AN ASSESSMENT OF ADULT PACIFIC LAMPREY SPAWNING WITHIN THE WELLS PROJECT
(Lamprey Spawning Assessment)

WELLS HYDROELECTRIC PROJECT

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ABSTRACT

In 2008, an adult Pacific lamprey (*Lampetra tridentata*) spawning assessment was conducted at the Wells Hydroelectric Project (Wells Project) in accordance with the Integrated Licensing Process (ILP) promulgated by Federal Energy Regulatory Commission (FERC). The goal of the study was to assess the level of spawning activity by adult Pacific lamprey in the Wells Project and if spawning is detected, determine whether the operations of the Wells Project are affecting this activity. Specific objectives of the study include: 1) identify areas within the Wells Project where suitable spawning habitat may exist for adult Pacific lamprey; 2) survey these areas of spawning habitat for use by lamprey to confirm suitability; and 3) if spawning is observed, assess whether the operations of Wells Dam are having adverse effects on these spawning areas (i.e., dewatering, flow alterations, scour, etc.).

Wells Project bathymetry and high resolution orthophotography were spatially analyzed using a Geographic Information System (GIS) to identify preliminary spawning habitat. Four field surveys were conducted to verify the suitability of preliminary spawning habitat. Criteria for acceptance as suitable spawning habitat during field verification consisted of appropriate substrate (gravel dominant), the presence of water velocity, and a minimum reach length of 10 feet. Four reaches were concluded to have suitable spawning habitat for Pacific lamprey; two in the Columbia River (C1 and C2), one in the Methow River (MR), and one in the Okanogan River (OR).

A total of 14 field visits were conducted between April 25 and August 5, 2008. Sites C1, C2, MR, OR were surveyed 13, 14, 6, and 4 times, respectively. Surveys were conducted over a wide range of water temperatures (8.5°C-21.5°C) and flows (0.001-19.5 kcfs). Tributary sites (MR, OR) were frequently inaccessible during the survey period due to high flows from spring runoff. During the study, no Pacific lamprey or signs of Pacific lamprey spawning (fish, nest construction activity, test digs, or nests) were observed. The evidence indicates that the Project area is not an important spawning area for Pacific lamprey.

Review of the scientific literature (Close et al., Jackson et al., 1997, Kan, 1975, and Pletcher, 1963) that describes suitable spawning habitat for Pacific lamprey indicates that the suitable habitat identified within the Wells Project can be described as marginal, at best. This conclusion is supported by extensive spawning ground surveys over the time period and during water quality conditions that typically define the Pacific lamprey spawning period.

1.0 INTRODUCTION

1.1 General Description of the Wells Hydroelectric Project

The Wells Hydroelectric Project (Wells Project) is located at river mile (RM) 515.6 on the Columbia River in the State of Washington (Figure 1.1-1). Wells Dam is located approximately 30 river miles downstream from the Chief Joseph Hydroelectric Project, owned and operated by the United States Army Corps of Engineers (COE); and 42 miles upstream from the Rocky Reach Hydroelectric Project owned and operated by Public Utility District No. 1 of Chelan County (Chelan PUD). The nearest town is Pateros, Washington, which is located approximately 8 miles upstream from the Wells Dam.

The Wells Project is the chief generating resource for Public Utility District No. 1 of Douglas County (Douglas PUD). It includes ten generating units with a nameplate rating of 774,300 kW and a peaking capacity of approximately 840,000 kW. The design of the Wells Project is unique in that the generating units, spillways, switchyard, and fish passage facilities were combined into a single structure referred to as the hydrocombine. Fish passage facilities reside on both sides of the hydrocombine, which is 1,130 feet long, 168 feet wide, with a crest elevation of 795 feet in height.

The Wells Reservoir is approximately 30 miles long. The Methow and Okanogan rivers are tributaries of the Columbia River within the Wells Reservoir. The Wells Project boundary extends approximately 1.5 miles up the Methow River and approximately 15.5 miles up the Okanogan River. The surface area of the reservoir is 9,740 acres with a gross storage capacity of 331,200 acre-feet and usable storage of 97,985 acre feet at the normal maximum water surface elevation of 781 above mean sea level (msl) (Figure 1.1-1).

