grating, plating through orifices adjacent to diffusion grating, ramps at perched orifices, and new crowders at fish counting stations designed for both lamprey and salmonids. These structural improvements were completed during the 2009-2010 winter fish ladder maintenance outage.[1]	No
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. Fish passage efficiency (FPE) and passage times are being calculated, although the sample size is insufficient for statistical comparisons. Based on two years of monitoring, estimated FPE for Priest Rapids Dam is 82% and estimated FPE for Wanapum Dam is 82%.	Yes, ahead of schedule. An evaluation program was implemented in 2010 and was continued in 2011.

[1] Typically scheduled between December 1 and February 28.

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2011	Variation from Schedule (if applicable)
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
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 after evaluation of existing fishway modifications (see PRFF meeting minutes for May 5, 2010).	No
10.	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
11.	Participate in regional studies, forums and measures and cooperate with other entities performing those activities when useful information may be obtained about Project impacts on adult Pacific lamprey. Forums will include (but not limited to) the Columbia River Basin Lamprey Technical Workgroup.	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
12.	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 2011	Variation from Schedule (if applicable)
Objective 3: Provide safe, effective and timely volitional passage for juvenile migration					
13.	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.	No
14.	Develop juvenile Pacific lamprey passage criteria	Unspecified	No	None. At this time, technology does not exist to measure juvenile Pacific lamprey passage.	No
15.	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 Columbia River Basin Lamprey Technical Workgroup.	Annually for the life of the license	Yes	Grant PUD is an active participant in all regional forums including workgroups, subgroups, initiatives and associated meetings that are described in Table 3 of Section 2.2.	No
Objective 4: Avoid and mitigate Project impacts on rearing habitat					
16.	Determine juvenile lamprey presence / absence, habitat use, and relative abundance in the Project area. If significant ongoing effects are identified, Grant PUD shall develop a plan and implement reasonable and feasible measures to address such effects.	No later than 10 years following license issuance (2018)	No	Currently, options for measuring Project effects on juvenile Pacific lamprey habitat are under consideration by the PRFF. 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.	No

Notes:
CRITFC = Columbia River Inter-Tribal Fish Commission
FERC = Federal Energy Regulatory Commission
FLA = Final License Application
FPE = Fish Passage Efficiency
NOAA = National Oceanic and Atmospheric Administration
PIT = Passive Integrated Transponder
PLMP = Pacific Lamprey Management Plan
PRFF = Priest Rapids Fish Forum
PUD = Public Utility District
USFWS = U.S. Fish and Wildlife Services

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 5 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 3 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 3. For planned or proposed efforts (which are not identified as current activities in Table 3) the source of the information is noted at the end of Table 5.

