Fish Passage Inventory and Barrier Assessment on U.S. Fish and Wildlife Service Lands: Watershed Resource Inventory Areas 24-29

By

Brian J. Peck, Heather J. Tschaekofske,
Linda Moore

U.S. Fish and Wildlife Service
Western Washington Fish and Wildlife Office
Division of Fisheries and
Division of Environmental Assessment and Restoration
Lacey, Washington

May 2006

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Introduction

The United States Supreme Court and other courts affirmed that, when treating with the United States in the mid 1800's, the Western Washington Treaty Tribes had reserved unto themselves the harvest rights to fish, and, hence, were managers of the resource. The courts also affirmed that, in exchange for concessions during the treating, the Tribes had ceded to society at-large the right to harvest fifty percent of the harvestable fish numbers. Consequently, the state became a co-manager along with the tribes, and cooperative fishery management is now common routine (Van Meter, Jerry, U.S. Fish and Wildlife Service, Pers. Comm., 2006).

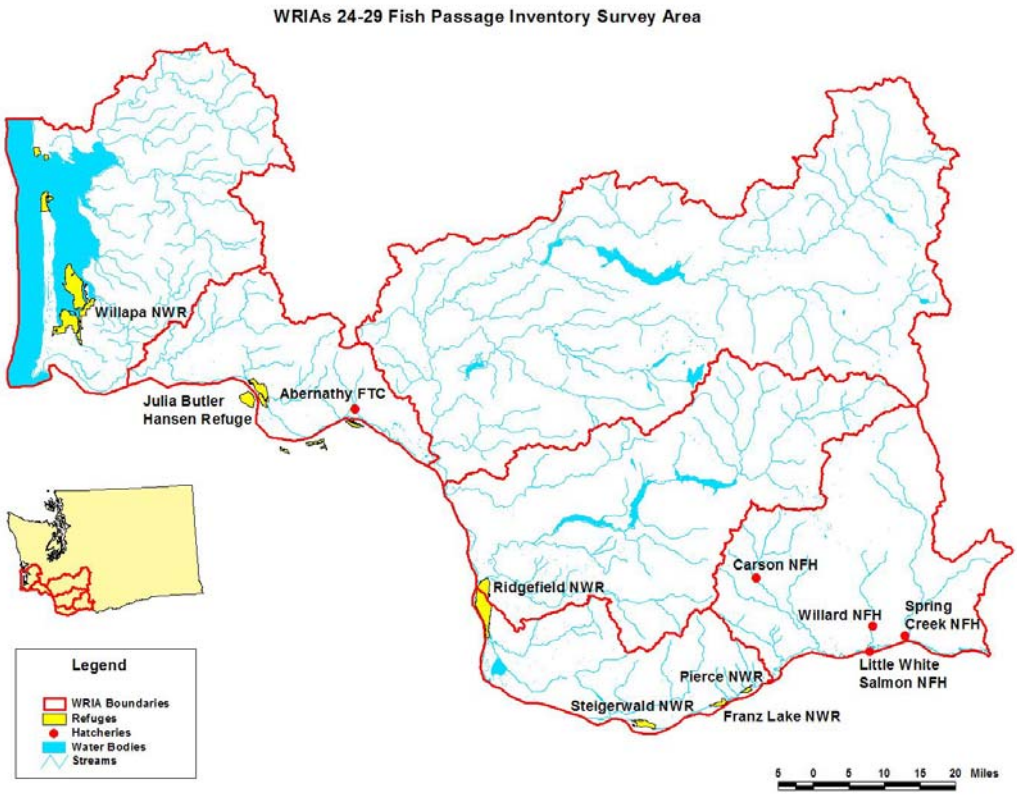
The current *United States* versus *Washington* sub-proceeding (*Boldt* culvert case) specifically addresses the impacts of barrier and partial barrier culverts on anadromous fish passage, and how these barriers may affect the number of salmon available with regard to Tribal Treaty fishing rights. Through participation in past settlement negotiations of the *Boldt* culvert case, the U.S. Fish and Wildlife Service (Service) recognized the need to document and prioritize all fish passage barriers on Service lands within the case area, specifically Watershed Resource Inventory Areas (WRIA) 1-23. A fish passage assessment of Service owned lands in WRIA's 1-23 was conducted in 2003, and a report completed in February 2004 (Tschaekofske et al. 2004).