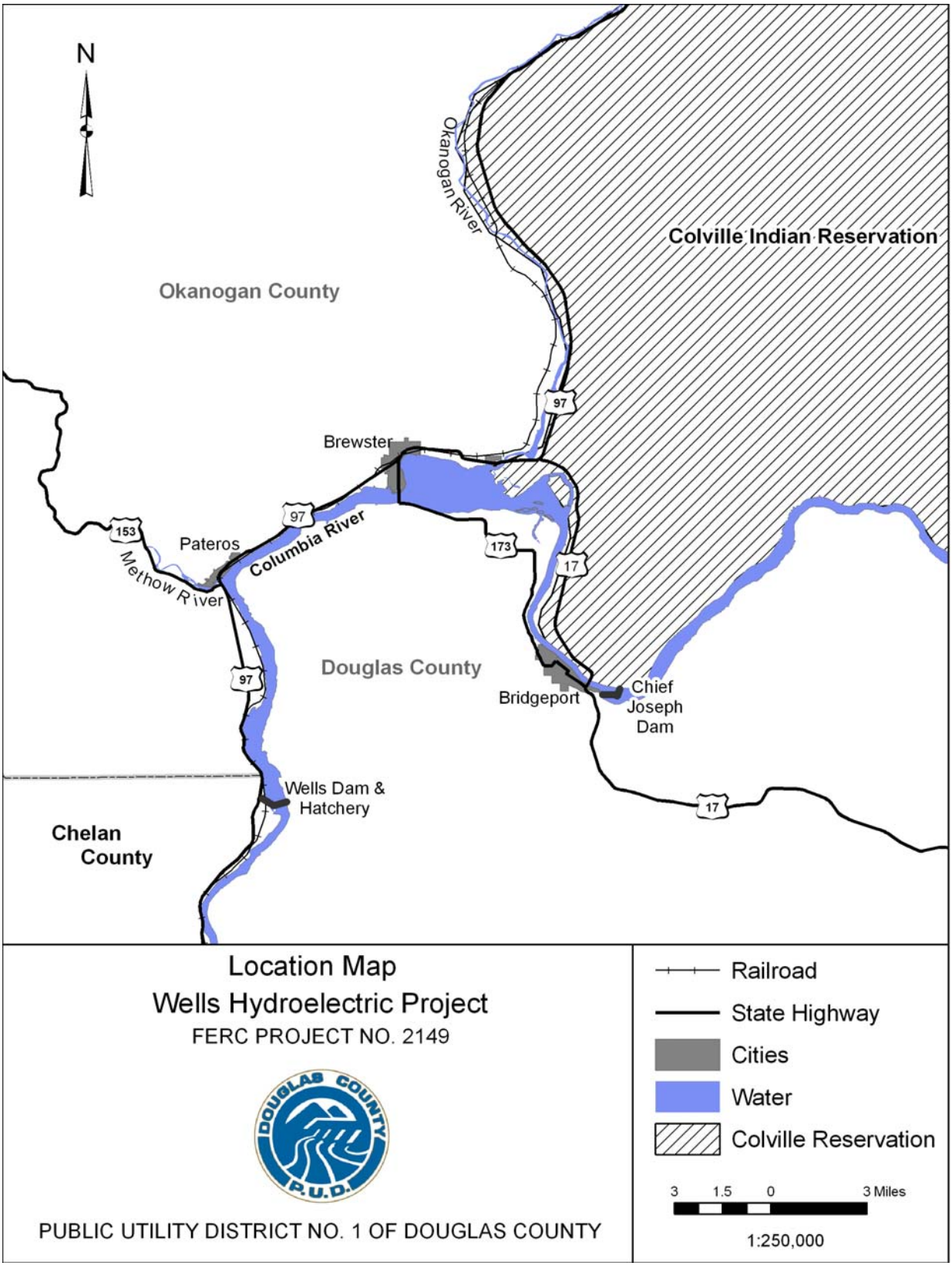

Figure 1.1-1 Location map of the Wells Project

1.2 Relicensing Process

The current Wells Project license will expire on May 31, 2012. Douglas PUD is using the Integrated Licensing Process (ILP) promulgated by Federal Energy Regulatory Commission (FERC) Order 2002 (18 CFR Part 5). Stakeholders consisting of representatives from state and federal agencies, tribes, local governments, non-governmental organizations and the general public have participated in the Wells Project ILP, from a very early stage, to identify information needs related to the relicensing of the Wells Project.

In August 2005, Douglas PUD initiated a series of Resource Work Group (RWG) meetings with stakeholders regarding the upcoming relicensing of the Wells Project. This voluntary effort was initiated to provide stakeholders with information about the Wells Project, to identify resource issues and to develop preliminary study plans prior to filing the Notice of Intent (NOI) and Pre-Application Document (PAD). The RWGs were formed to discuss issues related to the Wells Project and its operations.

The primary goals of the RWGs were to identify resource issues and potential study needs in advance of Douglas PUD filing the NOI and PAD. Through 35 meetings, each RWG cooperatively developed a list of Issue Statements, Issue Determination Statements and Agreed-Upon Study Plans. An Issue Statement is an agreed-upon definition of a resource issue raised by a stakeholder. An Issue Determination Statement reflects the RWGs' efforts to apply FERC's seven study criteria to mutually determine the applicability of each individual Issue Statement. Agreed-Upon Study Plans are the finished products of the informal RWG process.

Douglas PUD submitted the NOI and PAD to FERC on December 1, 2006. The PAD included the RWGs' 12 Agreed-Upon Study Plans. The filing of these documents initiated the relicensing process for the Wells Project under FERC's regulations governing the ILP.

On May 16, 2007, Douglas PUD submitted a Proposed Study Plan (PSP) Document. The PSP Document consisted of the Applicant's Proposed Study Plans, Responses to Stakeholder Study Requests and a schedule for conducting the Study Plan Meeting. The ILP required Study Plan Meeting was conducted on June 14, 2007. The purpose of the Study Plan Meeting was to provide stakeholders with an opportunity to review and comment on Douglas PUD's PSP Document, to review and answer questions related to stakeholder study requests and to attempt to resolve any outstanding issues with respect to the PSP Document.

On September 14, 2007, Douglas PUD submitted a Revised Study Plan (RSP) Document. The RSP Document consisted of a summary of each of Douglas PUD's revised study plans and a response to stakeholder PSP Document comments.

On October 11, 2007, FERC issued its Study Plan Determination based on its review of the RSP Document and comments from stakeholders. FERC's Study Plan Determination required Douglas PUD to complete 10 of the 12 studies included in its RSP Document. Douglas PUD has opted to complete all 12 studies to better prepare for the 401 Water Quality Certification process conducted by the Washington State Department of Ecology (Ecology) and to fulfill its commitment to the RWGs who collaboratively developed the 12 Agreed-Upon Study Plans with

Douglas PUD. These study plans have been implemented during the designated ILP study period. The results from the study plans have been developed into 12 Study Reports. Each report will be included in Douglas PUD's Initial Study Report (ISR) Document, which is scheduled for filing with FERC on October 15, 2008.

This study was voluntarily conducted by Douglas PUD based upon the agreed-upon study plan filed with FERC in the Revised Study Plan. There were no variances from the final study plan for the Lamprey Spawning Assessment.

This report completes the Lamprey Spawning Assessment.

2.0 GOALS AND OBJECTIVES

The goal of this study is to assess the level of spawning activity by adult Pacific lamprey in the Wells Project and whether Wells Dam operations are affecting this activity.

Specific objectives of the study include:

- Identify areas within the Wells Project where suitable spawning habitat may exist for adult Pacific lamprey,
- Survey these areas of spawning habitat for use by Pacific lamprey to confirm suitability, and
- If spawning is observed, assess whether the operations of the Wells Project are having adverse effects on these spawning areas (i.e., dewatering, flow alterations, scour, etc.).

3.0 STUDY AREA

The study area includes all water bodies within the Wells Project, including the Wells Reservoir and tailrace and sections of the Methow and Okanogan rivers within the Wells Project boundary (Figure 1.1-1).

4.0 BACKGROUND AND EXISTING INFORMATION

Pacific lamprey are present in most tributaries of the Columbia River below Chief Joseph Dam at RM 545 and in the mainstem Columbia River during their migration. Lamprey have cultural, utilitarian and ecological significance in the basin since Native Americans have historically harvested them for subsistence, ceremonial and medicinal purposes (Close et al., 2002).

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, they remain as larvae (also known as ammocoete) for 4 to 6 years (10-200 mm body length). Ammocoetes reside burrowed in fine sediment (Close et al. 2002) during this time filter feeding on diatoms, algae, and detritus by pumping water through their branchial chamber (Beamish and Levings, 1991). Pacific lamprey then enter a transformation phase (ocean-migrating macrophthalmia) and migrate from their parent streams to the ocean. 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 macrophthalmia migrate to the ocean between late fall and spring and are physiologically capable of handling life in salt water. They spend 1 to 4 years as adults feeding as external parasites on marine fish and mammals before returning to freshwater to spawn (Beamish, 1980 and Close et al., 2002).

Upstream migrating Pacific lamprey are likely heading to holding and/or spawning areas to overwinter. Though their exact timing likely varies among locations, upstream migration has been documented to cease in mid-September (Beamish, 1980), and resume in mid-March of the following spring if the final spawning destination has not been reached (Bayer et al., 2001). Somewhat like salmon, adult Pacific lamprey dig spawning depressions in the gravel of freshwater streams. Spawning occurs in the spring and early summer (May to July) following the upstream migration year (Lê et al., 2004). Spawning of Pacific lamprey on the coast typically occurs in May with water temperatures between 10°C and 15°C. Pacific lamprey migrating inland in the Columbia River spawn later (Close et al., 1995). Pacific lamprey prefer low-gradient reaches, with gravel-pebble-sand substrate for spawning (Mattson, 1949 and Close et al., 1995). Adults generally spawn in low-gradient stream reaches in the tail areas of pools and in riffles, over gravel substrates (Jackson et al., 1997). The presence of gravel substrate is a critical habitat feature for ensuring spawning (Close et al., 1995).