Table 5 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[1] or Proposed = PR[2]	River(s)	Table 3 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	No associated hydro project (I) BOR projects in Yakima (I) Winchester Dam (not a hydro project) (I)	Fifteen Mile Creek Yakima North Umpqua	#1 #3 #31	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
2.	Develop measures to protect spawning habitat	Wells (P) Rocky Reach (P)	Columbia Columbia	N/A[3] N/A[4]	No.	No. This activity is not required by Grant PUD's PLMP.	N/A
3.	Monitor adult population status and trends (unrelated to counting at hydroelectric projects)	No associated hydro project (I) BOR projects in Yakima (I) N/A (I) Willamette Falls (I)	Fifteen Mile Creek Deschutes and tributaries Yakima Clearwater, Salmon, and Snake Willamette	#1 #2 #3 #4 #5	No.	No. This activity is not required by Grant PUD's PLMP.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
4.	Determine the extent of juvenile rearing habitat	No associated hydro project (I) Bonneville (I) Wells (P) Rocky Reach (P) Priest Rapids and Wanapum (P)	Fifteen Mile Creek Lower Columbia White Salmon, Wind and Klickitat Columbia Columbia Columbia Columbia	#1 #7 #8 #6 N/A[3] N/A[4] N/A[5]	No.	Yes. PLMP Objective 4 requires quantification of lamprey habitat in the Project area.	Yes. Habitat surveys will be conducted to detect presence/absence and Project effects within the PRPA within 10 years of license issuance.
5.	Develop measures to protect juvenile rearing habitat	No associated hydro facilities (I) Wells (P) Rocky Reach (P)	Fifteen Mile Creek Columbia Columbia	#1 N/A[3] N/A[4]	No.	No. This activity is not required by Grant PUD's PLMP.	N/A
6.	Monitor juvenile population status and trends (unrelated to counting at hydroelectric projects)	N/A (I) No associated hydro project (I) Willamette Falls (I) Wells (P) Rocky Reach (P) Priest Rapids and Wanapum (P)	Clearwater, Salmon, and Snake Hood Yakima Entiat and Wenatchee Methow Methow (Chewuch) Willamette Columbia Columbia Columbia	#4 #9 #11 #12 #13 #14 #15 N/A[3] N/A[4] N/A[5]	No.	Yes. PLMP Objective 4 requires the assessment of juvenile presence / absence and relative abundance.	Yes. Population surveys will be conducted to detect presence / absence and Project effects within the PRPA within 10 years of license issuance.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 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	N/A (I) N/A (I) Willamette Falls (I)	N/A N/A Willamette	#16 #17 #18	No.	No. This activity is not required by the PLMP. Evaluating lamprey physiology, energy use, and swimming performance are not objectives, goals, or measures outlined in the PLMP.	N/A
8.	Evaluate, implement and/or monitor translocation or supplementation programs	Rocky Reach (I)	Columbia	#101	Yes.	No. This activity is not required by Grant PUD's PLMP.	N/A
9.	Evaluate the impact of contaminants on lamprey	No associated hydro project (I) No associated hydro project (I)	Willamette and Siletz Lower Willamette	#20 #21	No.	No. This activity is not required by the PLMP. Evaluating the impact of contaminants on lamprey are not objectives, goals, or measures outlined in the PLMP.	N/A
10.	Develop new technologies / methodologies / protocols for lamprey	No associated hydro projects (I) Willamette Falls (I) Bonneville (I) N/A (I)	Fifteen Mile Creek Lower Columbia White Salmon, Wind, and Klickitat Snake Willamette Columbia N/A	#1 #7 #8 #22 #5 #6 #23	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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
11.	Determine genetic structure and maintain genetic integrity	No associated hydro projects (I) PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	Entiat and Wenatchee Willamette (Agendy Creek) N/A	#24 #25 #26	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
12.	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	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
13.	Evaluate the need for a lamprey aquaculture facility based upon a limiting factor analysis	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	#101	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[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
14.	Restore tributary habitat and passage	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A	No.	No. This activity is not required by the PLMP. Radio-telemetry studies conducted in 2001-2002 did not show use of any tributaries in the PRPA (Nass et al. 2003).	N/A
	Lamprey Migration in Rivers						
15.	Evaluate adult migration in rivers	Bonneville (I) Dalles (I) John Day (I) McNary (I) Ice Harbor (I) Lower Monumental (I) Little Goose (I) Lower Granite (I) Priest Rapids (I) Wanapum (I) No associated hydro project (I) Winchester Dam (not a hydro project) (I)	Columbia Columbia Columbia Columbia Snake Snake Snake Snake Columbia Willamette North Umpqua	#27, 28, 29, 32 #27, 29 #27, 29 #27, 29 #27, 29 #27 #27 #27 #27, 29 #30 #31	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 and 2011 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.
16.	Assess impacts of irrigation water withdrawal structures on juvenile passage/habitat	N/A (I)	N/A	#33	No.	No. This activity is not required by the PLMP. Assessing the impacts of irrigation water withdrawal are not objectives, goals, or measures outlined in the PLMP.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 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) Dalles (I) John Day (I) McNary (I) Ice Harbor (I) Lower Monumental (I) Little Goose (I) Lower Granite (I) Priest Rapids and Wanapum (I) Wells (P)	Columbia Columbia Columbia Columbia Snake Snake Snake Snake Columbia Columbia	#34, 35, 36 #35, 36 #35, 36 #36 #36 #36 #36 #36 #37 N/A[3]	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, although the sample size is insufficient for statistical comparisons.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 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	Rocky Reach (I) Priest Rapids and Wanapum (I) Wells (P)	Columbia Columbia Columbia	#49 #98 N/A[3]	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) John Day (I) McNary (I) Dillon and Westland diversions	Columbia Columbia Columbia Umatilla	#38 #40 #41 #39	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 project, this method would not be appropriate to implement.	N/A
20.	Design / install bollard arrays	John Day (I)	Columbia	#40	No.	No. This activity is not required by the PLMP.	N/A
21.	Install / evaluate / operate slotted “keyhole” fishway entrances	Priest Rapids and Wanapum (I) John Day (P) McNary (P)	Columbia Columbia Columbia	#42 N/A[6] N/A[7]	Yes.	Yes. Keyhole entrances are currently utilized at both Wanapum and Priest Rapids dams.	Yes. See adjacent response.
22.	Develop / implement / evaluate ladder dewatering procedures	All ACOE projects[8] (I) Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia / Snake Columbia Columbia Columbia Columbia	#43 #44 #45 #45 #46	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
23.	Rehabilitate old or existing fishway for lamprey passage	Willamette Falls (I)	Willamette	#47	No.	Yes. Subsequent to fishway modifications completed in 2009-2010 outage at Priest Rapids and Wanapum dams, Grant PUD and the PRFF will continue to assess the applicability, feasibility, and appropriateness of other potential modifications.	Yes, as determined by Grant PUD and the PRFF.
24.	Address issues with diffuser gratings, 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) Other ACOE projects (exact ones unspecified) (P) Wells (P)	Columbia Columbia / Snake Columbia	#40 N/A[6] N/A[3]	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 grating that is 11/16-inch gap to ensure accurate adult counts.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
25.	Install/evaluate plates over diffuser along the bases of walls and weir	John Day (I) Ice Harbor (I) Lower Monumental (I) Rocky Reach (I)	Columbia Snake Snake Columbia	#40 #48 #48 #49	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.
26.	Install lamprey orifices	Ice Harbor (I) Lower Monumental (I)	Snake Snake	#48 #48	Yes.	No. The PLMP does not include a specific PM&E measure related to this activity, nor has it been identified by Grant PUD and the PRFF as an appropriate measure to implement at Priest Rapids and Wanapum dams.	N/A
27.	Install/evaluate ramps at sills and lips	The Dalles (P) John Day (P) McNary (P) Ice Harbor (P) Rocky Reach (P)	Columbia Columbia Columbia Snake Columbia	N/A[7] N/A[7] N/A[7] N/A[7] N/A[9]	Yes.	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD has committed to this activity as part of its ladder modification plan.	Yes. Grant PUD installed aluminum ramps during the 2009-2010 winter fish ladder outage at every perched orifice in the Priest Rapids Dam fishways.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
28.	Round sharp corners	John Day (I) Rocky Reach (I) Trail Bridge Dam (I) Ice Harbor (P)	Columbia Columbia McKenzie Snake	#40 #49 #51 N/A[7]	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
29.	Install monitoring technology (e.g., HDX-PIT arrays)	Rocky Reach (I)	Columbia	#49	Yes.	Yes. Grant PUD committed to the installation of a monitoring technology in their PLMP.	Yes. Grant PUD installed HDX-PIT systems during the 2009-2010 fishway outage. The arrays was operated during the 2010 and 2011 migration seasons.
30.	Design / install of water supply systems	Bonneville (I) Trail Bridge Dam (I)	Columbia McKenzie	#50 #51	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[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
31.	Reduce/evaluate ladder entrance flow velocities at night	Bonneville (I) McNary (I) Wells (I) Priest Rapids (P) Ice Harbor (P)	Columbia Columbia Columbia Columbia Snake	#53 #52, 54 #55 N/A[10] N/A[6]	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).
32.	Modify/evaluate weir head differentials	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
33.	Manage flows to a peaking hydrograph	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A	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
34.	Establish protocol for formal inspection of passage facilities	Priest Rapids and Wanapum (I)	Columbia	#98	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.
35.	Establish protocol for annual lamprey passage reporting	Priest Rapids and Wanapum (I)	Columbia	#98	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.
36.	Develop and/or maintain fishway operations criteria	Bonneville (I) Dalles (I) John Day (I) McNary (I) Ice Harbor (I) Lower Monumental (I) Little Goose (I) Lower Granite (I) Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia Columbia Columbia Columbia Snake Snake Snake Snake Columbia Columbia Columbia Columbia	#56 #57 #58 #59 #59 #59 #59 #59 #96 #97 #60 #61	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 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).