In an effort to expand on this previous assessment, the Western Washington Fish and Wildlife Office Fisheries Division received funds in fiscal year 2004 through the National Fish Passage Program. These funds were used to conduct a complete barrier assessment of Service lands in WRIA's 24-29 (Figure 1) during June and July of 2004. In addition to culverts at road-stream crossings, all other structures that potentially impact fish passage were assessed. The survey included National Fish Hatcheries (NFH), a fish health center, a fish technology center, and National Wildlife Refuges (NWR) owned and managed by the Service. These facilities included: the Little White Salmon, Willard, and Spring Creek NFH; the Lower Columbia River Fish Health Center; the Abernathy Fish Technology Center (FTC); and the Willapa, Julia Butler Hansen, Ridgefield, Pierce, Franz, and Steigerwald Lakes NWR.

In addition, the Willapa NWR complex has conservation easements on 12 properties throughout WRIA's 24-29. We do not know the number of conservation easements that the Ridgefield NWR complex has throughout WRIA's 24-29. At this time it is unclear if the Service is responsible for providing fish passage on the conservation easement properties. Therefore, these properties were not included in the fish passage assessment.

Documentation of barriers to fish passage and prioritization for replacement is a significant first step towards increasing habitat for anadromous and resident salmonids, as well as other native fish species and aquatic organisms. Future barrier replacement efforts may eventually focus on the full ecological function of streams, such as how these structures impact the movement of invertebrates, sediment, and wood, as well as the physical and biological function of streams.

Figure 1. WRIA 24-29 Refuge and Hatchery Facilities



Survey Methodology and Materials

National Environmental Protection Act compliance for this project was completed on June 11, 2004. This assessment met categorical exclusion B.(1) which states: "Research, inventory, and information collection activities directly related to the conservation of fish and wildlife resources which involve negligible animal mortality or habitat destruction, no introduction of contaminants, or no introduction of organisms not indigenous to the affected ecosystem."

Initial contact with the refuge and hatchery facility managers was made via phone to determine the possible presence of fish barriers within these properties. Site visits were conducted at each facility after permission was obtained to survey the refuge and hatchery facilities. ArcView Geographic Information System (GIS) generated maps were utilized while in the field to determine the location of potential fish barriers. The GIS maps included the following layers: hydrology, roads, Service ownership, Washington Department of Natural Resources (WDNR) stream typing, and township, range, and section locations.

Surveys were completed according to the protocols set forth in the Washington Department of Fish and Wildlife (WDFW) "Fish Passage Barrier Assessment and Prioritization Manual" of the Technical Applications Division (TAPPS 2000). We utilized this protocol because it is widely accepted throughout Washington and many local, state, and federal agencies and other groups have or are currently utilizing it. The protocol provides a standard method of data collection across the state, a means to prioritize fish barriers for replacement across differing jurisdictions, and a single database depository.

The first step at each site was to identify each feature as a culvert, fishway, dam, gravity diversion, pump diversion, or other. When applicable, additional information was obtained for each feature, which included the following:

Fish bearing waters The first step at each site was to identify whether the waterway was fish bearing. To make this determination, waterways were evaluated to determine if they:

(1) were WDNR mapped type 1-4 waterways;
(2) had documented presence of salmonids through visual observation, electrofishing, or verification by local biologists;
(3) were water courses having ordinary high water widths greater than 0.60 meters (m) and gradients less than 20%; or,
(4) were listed in "A Catalog of Washington Streams and Salmon Utilization" (Phinney and Bucknell 1975).

In most cases, the refuge and hatchery managers also had documentation of current and historical fish utilization for the waterways surveyed. If none of these criteria were met, the waterway was assessed as non-fish-bearing. If any of these criteria were met but fish presence was questionable, then the waterway was evaluated as unknown for fish presence. The barrier assessment was not necessarily intended to identify whether or not fish are currently using the habitat, but rather the potential use if the habitat above was made accessible.

Fish passage determination Within the TAPPS manual protocol, there are three categories for fish passability: passable, impassable, or unknown. The protocol has been designed to assess fish passability for all juvenile through adult salmonid life stages. Partial barriers were rated as a percentile of the degree of passability (0%, 33%, 67%, 100%); partial barriers do not indicate a barrier to all fish species and/or life stages.