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 (or foot: ft) (Kan, 1975). Both sexes begin moving rocks with their buccal funnel to create nests in excavated depressions (Pletcher, 1963). Courting consists of a male approaching a female with a gliding motion to stimulate the female. A male attaches his buccal funnel to a female's head, and then wraps his body around the female while releasing milt. 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 within 3 to 36 days (Kan, 1975).

Pacific lamprey populations of the Columbia River have declined in abundance over the last 40 years according to counts at dams on the lower Columbia and Snake rivers (Close et al., 2002). Starke and Dalen (1995) reported that adult lamprey counts at Bonneville Dam regularly exceeded 100,000 fish in the 1960's and more recently have ranged between 20,000 and 120,000 for the period 2000-2004 (DART- www.cqs.washington.edu/dart/adult.html).

Close et al. (2002) identified several factors that may account for the decline in lamprey counts in the Columbia River Basin. These include 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 (Nass et al., 2005). Returning adult Pacific lamprey have been counted at Wells Dam since 1998. Between the years of 1998 and 2007, the numbers of Pacific lamprey passing Wells Dam annually has averaged 350 fish and ranged from 21 fish in 2006 to 1,410 fish in 2003 (Table 4.0-1). The relatively small number of adults observed at Wells Dam can be attributed to fact that the Wells Project is the last passable dam on the mainstem Columbia River and the fact that the Wells Project is over 500

miles upstream from the Pacific Ocean. Pacific lamprey counts for Columbia and Snake river dams are presented in Table 4.0-1 and Table 4.0-2.

Table 4.0-1 Pacific lamprey counts at Columbia River mainstem dams, by dam and year, 1997-2007.

Year	Bonneville	The Dalles	John Day	McNary	Priest Rapids	Rock Island	Rocky Reach	Wells
1997	20,891	6,066	9,237	.	.	.	.	.
1998	.	.	.	.	.	.	.	343
1999	.	.	.	.	.	.	.	73
2000	19,002	8,050	5,844	1,281	.	822	767	155
2001	27,947	9,061	4,005	2,539	1,624	1,460	805	262
2002	100,476	23,417	26,821	11,282	4,007	4,878	1,842	342
2003	117,035	28,995	20,922	13,325	4,340	5,000	2,521	1,410
2004	61,780	14,873	11,663	5,888	2,647	2,362	1,043	647
2005	26,667	8,361	8,312	4,158	2,598	2,267	404	214
2006	38,941	6,894	9,600	2,459	4,383	1,326	370	21
2007	19,304	6,083	5,753	3,454	6,593	1,300	696	35
Total	432,043	111,800	102,157	44,386	26,192	19,415	8,448	3,502
Min	19,002	6,066	4,005	1,281	1,624	822	370	21
Max	117,035	28,995	26,821	13,325	6,593	5,000	2,521	1,410
Average	48,005	12,422	11,351	5,548	3,742	2,427	1,056	350
SD	37,162	8,364	7,611	4,417	1,631	1,632	750	416

Table 4.0-2 Pacific lamprey counts at Snake River mainstem dams, by dam and year, 1996-2007.

Year	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
1996	737	.	.	490
1997	668	.	.	1,122
1998	.	.	.	.
1999	.	.	.	.
2000	315	94	71	28
2001	203	59	104	27
2002	1,127	284	365	138
2003	1,702	476	660	282
2004	805	194	243	122
2005	461	222	213	42
2006	277	175	125	35
2007	290	138	72	34
Total	6,585	1,642	1,853	2,320
Min	203	59	71	27
Max	1,702	476	660	1,122
Average	659	205	232	232
SD	469	130	200	346

Pacific lamprey pass Wells Dam from early July until late November with peak passage times between mid-August and late October (Figure 4.0-1). In all years since counting was initiated, Pacific lamprey counts at the east fish ladder are greater than at the west fish ladder. It is important to note that historically, counting protocols were designed to assess adult salmonids and did not necessarily conform to lamprey migration behavior (Moser and Close 2003). Traditional counting times for salmon did not coincide with lamprey passage activity which occurs primarily at night; the erratic swimming behavior of adult lamprey also makes them inherently difficult to count (Moser and Close, 2003). Furthermore, Beamish (1980) noted that lamprey overwinter in freshwater for one year prior to spawning. Consequently, lamprey counted in one year may actually have entered the system in the previous year (Moser and Close, 2003) which confounds annual returns back into the Columbia River Basin. It is unknown to what degree these concerns are reflected in Columbia River lamprey passage data. However, it is important to consider such caveats when examining historic lamprey count data at Columbia River dams including Wells Dam.

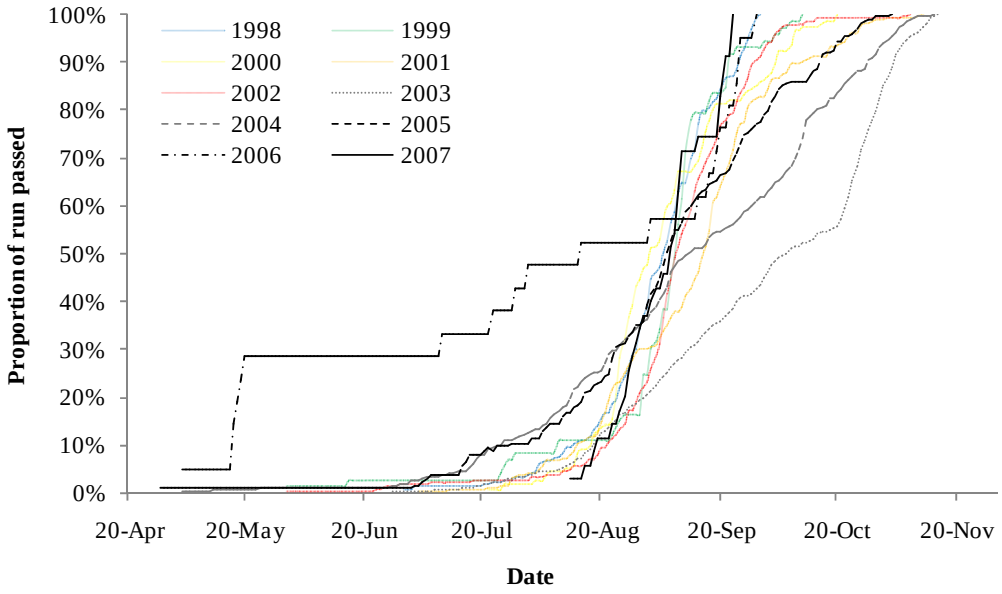

Figure 4.0-1 Run timing of Pacific lamprey at Wells Dam by year, 1998-2007. Years 1998-2002 are lightened to allow better view of past five years (in grayscale).