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 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						
37.	Develop adult lamprey passage criteria	Rocky Reach (P) Priest Rapids and Wanapum (P)	Columbia Columbia	N/A[4] N/A[5]	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.
38.	Passage modification prioritization	Federal projects	Columbia and Snake	#62	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[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
39.	Evaluate effectiveness of dam passage	Bonneville (I) The Dalles (I) John Day (I) McNary (I) Ice Harbor (I) Lower Monumental (I) Little Goose (I) Lower Granite (I) Priest Rapids (I) Wanapum (I) Winchester Dam (not a hydro project) (I) Rocky Reach (P)	Columbia Columbia Columbia Columbia Snake Snake Snake Snake Columbia Columbia North Umpqua Columbia	#27, 36, 64, 65 #27,36, 64 #27, 36 #27, 52, 63 #27, 63 #27 #27 #27 #27, 66 #66 #31 N/A[4]	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 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. Fish passage efficiency (FPE) and passage times are being calculated, although the sample size is insufficient for statistical comparisons. Based on two years of monitoring, estimated FPE for Priest Rapids Dam is 82% and estimated FPE for Wanapum Dam is 82%.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
40.	Evaluate upstream passage modifications	Priest Rapids and Wanapum (I) Rocky Reach (P) [Note: evaluations performed on existing structural / operational improvements at ACOE dams are identified earlier in the table, under the heading, *Structural and Operational Fishway Modifications*.]	Columbia Columbia	#67 N/A[4]	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 modification 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 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. Fish passage efficiency (FPE) and passage times are being calculated, although the sample size is insufficient for statistical comparisons.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 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						
41.	Develop feasibility, techniques, and protocols to improve 24-hour counting / conduct counts	McNary (I) Dalles (I) John Day (I) Lower Granite (I) Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia Columbia Columbia Snake Columbia Columbia Columbia Columbia	#68 #72 #72 #68 #69 #70 #70 #71	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.
42.	Develop/evaluate passage alternatives related to count facilities	Bonneville (I) Wells (P)	Columbia Columbia	#73 N/A[3]	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.
	Predation						
43.	Establish predation control measures (sea lions)	Bonneville (I)	Columbia	#74	Yes.	No. Sea lions are not present in the PRPA.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
	Juvenile Passage at Hydroelectric Facilities						
	Structural and Operational Fishway Modifications						
44.	Conduct a literature review of juvenile Pacific lamprey passage and survival	Priest Rapids and Wanapum (I) Wells (P)	Columbia Columbia	#98 N/A[3]	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.
45.	Replace turbine intake screens with smaller spacing	All ACOE projects (P)	Columbia / Snake	N/A[7]	No.	No. Grant PUD dams are not equipped with turbine intake or diversion screens.	N/A
46.	Lift/remove extended length screens during outmigration	McNary (I)	Columbia	#75	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
47.	Manage flows to a peaking hydrograph	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A	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[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
48.	JBS modifications	Little Goose (I) Lower Granite (I)	Snake Snake	#76 #77	Yes.	No. Grant PUD has existing bypass systems, which includes gatewells, spillways, the Wanapum Future Unit Fish Bypass (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.
49.	Establish/continue salvage activities during ladder maintenance de-watering	All ACOE projects (I) Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia / Snake Columbia Columbia Columbia Columbia	#78 #79 #80 #80 #81	Yes.	Yes. Dewatering procedures were identified as existing at the Project in the PLMP.	Yes. Grant PUD operates its fishways according to the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for dewatering and the recovery of all fish during all maintenance activities.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
50.	Develop and/or maintain bypass operations criteria	Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia Columbia Columbia Columbia	#96 #97 #82 #83	Yes.	Yes. Grant PUD has existing bypass systems, which includes gatewells, spillways, the Wanapum Future Unit Fish Bypass (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 operations.
	Project Passage Effectiveness						
51.	Evaluate tagging and development of miniature tags	N/A	N/A	#84	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
52.	Develop juvenile lamprey passage criteria	Priest Rapids and Wanapum (P)	Columbia	N/A[5]	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
53.	Evaluate downstream passage and survival when technology available	Wells (P) Rocky Reach (P) Priest Rapids and Wanapum (P)	Columbia Columbia Columbia	N/A[3] N/A[4] N/A[5]	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.
54.	Laboratory passage evaluation	N/A (I)	N/A	#85	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
55.	Monitor passage timing, number, and mortalities of juvenile lamprey collected at projects with juvenile fish bypass facilities	Bonneville (I) John Day (I) McNary (I) Lower Monumental (I) Little Goose (I) Lower Granite (I) Rock Island (I)	Columbia Columbia Columbia Snake Snake Snake Columbia	#86, 87 #87 #686, 87 #86, 87 #86, 87 #86, 87 #87	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
56.	Monitor and report on juvenile impingement	Rocky Reach (I) Priest Rapids and Wanapum (I)	Columbia Columbia	#97 #88	Yes.	Yes. Grant PUD did not conduct any monitoring activities in 2011 that would result in observation of juvenile impingement. However, neither Priest Rapids or Wanapum dams are equipped with turbine intake or diversion screens.	N/A.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
	Predation						
57.	Continue predation control measures (pike minnows and birds)	<u>Pike minnow only</u> All ACOE projects (I) <u>Pike minnow and birds</u> Dalles (I) Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia / Snake Columbia Columbia Columbia Columbia Columbia	#89 #90 #91 #92 #92 #93	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 be expected to provide a benefit to lamprey.
	<u>Policy and Recovery Activities</u>						
58.	Develop/implement Pacific Lamprey Management Plans	All ACOE projects (I) Wells (I) Rocky Reach (I) Priest Rapids and Wanapum (I)	Columbia / Snake Columbia Columbia Columbia	#94, 95 #96 #97 #98	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 this plan is in progress.
59.	Establish regional data protocols for collection, storage and analysis; develop means to widely access and share information	All ACOE projects (I) Wells (I) Rocky Reach (I) Priest Rapids and Wanapum (I) N/A (I)	Columbia / Snake Columbia Columbia Columbia N/A	#94, 95 #96 #97 #98 #99	Yes.	Yes. PLMP Objectives 2 and 3 require “Regional Studies” which includes participation and cooperation in studies where useful information may be obtained about project impacts to lamprey.	Yes. Grant PUD participates in regional forums such as the Columbia River Basin Lamprey Technical Workgroup the USFWS Lamprey Conservation Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
60.	Establish coordinated public education and other outreach programs	Priest Rapids and Wanapum (I)	Columbia	#98	No.	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD participates in education 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.
61.	Participate in regional lamprey activities	All ACOE projects (I) Wells (I) Rocky Reach (I) Priest Rapids and Wanapum (I)	Columbia / Snake Columbia Columbia Columbia	#94, 95, 102, 103 #96 #97 #98	Yes.	Yes. PLMP Objectives 2 and 3 require "Regional Studies" which includes participation and cooperation in studies where useful information may be obtained about Project impacts to lamprey.	Yes. Grant PUD participates in regional forums such as the Columbia River Basin Lamprey Technical Workgroup the USFWS Lamprey Conservation Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.
62.	Environmental analysis and feasibility investigations	No associated hydro projects (I) Rocky Reach (I)	Columbia Columbia	#100 #101	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 for implementation in the ACOE Pacific Lamprey Passage Improvement Implementation Plan (ACOE 2009) or the mid-Columbia PUDs' Pacific lamprey management plans (Chelan PUD 2005, Grant PUD 2009, and Douglas PUD 2009, respectively), that has not yet been implemented.
2. 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.
3. Per requirement in Wells Project PLMP (Douglas PUD 2009).
4. Per requirement in Rocky Reach PLMP (Chelan PUD 2005).
5. Per requirement in Priest Rapids PLMP (Grant PUD 2009); see Table 4 for status.
6. Per commitment in ACOE's 10-year implementation plan (ACOE 2009).

7. Per personal communications with David Clugston, ACOE (11/9/09, 11/10/09, and 12/11/09).
8. "All ACOE projects" includes Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite.
9. Planned for 2010-2011 fishway maintenance period, per personal communication with Jeff Osborn, Chelan PUD (12/13/10).
10. An evaluation of reducing fishway flows at night was planned for the 2009-2010 winter work period; however, the evaluation was not done (as agreed to by the PRFF) as returning numbers were insufficient.

ACOE = Army Corps of Engineers
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
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 third 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;
2). Evaluate the passage of adult lamprey through sections of the Priest Rapids fishways where new structures have been installed to facilitate upstream movement;
3). Determine if a reduction of flow (i.e., velocity) in the lower fishways at Priest Rapids Dam affects the use and passage of lamprey in lower sections of the fishway.

In 2010 and 2011, the returns of adult Pacific lamprey were historically low. As a result, tagging activities and parts of the study were cancelled by Grant PUD in consultation with the PRFF so that there would be no additional handling-effects. Further, the PRFF and NOAA Fisheries determined that objective 3 (reduction in flows) was not appropriate to implement given its potential impacts on the passage of migrating salmon.

In summary, all three of the 2010-2011 study plan objectives were modified to some extent. Despite these limitations, Grant PUD was able to continue studying aspects of objectives 1 (dam passage efficiency) and 2 (use of fishway structures) through the use of passive monitoring techniques. First, using the newly installed HDX-PIT detection array at Priest Rapids and Wanapum dams, Grant PUD monitored the passage of lamprey that had been tagged at ACOE projects in the lower Columbia River, and added valuable information to the cumulative data set (Appendix C). Second, Grant PUD analyzed the underwater video of lamprey collected in 2010 to assess the use of plating on diffusion grates, through orifices, and at the new fish count station crowders (Appendix D).

In 2012, 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 2011-2012 winter fish ladder maintenance outage.
2). Pre-season testing and calibration of HDX-PIT arrays.
3). Tracking lamprey enumeration statistics for the Priest Rapids Project and lower Columbia River dams.
4). Pilot study on the distribution and abundance of juvenile lamprey in the operations zone of the PRPA.

Assuming the trend toward increased tagging effort in the lower Columbia River, monitoring activities will begin in April and continue until the seasonal migration of lamprey appears to have ceased. HDX-PIT technology will be used to monitor the behavior of adult Pacific lamprey, and quantify the overall passage effectiveness through standard metrics (Nass et al. 2003). Data

analysis and reporting will be conducted through the period November 15, 2012 and March 31, 2013, respectively.