Until recently, relatively little information was available on Pacific lamprey in the mid-Columbia River Basin. However, with increased interest in the species coupled with a petition for listing under the Endangered Species Act (ESA), the mid-Columbia PUDs have initiated studies to address Pacific lamprey passage and migratory behavior in their respective project areas.

The study of adult Pacific lamprey migration patterns past dams and through reservoirs in the lower Columbia River has provided the first data sets on lamprey passage timing, travel times, and passage success at hydroelectric projects (Moser et al., 2002a, 2002b). These studies have shown that approximately 90% of the radio-tagged lamprey released downstream of Bonneville Dam, migrated back to the tailrace below Bonneville Dam; however, less than 50% of the

lamprey which encountered a fishway entrance actually passed through the ladder exit at the dam (Nass et al., 2005).

Similar collection and passage efficiency results were observed at Rocky Reach, Wanapum and Priest Rapids dams during tagging studies conducted at those projects (Nass et al., 2003 and Stevenson et al., 2005).

Of the 125 radio-tagged lamprey released approximately 7 kilometers downstream of Rocky Reach Dam, 93.6% were detected at the project, and of those fish, 94.0% entered the fishway. Of the fish that entered the Rocky Reach fishway, 55.5% exited the ladder.

During studies at Wanapum and Priest Rapids dams in 2001 and 2002, a total of 51 and 74 lamprey were radio-tagged and released downstream of Priest Rapid Dam, respectively. Over the two years of study, the proportion of fish that approached the fishway that exited the ladders was 30% and 70% at Priest Rapids and 100% and 51% at Wanapum Dam in 2001 and 2002, respectively.

In 2004, Douglas PUD contracted with LGL Limited to conduct a Pacific lamprey radio-telemetry study at Wells Dam in coordination with the Chelan PUD who was conducting a similar study at Rocky Reach Dam. A total of 150 lamprey were radio-tagged and released at or below Rocky Reach Dam. The radio-tags used in this study had an expected operational life of 45 days (Nass et al., 2005). It is important to note that because the release site of the fish was over 50 miles downstream of Wells Dam the value of the study was limited by the relatively small numbers of tagged fish observed at Wells (n=18) and the fact that many of the radio-tags detected at Wells Dam were within days of exceeding their expected battery life.

With that stated, the 2004 study at Wells was implemented through a combination of fixed-station monitoring at Wells Dam and fixed-stations at tributary mouths. Collectively, these monitoring sites were used to determine migration and passage characteristics of lamprey entering the Wells Project area. Of the 150 adult lamprey released at or below Rocky Reach in 2004, 18 (12% of 150) were detected in the Wells Dam tailrace, and ten (56% of 18) of these were observed at an entrance to the fishways at Wells Dam. Two of the 10 lamprey approached both fishways to produce 12 total entry events. A total of 3 radio-tagged lamprey passed Wells Dam prior to expiration of the tags, resulting in a Fishway Efficiency estimate of 30% (3 of 10) for the study period. A single lamprey was detected upstream of Wells Dam at the mouth of the Methow River (Nass et al., 2005).

For lamprey that passed the dam, the majority (92%) of Project Passage time was spent in the tailrace. Median time required to pass through the fishway was 0.3 d and accounted for 8% of the Project Passage time (Nass et al., 2005).

In 2007, Douglas PUD contracted with LGL Limited to conduct another Pacific lamprey radio-telemetry study at Wells Dam. Twenty one Pacific lamprey were captured, surgically radio-tagged, and released. Of these fish, 10 were released into the tailrace and 11 were released into the fishway between mid-August and early October. One tailrace-released fish was recaptured and re-released into the fishway, bringing total ladder releases to twelve. Ten of the twelve

(83%) lamprey released into the middle fishway successfully ascended, with a median upper fishway passage time of 7.9 hours. Seven of the ten (70%) lamprey released into the tailrace were detected at the outside of a fishway entrance. Only one of these seven (14%) lamprey entered into the collection gallery and ascended the fishway with a lower fishway passage time of 6.1 hours and upper fishway passage time of 5.9 hours. This fish, along with at least one mid-ladder release, traveled through some portion of the auxiliary water supply (AWS) chamber. Including one tailrace-released fish, 6 of 11 (55%) tagged-lamprey that ascended the upper fishway were detected inside the video bypass area. Three of the eleven (27%) fish that exited the ladder passed through the upper fish ladder without being observed at the counting window. No downstream passage events were detected by fish that exited the fishway. These results suggested that: 1) lamprey are having difficulty negotiating the fishway entrance; 2) lamprey are passing the upper fishway at high rates, in a reasonable amount of time, and with negligible drop back within the ladder; and 3) some lamprey are bypassing the adult counting windows.

Two recent reviews of Pacific lamprey (Hillman and Miller, 2000 and Golder Associates Ltd., 2003) in the mid-Columbia River have indicated that little specific information is known about the life history of lamprey (Stevenson et. al., 2005). They are known to occur in the Methow, Wenatchee and Entiat rivers (NMFS, 2002) and recently have been captured during juvenile salmonid trapping operations in the Okanogan River above the Wells Project boundary (Mike Rayton, Colville Tribes, personal communication). In the mid-Columbia River basin, available information exclusively addresses adult lamprey passage and behavior through hydroelectric projects via radio-telemetry studies and dam counts (Nass et al., 2003 and 2005 and Stevenson et al., 2005). Similarly in the Wells Project, adult passage information is available through radio-telemetry studies (Nass et al., 2003 and LGL Limited, 2007) and counts at Wells Dam (since 1998). Currently, no studies have been conducted on adult Pacific lamprey related to spawning within the Wells Project.

4.1 Aquatic Resource Work Group

As part of the relicensing process for the Wells Project, Douglas PUD established an Aquatic Resource Work Group (Aquatic RWG) which began meeting informally in November, 2005. This voluntary effort was initiated to provide stakeholders with information about the Wells Project, to collaboratively identify potential resource issues related to Project operations and relevant to relicensing, and to develop preliminary study plans to be included in the Wells Pre-Application Document (PAD) (DCPUD, 2006).

Through a series of meetings, the Aquatic RWG cooperatively developed a list of Issue Statements, Issue Determination Statements and Agreed-Upon Study Plans. An Issue Statement is an agreed-upon definition of a resource issue raised by a stakeholder. An Issue Determination Statement reflects the RWG's efforts to review the existing project information and to determine whether an issue matches with FERC's seven criteria and would be useful in making future relicensing decisions. Agreed-Upon Study Plans are the finished products of the informal RWG process.

Based upon these meeting and discussions, the Aquatic RWG proposed to conduct a study to determine whether adult Pacific lamprey are spawning within the Wells Project and if so,

whether the operation of Wells Dam is affecting this habitat. The need for this study was agreed to by all of the members of the Aquatic RWG, including Douglas PUD. This study will help to inform future relicensing decisions and will fill data gaps that have been identified by the Aquatic RWG.

The Issue Statement and Issue Determination Statement listed below were included in the PAD (section number included) filed with FERC on December 1, 2006:

4.1.1 Issue Statement (PAD Section 6.2.1.2)

The Wells Project may affect adult Pacific lamprey habitat use.

4.1.2 Issue Determination Statement (PAD Section 6.2.1.2)

There were two types of habitat identified by the group (spawning and overwintering habitat). It is unlikely that there is a Project effect on adult lamprey overwintering habitat. Literature suggests that overwintering habitat for adult Pacific lamprey consists of deep pools. In the Wells Reservoir deepwater habitat is plentiful and undisturbed by Project operations.

There is no information currently available related to adult lamprey spawning habitat within the Wells Project. Existing literature (Beamish, 1980 and Jackson et al., 1997) suggests that adult lamprey prefer smaller tributaries that are characterized by suitable spawning substrate and velocities (pool-tailouts, gravel to small cobble substrate, depth of 1 meter). This type of habitat is generally not available within the Wells Project.

Adult Pacific lamprey spawning has not been documented within the Wells Project; however, there may be areas within the Wells Project that may have marginal spawning habitat for adult Pacific lamprey.

The Aquatic RWG agreed that a study is needed to determine whether adult lamprey are spawning within the Wells Project and if so, whether the operation of Wells Dam is affecting this habitat. This study should be conducted during the two-year ILP study period.

4.2 Project Nexus

Two recent reviews of Pacific lamprey (Hillman and Miller, 2000 and Golder Associates Ltd., 2003) in the mid-Columbia River have indicated that little specific information is known on their status. Within the Wells Project waters, no studies have been conducted to address the level of spawning that may be occurring and whether Project operations affect lamprey spawning habitat. Pacific lamprey spawning has been observed in the Lower Columbia River from May to July (Lê et al., 2004)) and habitat preferences consist of the tail-outs of pools and riffles over gravel substrate (Jackson et al., 1997). This type of habitat is characteristic of the upper reaches of tributary streams in the mid-Columbia River system; however, within the Wells Project Boundary there may be patches of habitat meeting these criteria. If adult Pacific lamprey are utilizing these areas of suitable habitat, it is important to assess whether Wells Project operations have any adverse effects on these areas during periods of lamprey spawning. Potential adverse

effects attributed to Project operations may include flow fluctuations or dewatering of lamprey nests. The proposed lamprey spawning study will assist in filling the information gap identified by the Aquatic RWG and in the development of licensing requirements for the Wells relicensing process.

5.0 METHODOLOGY

Implementation of the study consists of three separate components:

- The use of detailed bathymetry, high resolution orthophotographic information, and preliminary site validation to identify areas within the Wells Project that are consistent with preferred spawning habitat requirements of Pacific lamprey (Beamish, 1980 and Jackson et al., 1997),
- Conduct spawning surveys of these identified potential spawning areas when the probability of adult lamprey spawning is highest (May to July), and
- If spawning is observed, assess whether Wells Dam operations affect habitat in such a way to adversely impact spawning or spawning success.

5.1 Identification of Suitable Spawning Habitat

In order to identify potential spawning habitat in the Wells Project, a Geographic Information System (GIS) was used to integrate existing bathymetric data and high resolution orthophotography to develop a map of potentially suitable spawning areas. To ensure the GIS analysis is robust in capturing all potential spawning habitat, an initial water depth criterion of 10 ft or less (at full reservoir elevation of 781 ft msl) was used. A depth criterion of 10 ft was chosen since available literature on lamprey spawning habitat indicates that Pacific lamprey spawning is typically observed at depths of 1.0 to 3.3 ft (Pletcher, 1963 and Kan, 1975) and depths greater than 10 ft cannot be effectively surveyed. The GIS analysis based upon the 10-ft water depth criterion provided a preliminary spawning habitat map.

In early spring 2008, field staff conducted site visits (by foot and boat) to all potential habitat areas identified on the preliminary spawning habitat map to field verify spawning habitat suitability for Pacific lamprey. In order to ensure that site selection is robust, habitat suitability criteria analysis during site visits consisted of an assessment of whether appropriate substrate (dominant gravel substrate 0.08-2.51 inches (in) in diameter) (Overton et al., 1997), and the presence of water velocity (or discharge) exist. Additionally, a minimum reach length of 10 ft was required for each area meeting the criteria above to avoid including small gravel patches unlikely to support Pacific lamprey spawning activity. All preliminary spawning habitat areas not meeting these criteria were considered unsuitable spawning habitat for Pacific lamprey. Spawning habitat maps were produced for areas within the Wells Project that were less than 10 ft in depth, had dominant gravel substrate, and had the water velocity present.

5.2 Spawning Ground Surveys

Foot surveys of the potential spawning areas were conducted in spring 2008 or as river flows allowed. All field sites were visited approximately once per week by one to two field biologists.

At least one biologist present during the survey had training or field experience in Pacific lamprey nest identification. In the event that nests were observed, physical characteristics of nests were to be measured, including: habitat type (riffle, pool-tailout, run, pool), nest dimensions, substrate (dominant, sub-dominant and % fines), and water velocity. If applicable, presence of adults on the nest would be noted as well as number and sex of fish. Locations of each nest would be recorded with a global positioning system (GPS). Identified nests were planned to be marked with weighted flagging to determine nest longevity and to avoid counting nests twice upon subsequent surveys. Pacific lamprey in the lower Columbia River basin typically spawn from May to July. Spawning ground surveys were conducted in the Wells Project over a broader time period with spawning ground surveys starting in late April and ending in early August 2008.

5.3 Operational Effects on Spawning

Because no lamprey spawning was observed during this study the Project is not expected to have any potential effects on this aspect of the lamprey life cycle.

6.0 RESULTS

6.1 Identification of Suitable Spawning Habitat

The GIS analysis using bathymetry and high resolution orthophotography identified approximately 1,800 acres of Wells Project habitat less than 10 ft depth at a Wells Reservoir elevation of 781 ft msl. As expected, the majority of preliminary habitat identified through GIS analysis was along the shoreline and around islands.

Between March 12 and April 11, 2008, 4 site visits (March 12 and 14, March 21, April 11) were made by Douglas PUD biologists to field verify all preliminary habitat areas for Pacific lamprey spawning suitability. Based upon field verification surveys, much of the preliminary habitat was unsuitable as Pacific lamprey spawning habitat with the lack of dominant gravel substrate as the limiting factor. However, four locations were identified with potentially suitable habitat (Figure 6.1-1).