Grant PUD will implement a pilot study on the distribution and relative abundance of juvenile lamprey in the operations zone of the Project area. More specifically, desk top assessments and field surveys determining juvenile lamprey presence and habitat use will be conducted for biologically appropriate locations within elevations consistent with the low and high water levels for operations. The main purpose of this initial and reconnaissance level survey is to develop and test the effectiveness of a methodological approach for identifying potential Project effects on juvenile lamprey.

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
PRFF Comments on Draft PLMP Comprehensive Annual Report

From:	Mike Clement
To:	Debbie Firestone
Subject:	FW: Draft 2011 Pacific Lamprey Management Plan Comprehensive Annual Report comments
Date:	Thursday, March 01, 2012 3:09:05 PM

From: Mangold, Marcie (ECY) [mailto:DMAN461@ECY.WA.GOV]
Sent: Tuesday, January 31, 2012 3:29 PM
To: Mike Clement
Cc: Moore, David (ECY)
Subject: Draft 2011 Pacific Lamprey Management Plan Comprehensive Annual Report comments

Mike,

Thank you for the opportunity to review and comment on the **Draft 2011 Pacific Lamprey Management Plan Comprehensive Annual Report** that you provided via email to Ecology on January 28, 2012. We are providing the following comments for your consideration.

In the Executive Summary and in Table 4, it is mentioned that the overall estimated fish passage efficiency for lamprey at the Projects is 82%, but not mentioned in Section 2.1.4 Adult Passage at Hydroelectric Facilities. Would it be possible to mention it in this Section?

In the Literature Cited, your personal communications are referenced in the body of the document, but not in the Literature Cited section.

Overall this was an excellent comprehensive annual report summarizing the activities GPUD has undertaken regarding Pacific Lamprey. Again thank you for the opportunity to review and comment. Please feel free to contact me with any further comments or questions.

Thank you,

D. Marcie Mangold
Department of Ecology
Water Quality Program
phone (509) 329 3450
fax (509) 329 3570

Appendix B
Summary of PRFF Comments on Draft PLMP Comprehensive Annual Report and Grant PUD Responses

Summary Table of Agency/Tribal Comment and Grant PUD Responses for 2011 PLMP Annual Comprehensive Report

Submitting Entity	Date Received	Paragraph #	Agency Comment	Grant PUD Response
Ecology	1/31/12	Executive summary and in Table 4	These sections mention that the overall estimated fish passage efficiency for lamprey at the Projects is 82% but this is not mentioned in Section 2.1.4 Adult Passage at Hydroelectric Facilities. Would it be possible to mention it in this section?	Grant PUD has inserted language regarding overall estimated Project fish passage efficiency information into Section 2.1.4 of the document (paragraph 3, pg. 14) per this request.
Ecology	1/31/12	Literature Cited section	Personal communications are noted in the body of the document but are not included in the Literature Cited section.	Grant PUD has cited all personal communications found in the body of the document in the Literature Cited section.
Ecology	1/31/12	General Comment	Overall this was an excellent comprehensive annual report summarizing the activities GPUD has undertaken regarding Pacific Lamprey. Again thank you for the opportunity to review and comment. Please feel free to contact me with any further comments or questions.	Comment noted.

Appendix C Adult Lamprey Assessment using HD PIT: Presentation to the PRFF

Lamprey in Priest Rapids Project

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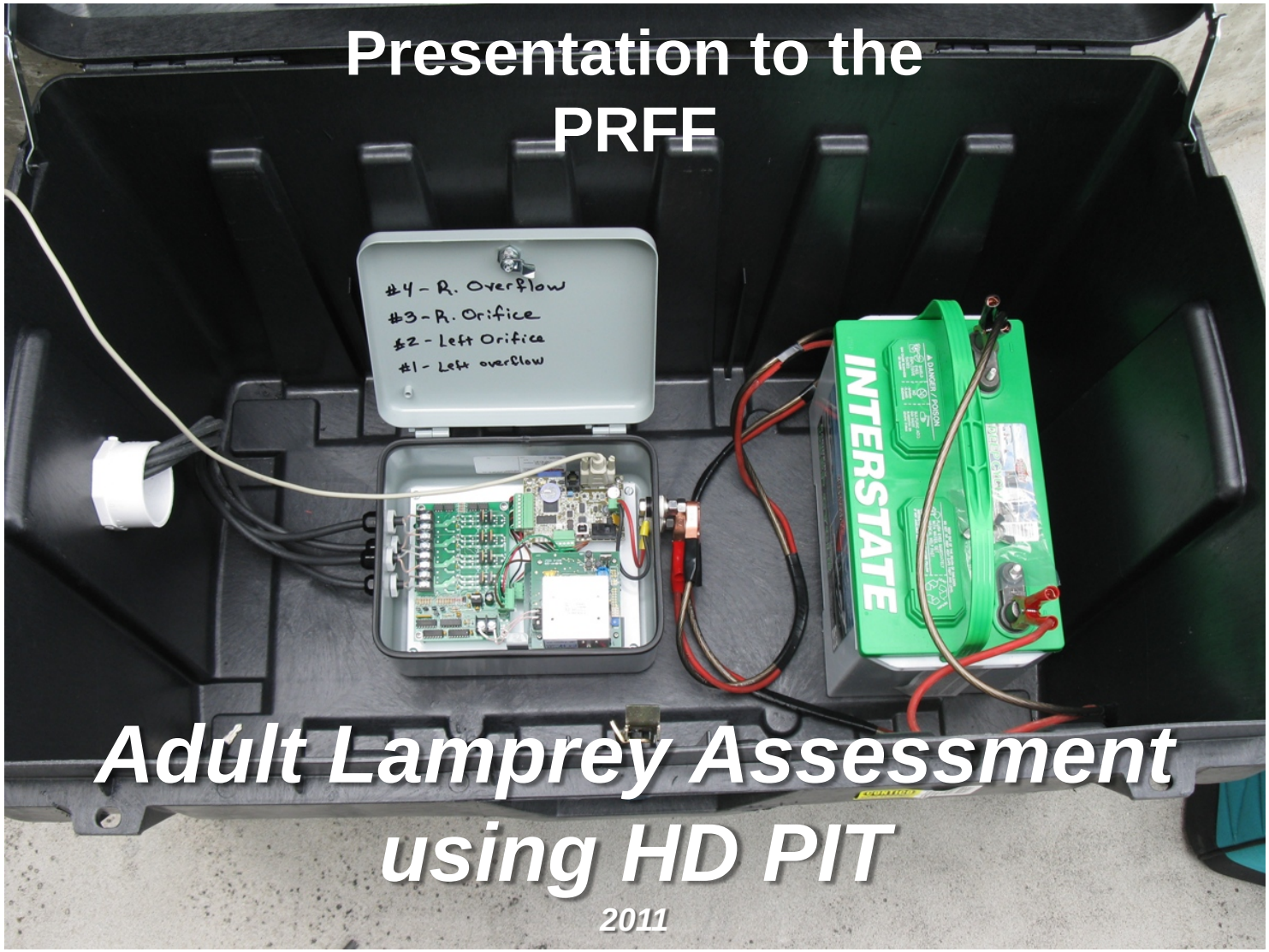

Presentation to the PRFF

Adult Lamprey Assessment using HD PIT

2011

Presentation Outline

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- Background
- Objectives
- Approach
- Activities
- Methods
- Results

Background

2010 season

- GPUD implements PRFF approved study plan;
- Low run year – passive monitoring of tags applied downstream;
  - 470 fish tagged with 94 (20%) predicted to make it past McNary.