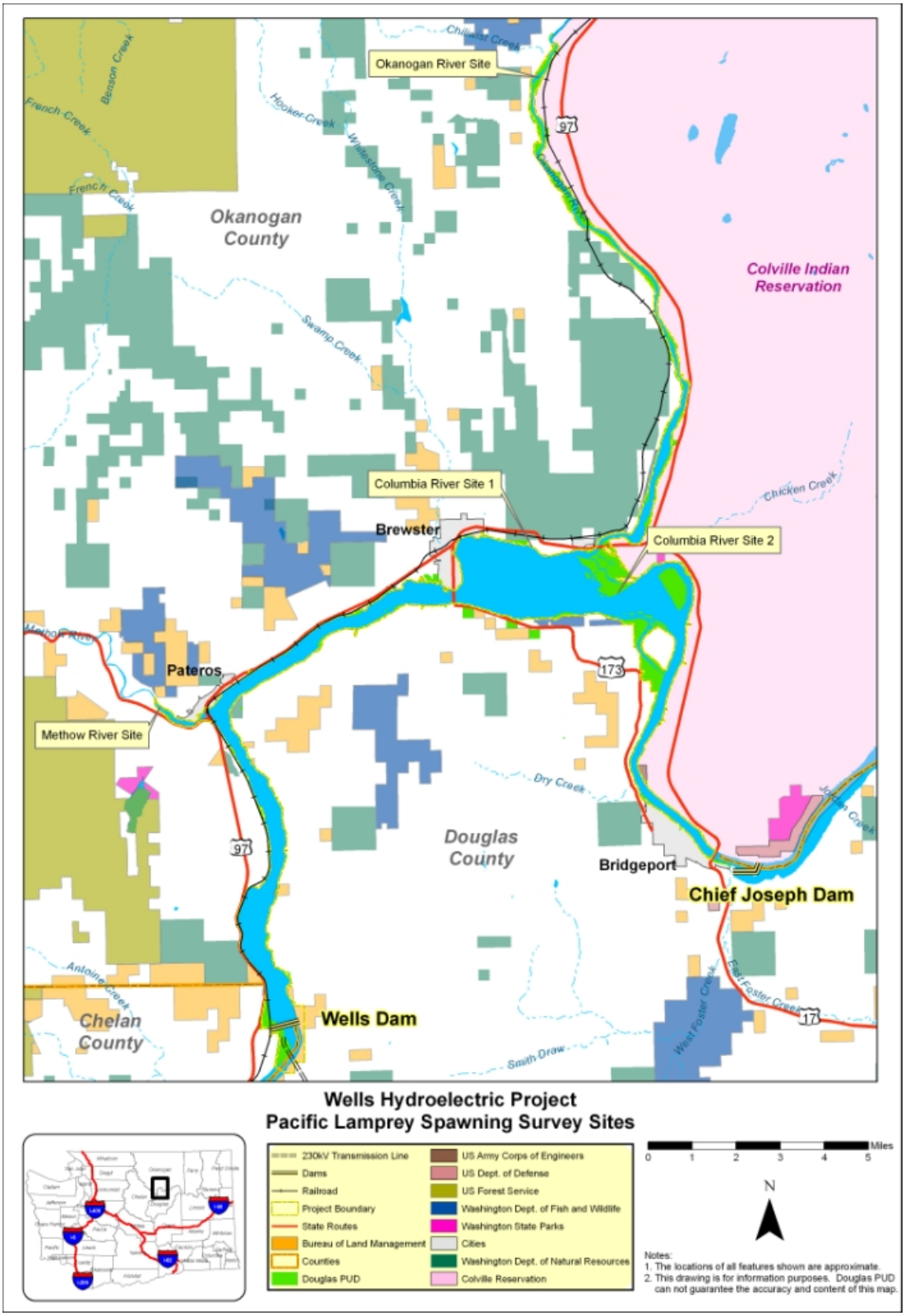

Figure 6.1-1 Four potential areas suitable for Pacific lamprey spawning.

In the Wells tailrace, velocities were typically much greater than preferred velocities for Pacific lamprey spawning (3-4 ft/sec). Additionally, substrate within the 10 ft depth range (exclusively along the shoreline) is dominated by large cobble (5-10 in) and boulder (>20 in) (substrate based on Overton et al., 1997). No suitable spawning habitat within the Wells tailrace region was identified.

The lower-most 15-mile section of the Wells Reservoir (mainstem) is relatively narrow and fast flowing compared to the middle reach of the reservoir. An exception to this observation is near the Wells forebay where the river eventually slows and deepens. Substrate in this section is dominated by sand and fines along beaches and backwater areas and large boulder and bedrock (solid rock) adjacent to the river. On the right bank, the shoreline gradient is steep and sections near Highway 97 and the railroad have been armored for erosion prevention. Some patches of small gravel were identified however these areas were only several feet long and wide and did not meet the 10-ft length criterion for spawning habitat suitability. No suitable spawning habitat was identified within this lower reach.

The upper 5-mile section of the Wells Reservoir (mainstem) downstream from the Chief Joseph Dam tailrace is characteristic of a riverine system. Velocities are high due to discharge from Chief Joseph Dam and as such, shoreline substrate is dominated by large cobble, boulder and bedrock. No suitable spawning habitat was identified within the upper reach.

The middle 10-mile section of the Wells Reservoir (mainstem) is more characteristic of a lacustrine environment. In this section, the Wells Reservoir widens and is relatively shallow with low velocities relative to the upper and lower sections. Islands are present with shorelines dominated by cobble substrate. Shoreline substrate typically consisted of fines, sand, and cobble. However, two reaches were identified within this section that had dominant gravel substrate greater than 10 ft in length and the presence of suitable water velocity.

The first Columbia River reach (C1) is located on the right bank of the Columbia River directly downstream of the Okanogan River confluence at RM 534 (Figure 6.1-2 and Appendix A). Dominant gravel substrate with patchy areas of sand, fines, and cobble define a 10 ft band of suitable habitat along the shoreline. The reach is approximately 1 mile in length. Water depth ranged from 0.5 to 4 feet. Velocity was also extremely low (<1.0 ft/sec) however the original Columbia River channel flows adjacent to this reach. Approximate total area of this reach is 4 acres.

Figure 6.1-2 Photo of Pacific lamprey spawning habitat reach (C1) located at RM 534 in the Wells Reservoir.

The second Columbia River reach (C2) is located on the right bank of the Columbia River upstream of the Okanogan River confluence at RM 536 (Figure 6.1-3 and Appendix A). Dominant gravel substrate with patchy areas of sand and cobble define an 8 ft band of suitable habitat along the shoreline. The reach is approximately 0.5 miles in length. Water depth ranged from 0.5 to 4 feet and a row of yellow willow trees along the shoreline shades much of this reach. Velocity is extremely low (<1.0 cfs) at this site, however the original Columbia River channel also flows adjacent to this reach. Approximate total area of this reach is 2 acres.

Figure 6.1-3 Photo of Pacific lamprey spawning habitat reach (C2) located at RM 536 in the Wells Reservoir.

The Methow River enters the Columbia River (RM 524) at the town of Pateros, Washington. The Wells Project boundary extends approximately 1.5 miles up the Methow River from the Highway 97 bridge. The lower 1.0 mile of the Methow River is wide, relatively shallow and characteristic of a lacustrine environment. The northern shoreline of this section is residential with a high frequency of boat docks. The southern shoreline is adjacent to state route 153 and is rip rapped with large angular rock. The substrate in the middle of the river varies from sandy bottom areas with high macrophyte growth and cobble dominant areas. The upper 0.5-mile reach of the Methow River below the Wells Project boundary is more characteristic of a riverine environment. In this reach, suitable spawning habitat was identified.

The Methow River spawning habitat reach (MR) is located at RM 1.4 (Figure 6.1-4 and Appendix A) near the upper end of an island in the right channel of the Methow River. This area is characterized as a pool-tailout/riffle-run habitat type (depending on flows). Dominant substrate is large gravel with cobble substrate subdominant. Water depth ranges from 1 to 3 ft. Velocity is highly variable depending upon season with flows reaching as high as 9 thousand cubic feet per second (kcfs) in 2008. Approximate total area of this reach is 1 acre. Although

this site is within the Wells Project boundary, it does not appear to be influenced by the backwater of the Project.

Figure 6.1-4 Photo of Pacific lamprey spawning habitat reach (MR) located at RM 1.4 in the Methow River.

The Okanogan River enters the Wells Reservoir at RM 534. The Wells Project boundary extends approximately 15.5 miles up the Okanogan River confluence with the Columbia River. The lower 10.5 miles, where inundation from Wells Dam is observed, are characterized by high turbidity, macrophytes along the shoreline, and substrates dominated by sand and fines. The upper 5.0 miles of the Okanogan River within the Wells Project boundary are more characteristic of a riverine environment. Much of the substrate was dominated by cobble and sand. Some patches of gravel dominant habitat were identified, however these areas were only several feet long and wide and did not meet the 10-ft length criterion for suitability. One area in the upper Okanogan reach was identified as suitable Pacific lamprey spawning habitat.

The Okanogan River spawning habitat reach (OR) is located at RM 14.5 (Figure 6.1-5 and Appendix A) and was characterized as riffle/run habitat type (depending on flows). Dominant substrate is gravel with cobble substrate subdominant. Water depth ranges from 2 to 5 ft. Discharge is highly variable depending upon season with flows reaching as high as 19.5 kcfs in 2008. Approximate total area of this reach is 1.5 acres. Although this site is within the Wells Project boundary, it does not appear to be influenced by the backwater of the Project.

Figure 6.1-5 Photo of Pacific lamprey spawning habitat reach (OR) located at RM 14.5 in the Okanogan River.

6.2 Spawning Ground Surveys

Spawning ground surveys for the study began on April 25^{h} and ended on August 5, 2008 (Appendix B). In total, 14 field visits were conducted. Sites C1, C2, MR, OR were surveyed 13, 14, 6, and 4 times respectively (Table 6.2-1). Surveys were conducted over a wide range of water temperatures (8.5°C-21.5°C) and flows (.001-19.5 kcfs). Tributary sites (MR, OR) were frequently inaccessible during the high flows associated with the spring run-off. In addition to safety concerns, high flows resulted in low visibility during visits to reaches where surveys were not conducted. In all instances of high flow and low visibility, follow up surveys were scheduled. Follow up surveys were used to ensure detection of any lamprey nests constructed during high water events.

Table 6.2-1 Number of surveys conducted and range of water temperatures and flows observed during Wells Project Pacific lamprey spawning assessment.

Site	Number of Times Surveyed	Water Temperature Range (°C)	Discharge Range (kcfs)
M1	6	8.5-17.50	0.73-9.82
C1	13	8.9-16.0	<.001-.011[1]
C2	14	9.0-16.0	<.001-.011
OR	4	10.5-21.5	1.2-19.50

[1] Flows were extremely low at this reach. Regular flow measurements were discontinued.

During the study, no Pacific lamprey or signs of Pacific lamprey spawning (fish, nest construction activity, or nests) were observed.

6.3 Operational Effects

Since no Pacific lamprey or signs of Pacific lamprey spawning were observed, the Wells Project operations are unlikely to affect lamprey spawning. However, if lamprey spawning were to occur at either the Methow River or the Okanogan River sites, there would have been no effect of the Project on spawning behavior, nest construction or incubation of lamprey eggs. Both of these sites are riverine and are located outside the influence of Wells Reservoir.

7.0 DISCUSSION

Pacific lamprey spawning sites generally occur in low gradient stream sections where gravel is deposited. Nest sites are typically found in tail-out areas of pools and in riffles (Kan, 1975). These types of habitat within the inundated mainstem Columbia River and associated tributary (Okanogan and Methow rivers) reaches of the Wells Project are rare. GIS analysis and subsequent habitat verification surveys based upon robust criteria (dominant gravel substrate, presence of water velocity, and minimum 10-ft reach length) yielded only 4 potential spawning habitat reaches within the Wells Project. Review of the scientific literature (Close et al., 1995, Jackson et al., 1997, Kan, 1975, and Pletcher, 1963) that describes suitable spawning habitat for Pacific lamprey indicates the suitable habitat identified within the Wells Project can best be described as marginal. Extensive spawning ground surveys over the time period and water quality conditions (Close et al., 1995, Jackson et al., 1997, Kan, 1975, and Pletcher, 1963) that typically define the Pacific lamprey spawning period support this conclusion.

In total, each spawning habitat reach was visited a maximum of 14 times over the approximate 3.5 month study period. Columbia River reaches (C1 and C2) were visited regularly throughout the study period. Although the Methow River reach (MR) and Okanogan River reach (OR) were surveyed less frequently (6 and 4 times, respectively) due to high flow conditions, it is important to note that both reaches were surveyed at the beginning and end of the study. It is not uncommon for spawning reaches to be inaccessible due to high flows for various species of spring spawning fish. Surveys can be conducted when flows recede and signs of past spawning

activity can be recorded retrospectively. The last survey date (August 5, 2008) of the study had water temperatures well above what is indicative of Pacific lamprey spawning which implies that if spawning had occurred, it was likely prior to this date. Signs of spawning (nests, test digs, depressions, spawning fish, or fish) were not observed during this final survey at any of the four sites.

8.0 STUDY VARIANCE

This study was not required by FERC as part of the October 11, 2007 Study Plan Determination. This study was voluntarily conducted by Douglas PUD based upon the agreed-upon study plan filed with FERC in the Revised Study Plan. There were no variances from the FERC approved study plan for the Lamprey Spawning Assessment.