2011 season

- Continued passive monitoring;
  - 1000 fish tagged with 200 (20%) predicted to make it past McNary.

Study Objectives

- Study Plan
  - "*Assessment of Pacific Lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams*"
- Relevant Objectives
  - Determine the FPE for adult lamprey at Priest Rapids and Wanapum dams;
  - Evaluate the passage of adult lamprey through sections of the Priest Rapids fishways where new structures have been installed to facilitate upstream movement.

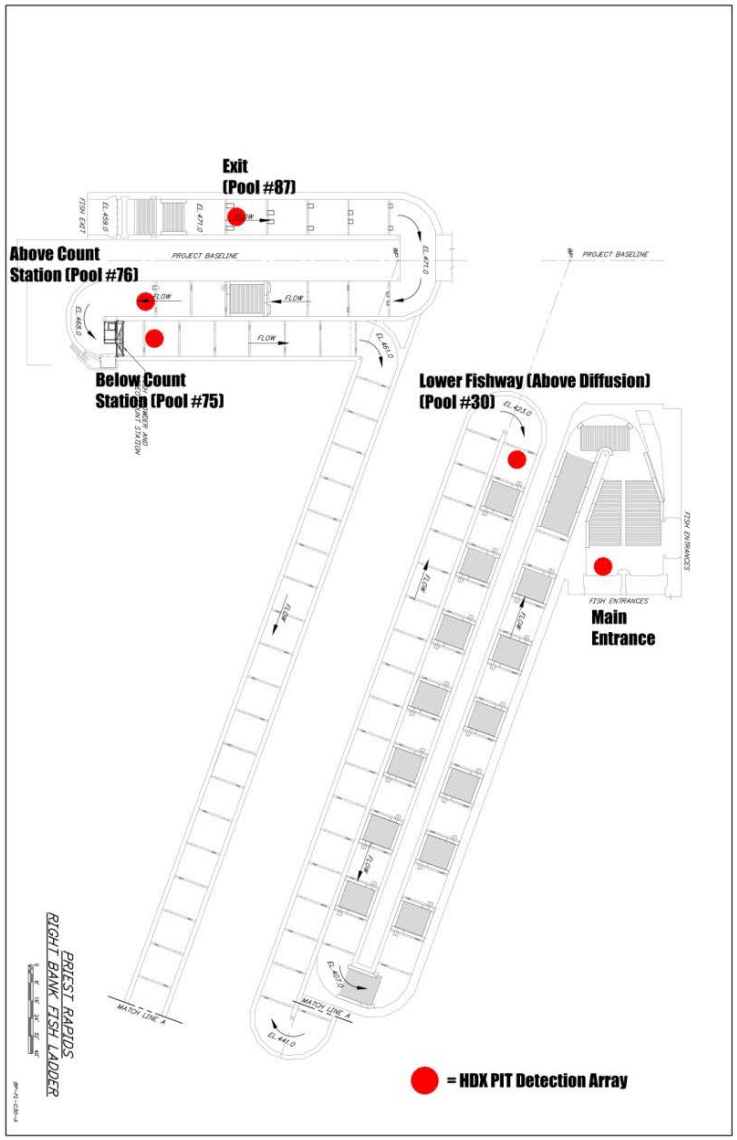
Study Approach – Passage Metrics

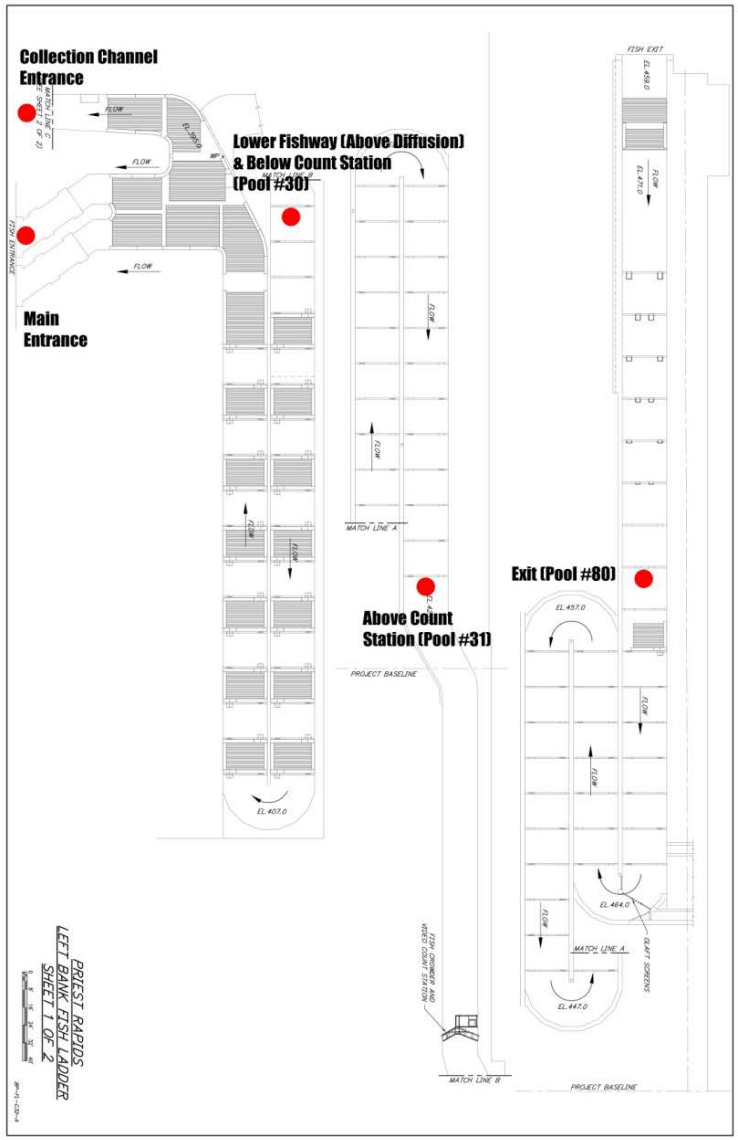
- HD PIT
  - Uniquely identifiable fish;
  - Application to entire size range of population;
  - Antennas installed at strategic locations;
- Fishway efficiency
  - Number of exits divided by number entrances.
- Travel times
  - Time at location B minus time at location A.

Study Activities

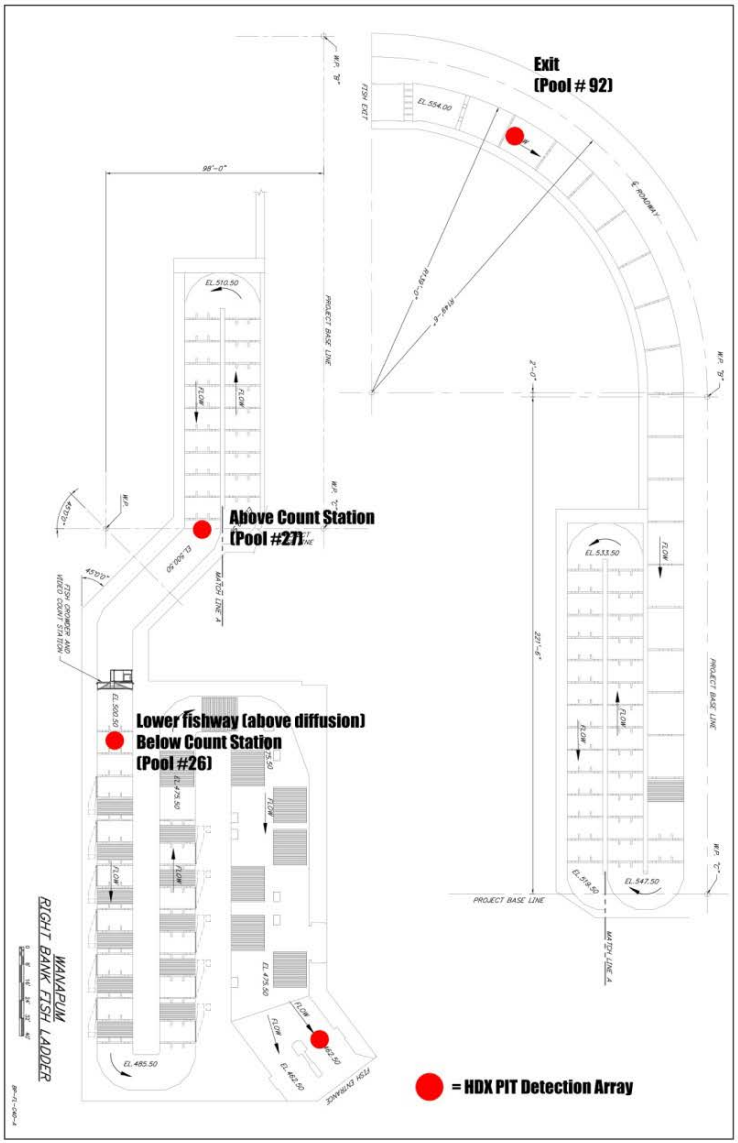
- Redeploy and test HD PIT array;
- Operate array during lamprey passage;
- In-season data processing;
- Conduct analysis of lamprey detections to estimate passage metrics;

Priest Rapids arrays





Wanapum arrays



HD PIT - Configuration

HD PIT – Data Processing

- Diagnostics and download every two weeks;
- QA/QC Rx files;
- Review Rx files for valid codes;
- Import Rx files into Telemetry Manager;
- QA/QC individual fish histories;
- Calculate metrics.

HD PIT results – Synopsis ‘10 + ‘11

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	PR	WA
Unique tags detected at dam	67	38
Total passage and exit	46	31
Right passage and exit	15	10
Left passage and exit	31	21
Total detected at only entrance	5	4
Right entrance	2	0
Left entrance	3	4
Total last detected in fishway	16	3
Right fishway	2	1
Left fishway	14	2
Total last in upstream pool	8-12	31

Total at dam = exit + only entrance + last fishway
2010 tags – 14 PR, 9 WA
Based on last detections

HD PIT results – FPE fishways

Fish Passage Efficiency (2010 & 2011)				
	Left	Right	Total	2002
Priest	57% (30 of 53)	71% (17 of 24)	70% (47 of 67)	87% (41 of 47)
Wanapum	71% (22 of 31)	69% (9 of 13)	82% (31 of 38)	82% (23 of 28)

Minimum estimates. Cannot account for fish at large. Eight (8) tagged recoveries at PR released upstream give an adjusted FPE of 82%.

HD PIT results – FPE Count Stations

Passage Times	Priest Left	Priest Right	Wanapum Left	Wanapum Right
median (minutes)	25	13	11	7
count (n)	31	14	18	11
Passage Success	**Priest Left**	**Priest Right**	**Wanapum Left**	**Wanapum Right**
# encounter	44	20	22	12
# passed	44	20	22	12
# did not pass	0	0	0	0
% Passage Success	100%	100%	100%	100%

HD PIT – Fallback Events

2010 & 2011	PR	WA
Fallback	4 of 46 (8.7%)	2 of 31 (6.5%)
Reascend	3	1
Net Fallback	1	1

HD PIT results – Passage Times

		Lower	Upper	Total	Total 2002
Priest	median (d)	0.1	0.8	2.2	1.0
	median (h)	1.9	18.4	53.4	24.0
	count	35	35	35	28
Wanapum	median (d)	0.3	0.2	2.1	1.8
	median (h)	7.4	5.2	49.4	43.2
	count	31	29	30	22

Total: fish with both an entrance and exit time.

Lower (diffusion): fish with both an entrance and above diffusion time.

Upper (no diffusion): fish with both an above diffusion and exit time.

HD PIT – Other observations

- 8 live, tagged fish recovered during PR left dewatering. 6 of these were detected at the below count station immediately upon dewatering of the upper fish ladder;
- 2 of 54 (4%) tags were from the previous tagging year, compared to 36% last year;
- One tag detected last year was seen this year;
- 470 tags applied in 2010, 9 (2%) detected at PR;
- 1000 tags applied in 2011, 52 (5%) detected at PR;
- 83% of fish exiting PR were detected at WA;

Conclusions

- 2011 HD PIT program contributed substantially to the passage database, locally and regionally;
- FPE (>80%) and travel times (2d) are in range of previous years data, except for PR Left (?);
- Sample size limits travel rate analysis for plated fishway sections;
- Count station data indicates effective passage at that location;
- Fallback fish usually re-ascend the dams;
- Study plan objectives are being achieved.

Discussion

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- Comments and Questions

Appendix D Adult Lamprey Assessment using Underwater Video: Presentation to the PRFF

Lamprey at Priest Rapids Dam

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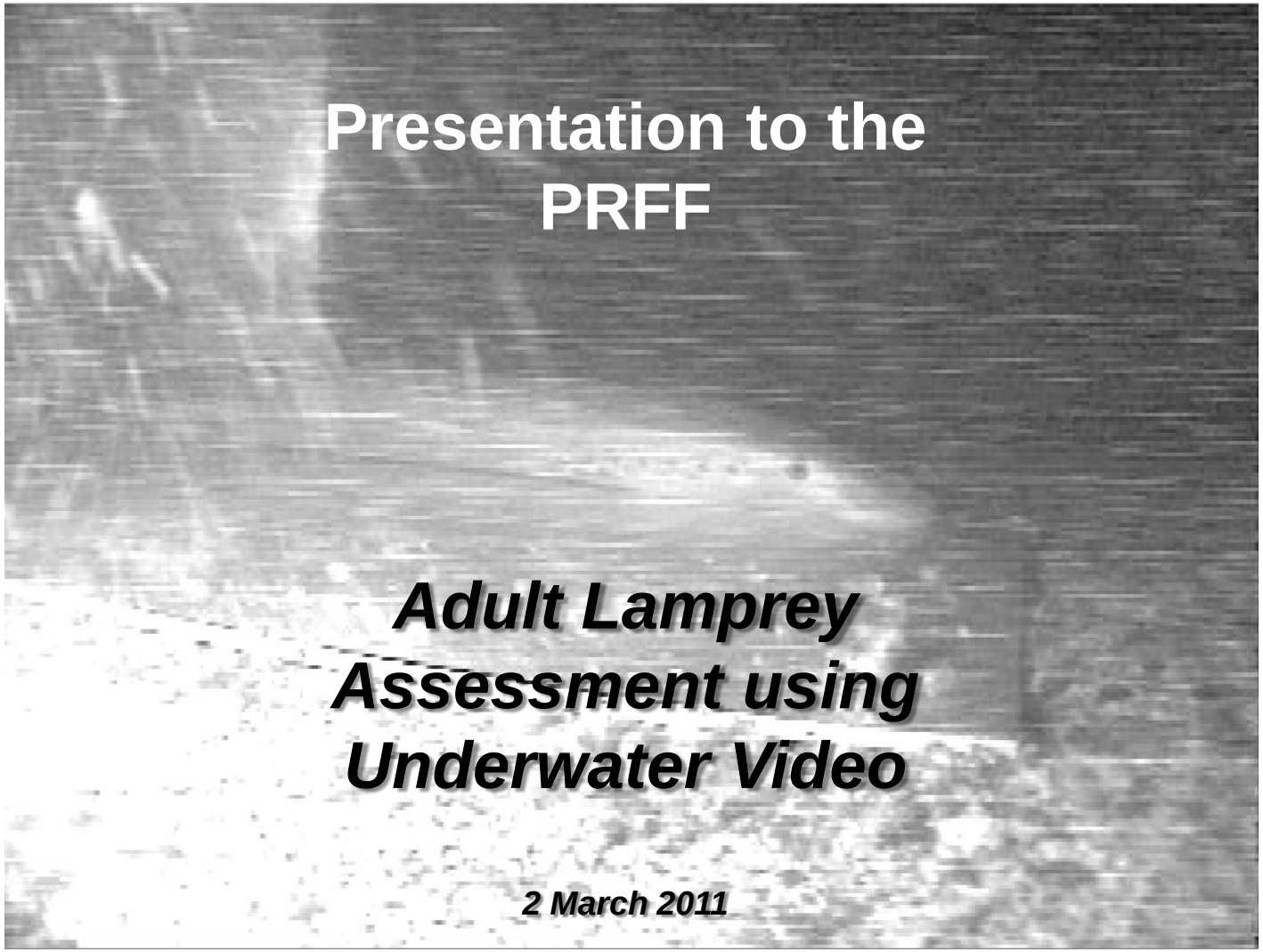