9.0 ACKNOWLEDGMENTS

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Appendix A

Wells Project Pacific Lamprey Spawning Ground Reaches

Pacific Lamprey Spawning Survey
Columbia River Site 1

Area surveyed for Pacific lampery

Wells Project Boundary

0 200 400 600 Feet

Notes:
1. The locations of features shown on this drawing are approximate.
2. This drawing is for information purposes only. Douglas PUD cannot guarantee the accuracy and content of this map.

S: Data/EARS/DistrictMapDocs/Kreiter/Lamprey Spawning/Lamprey Spawning Survey Site MR.mxd Aug 04, 2008

Pacific Lamprey Spawning Survey
Columbia River Site 2

Area surveyed for Pacific lampery

Wells Project Boundary

0 200 400 600
Feet

Notes:
1. The locations of features shown on this drawing are approximate.
2. This drawing is for information purposes only. Douglas PUD cannot guarantee the accuracy and content of this map.

S: Data/EARS/DistrictMapDocs/Kreiter/Lamprey Spawning/Lamprey Spawning Survey Site MR.mxd Aug 04, 2008

Pacific Lamprey Spawning Survey
Methow River Site

Area surveyed for Pacific lampery

Wells Project Boundary

0 200 400 600
Feet

Notes:
1. The locations of features shown on this drawing are approximate.
2. This drawing is for information purposes only. Douglas PUD cannot guarantee the accuracy and content of this map.

S: Data/EARS/DistrictMapDocs/Kreiter/Lamprey Spawning/Lamprey Spawning Survey Site MR.mxd Aug 04, 2008

Pacific Lamprey Spawning Survey
Okanogan River Site

Area surveyed for Pacific lampery

Wells Project Boundary

0 200 400 600 Feet

Notes:
1. The locations of features shown on this drawing are approximate.
2. This drawing is for information purposes only. Douglas PUD cannot guarantee the accuracy and content of this map.

S: Data/EARS/DistrictMapDocs/Kreiter/Lamprey Spawning/Lamprey Spawning Survey Site MR.mxd Aug 04, 2008

Appendix B

Wells Project Pacific Lamprey Spawning Ground Survey Data

Date	Site	Temp ©	Discharge (kcfs)	Activity	StartTime	End Time	Surveyed?	Activity?	Comments	Surveyor
4/25/2008	MR	8.50	0.987	None	11:20am		y	n	water cold	BL, SK
	C1	11.50	Low	None			y	n	water cold	BL, SK
	C2	11.40	Low	None			y	n	water cold	BL, SK
	OR	11.40	1.13	None		3:00pm	y	n	Inaccessible due to high water	BL, SK
5/2/2008	MR	9.00	1.47	None	10:22am		y	n	water cold	BL
	C1	10.00	low	None			y	n	water cold	BL
	C2	9.95	low	None			y	n	water cold	BL
	OR	13.00	1.88	None		2:00pm	n	n	Inaccessible due to high water, no visibility	BL
5/7/2008	MR	10.50	3.42	None	11:10am		n	n	Low visibility, high flows, no access	SK
	C1	8.90	low	None			y	n	good visibility, no activity	SK
	C2	9.00	low	None			y	n	good visibility, no activity	SK
	OR	10.60	2.95	None		2:00pm	n	n	Inaccessible due to high water, no visibility	SK
5/16/2008	MR	10.00	7.57	None	11:00am		n	n	High flows, warm weather, no visibility	SK
	C1	9.80	low	None			y	n	Good visibility, no activity	SK
	C2	9.80	low	None			y	n	Good visibility, no activity	SK
	OR	10.50	4.95	None		2:00pm	n	n	High flows, warm weather, no visibility	SK
5/22/2008	MR	ND	9.82	None	11:00am		n	n	High flows, warm weather, no visibility	BL
	C1	ND	low	None			y	n	Good visibility, no activity	BL
	C2	ND	low	None			y	n	Good visibility, no activity	BL
	OR	ND	19.5	None		2:00pm	n	n	High flows, warm weather, no visibility	BL
5/29/2008	MR	10.50	9	None	12:15pm		n	n	High flow, no vis or access	BL
	C1	13.80	low	None			n	n	Turbidity from OK, no visibility	BL
	C2	13.70	low	None			y	n	High water, medium visibility	BL
	OR	12.50	17	None		2:22pm	n	n	High flow, no vis or access	BL
6/6/2008	MR	10.00	5.5	None	12:30pm		n	n	High flow, no vis or access	BL
	C1	12.80	low	None			y	n	Windy, medium visibility	BL
	C2	12.80	low	None			y	n	windy, medium visibility	BL

	OR	11.00		12	None		3:30pm	n	n	High flow, no vis or access	BL
6/10/2008	MR	11.20		4.8	None	11:30am		n	n	High flow, no vis or access	BL
	C1	13.50	low		None			y	n	Turbidity from OK, no visibility	BL
	C2	13.50	low		None			y	n	Good visibility, no activity	BL
	OR	12.30		8.95	None		2:15pm	n	n	High flow, no vis or access	BL
6/17/2008	MR	13.50		4.5	None	11:40am		n	n	High flow, no vis or access	BL
	C1	14.00	low		None			y	n	Turbidity from OK, no visibility	BL
	C2	13.50	low		None			y	n	med vis, increased algal growth on substrate	BL
	OR	15.50		9	None		2:50pm	n	n	High flow, no vis or access	BL
6/26/2008	MR	13.00		3.5	None	11:00am		n	n	High flow, no vis or access	BL
	C1	14.30	low		None			y	n	no activity	BL
	C2	14.30	low		None			y	n	no activity	BL
	OR	16.00		6.6	None		2:15pm	n	n	High flow, no vis or access	BL
7/2/2008	MR	13.80		4.5	None	10:43am		y	n	High flow, no vis or access, sunny and warm	BL
	C1	11.00	low		None			y	n	no activity	BL
	C2	11.00	low		None			y	n	no activity	BL
	OR	20.50		6.4	None		2:00pm	n	n	High flow, no vis or access	BL
7/11/2008	MR	16.50		1.9	None	11:00am		y	n	no activity	SK
	C1	15.20	low		None			y	n	no activity	SK
	C2	15.20	low		None			y	n	no activity	SK
	OR	20.00		3.3	None		2:00pm	y	n	no activity	SK
7/18/2008	MR	16.50		1.18	None	8:30am		y	n	no activity	SK
	C1	15.40	low		None			y	n	no activity	SK
	C2	15.50	low		None			y	n	no activity	SK
	OR	20.50		1.9	None		10:30am	y	n	no activity	SK
7/25/2008	MR	n/a	n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a
	C1	16.00	low		None			y	n	no activity	SK

	C2		16.00	low		None			y	n	no activity	SK
	OR	n/a		n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a
8/1/2008	MR		17.50		0.73	None	8:30am		y	n	no activity	BL/SK
	C1	n/a		n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a
	C2	n/a		n/a		n/a	n/a	n/a	n/a	n/a	n/a	n/a
	OR		21.50		1.2	None		10:30am	y	n	no activity	BL/SK