Presentation Outline

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- Background
- Objectives
- Approach
- Activities
- Methods
- Results

Background

- GPUD implements PRFF approved study plan in 2010;
- Low run year;
- Emphasis on passive monitoring;
- Underwater video & HD PIT components become even more important;

Study Objectives

- Study Plan - "*Assessment of Pacific Lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams*"
- Relevant Objective
  - Evaluate the passage of adult lamprey through sections of the Priest Rapids fishways where new structures have been installed to facilitate upstream movement;

Study Approach

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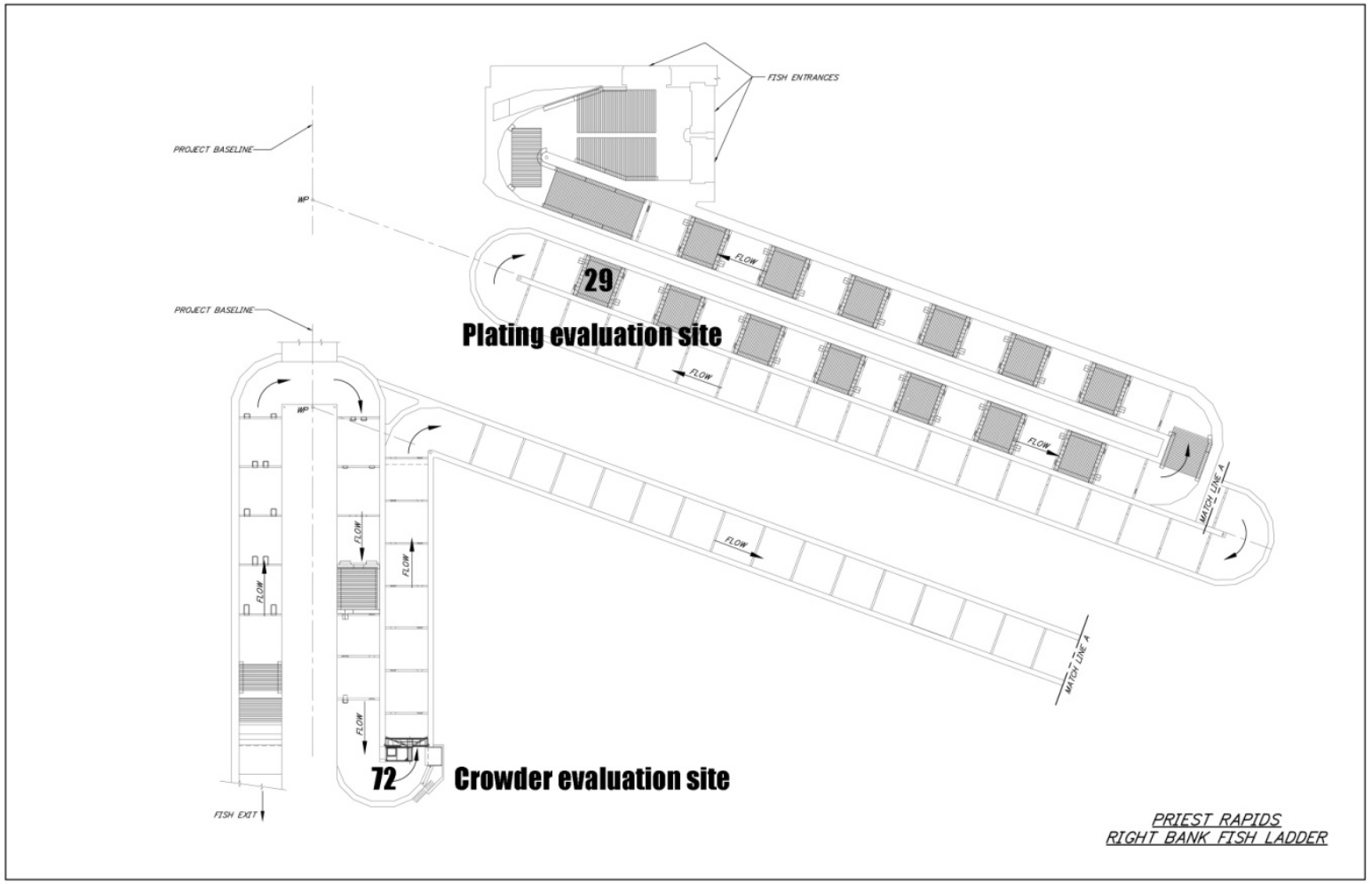
- Use Underwater Video to Observe Behavior
  - Documented method
  - Ability to capture behavior
  - Uses run-at-large
  - Adaptable & Focused

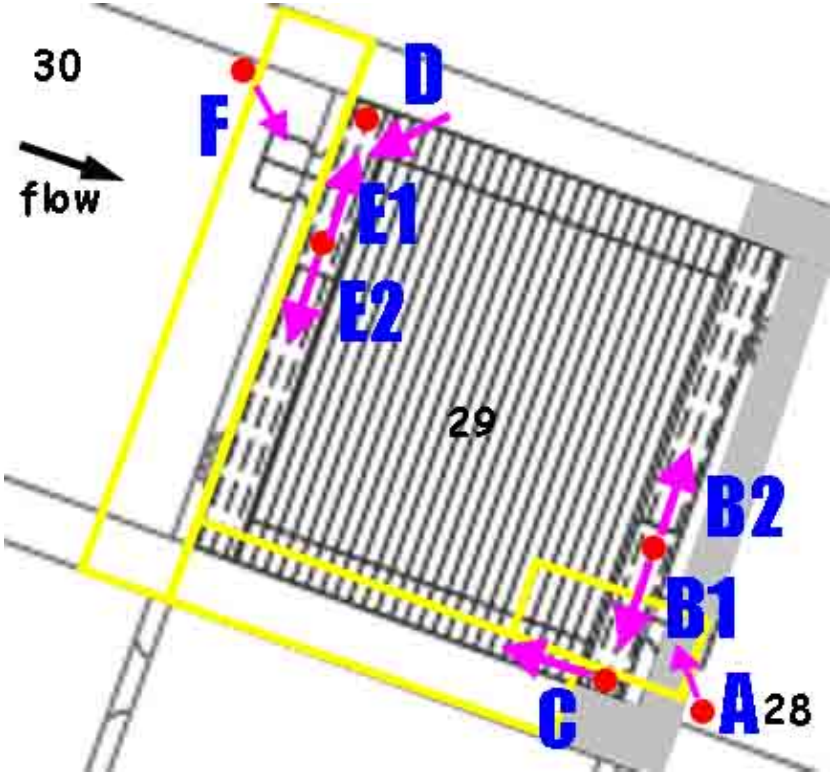
Study Activities

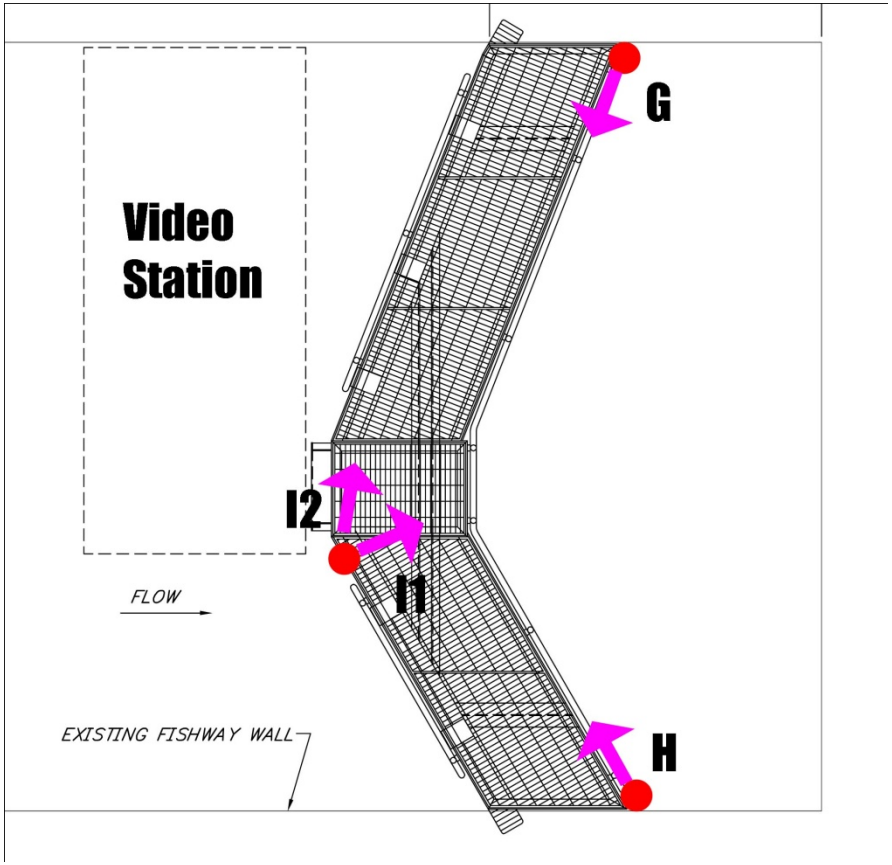
- Design & install suitable video array;
- Operate video array during lamprey passage;
- Review imagery for lamprey events, and archive;
- Conduct analysis of lamprey events to characterize behavior;
- Provide an evaluation of structural modifications of the Priest Rapids fishways relative to lamprey passage.

Underwater Video - Locations

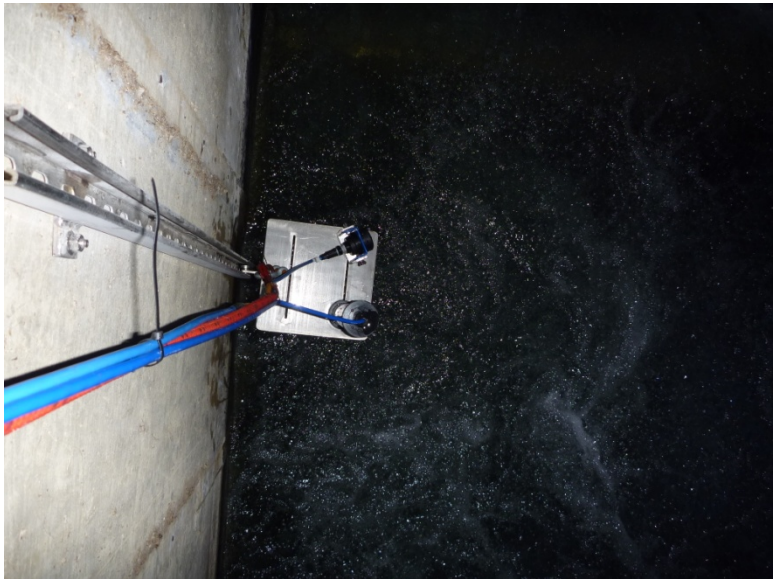


Underwater Video - Arrays





Underwater Video - Setup



Record daily from
19:00 hrs to 07:00 hrs

Underwater Video - Review

- Pool 29
  - Start with Camera 8, fast forward;
  - Save archive file for any events;
  - Look for same fish on adjacent cams B-E (within previous 1hr). Save respective archive files.

- Pool 72
  - Start with date / time stamp from fish counter observations;
  - Look for same fish on adjacent cams I1 & I2 (seconds prior), Save archive files for any events;

Note: motion detection algorithms are not useful in turbulent environments

Underwater Video - Analysis

- Key structures:
  - plating on the edges of diffusion grating;
  - plating on the fishway floor of weir orifices;
  - redesigned counting station with plating.

- Biological image analysis:
  - “Is the plating used by lamprey during passage, and how so?”
  - “Does a lamprey successfully pass the location?”

Underwater Video - Database

- Filename
- Camera number
- Date, first and last seen times;
- Sequential fish #;
- Speed
- Using/Guided by plating?
- Orientation
- Attached?
- Successful pass?
- # Attempts to pass
- Event description
- Notes

Underwater Video – Imagery Review

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- See for yourself – event analysis

Underwater Video - Results

- Pool 29
  - Useable data primarily on upper orifice (24 events on D, E, & F cams). Few events elsewhere;
  - 19 complete events archived (observation from downstream side through upstream side of orifice);
  - *70% from directly downstream, 30% from sides;
  - 95% attached to plating, 65% attached above orifice;
  - 90% staged below orifice;
  - 100% passage success;
  - Mean time of event: 1 min 22 sec. (3 sec –> 5 min)

* % of those that could be determined

Underwater Video - Results

- Pool 72
  - Useable data primarily on upper ramp (I1 & I2 cams). Few events elsewhere;
  - *123 events archived (on one or two cameras);
  - 79% near crowder, 21% unassociated with crowder;
  - 40% attached to or guided by ramp, or 55% of successful events;
  - 71% of searches for counting chute were successful;
  - Observed similar speed on ramp and at chute, low % of diversions (no problem with transition);
  - Observed searching behavior;
  - Observed attachment and resting along lower crowder plate.

* not necessarily unique individuals

Conclusions

- Pool 29 - Plating at the orifice was extensively used, events were of short duration, and all passage attempts were successful. Lamprey behavior indicates that plating facilitates passage.
- Pool 72 – Plating at the crowder was used by about half of the migrants and search behaviors for count entrance were largely successful. Overall, the crowder guided most lamprey to the chute. Lamprey behavior indicates that plating facilitates passage.

Discussion

- Comments and Questions

Before

After

Additional Observations

- Dimensions of plating appear suitable for lamprey use;
- Apparent velocity threshold in proximity to orifice influences where they hold temporarily.
- Surging technique predominantly used to get through orifice. Burst less common;
- Utility of crowder ramp partly influenced by weed buildup on grates, so modifications made;
- Predominance of free swimming at ramp-crowder interface.