A Level A analysis was completed for initial barrier determination of culverts, and if barrier status could not be determined at this level, a Level B analysis was initiated (see Appendix B for Level A and B analysis flow charts). Based on the Level B analysis, the barrier status of a culvert was unknown if there was a grade break within the culvert, a downstream control point was inaccessible, or the culvert was submerged. The downstream control was typically the head of the first riffle downstream of the culvert, where measurements must be taken for the Level B analysis. The downstream control was inaccessible if the culvert was tidally influenced or there was a wetland or large pond downstream of the culvert.

In accordance with the TAPPS manual protocol, pump and gravity water diversions were evaluated on the basis of fish protection, not fish passage, and therefore were recorded as no-status for the barrier assessment. If a dam was associated with a water diversion, the facility was evaluated for fish passage at the dam. Fish passage at dams was evaluated based on the following criteria: In streams where chum salmon were present, and the water level difference up and downstream of the dam was greater than 0.24 m, the dam was identified as a barrier. If the stream was not used by chum salmon and the water level difference up and downstream of the dam was greater than 0.30 m, the dam was a barrier.

A laser mounted on a monopod was used to obtain the culvert length and slope, and a metric stadia rod was used for all other measurements. Photographs were taken with a digital camera, and site location was recorded using a GPS receiver.

Stream simulation determination A discrepancy exists between the TAPPS manual protocol determination of a fish barrier and the WDFW stream simulation design for installing fish passable culverts. In order to address this discrepancy (explained in the next paragraph) additional measurements were taken for the WDFW stream simulation model on culverts that satisfied certain requirements (see Appendix B for stream simulation model flow chart). The stream simulation model is "a design method used to create or maintain natural stream processes in a culvert. Stream simulation is based on the principle that, if fish can migrate through the natural channel, they can also migrate through a man-made channel that simulates the stream channel" (Bates et al. 2003).

According to the TAPPS manual protocol, a culvert is considered passable if it has streambed material throughout, and the ratio of the diameter of the culvert to the toe width of the stream is 75% or greater. However, a culvert that is determined passable by the TAPPS manual protocol may not meet the specifications required of the WDFW stream simulation design criteria. To determine whether an existing culvert meets the stream simulation criteria, the bankfull channel width and the slope of the streambed are measured in comparison with the existing culvert diameter and slope. The culvert bed diameter should be 1.2 times the bankfull channel width, plus 2 feet; and the slope ratio of the stream to the culvert should be no greater than 1.25 (see Appendix B for stream simulation model flow chart).

Overall Results

A total of 191 sites were visited, which included all potential fish passage barriers on Service-owned property in WRIA's 24-29. Of these sites, 30 culverts and 2 dams were found to be partial or complete barriers. Total features evaluated were 163 culverts, 2 dams, 8 fish ladders, 14 gravity diversions, and 4 as other (Tables 1 and 2).

Table 1. Total Features Evaluated on Service lands in WRIA's 24-29

Feature	Non-fish Bearing	Barrier	Passable	Unknown Passability	No Status for Passability	Total
Culverts	102	30	0	31	0	163
Dams	0	2	0	0	0	2
Fishways	0	0	0	0	8	8
Gravity Diversions	0	0	0	0	14	14
Pump Diversions	0	0	0	0	0	0
Other	0	0	3	0	1	4
Total	102	32	3	31	23	**191**

Table 2. Status for Features Evaluated on Service lands in WRIA's 24-29

Site	Non-fish Bearing	Barrier	Passable	Unknown Passability	No Status for Passability	Total
Willapa NWR	75	8	1	9	4	97
Julia Butler Hansen NWR	6	14	0	20	0	40
Ridgefield NWR	1	1	1	1	0	4*
Pierce Lake	1	4	1	1	0	7
Franz Lake	1	0	0	0	0	1
Steigerwald Lake	1	3	0	0	0	4
Carson NFH	2	0	0	0	4	6
Willard NFH	2	0	0	0	1	3
Little White Salmon NFH	7	2	0	0	5	14
Spring Creek NFH	2	0	0	0	7	9
Abernathy FTC	4	0	0	0	2	6
Total	102	32	3	31	23	**191**

* The total at Ridgefield NWR does not include the culverts located on the inside of dikes in the River S and Bachelor Units. See pages 29 and 30 for more information.

Hatchery, Fish Health, and Fish Technology Facilities

Abernathy Fish Technology Center

Introduction

The Abernathy FTC is located at river kilometer (RK) 4.8 on Abernathy Creek, a direct tributary to the Columbia River in Cowlitz County, Washington. Abernathy Creek originates in the southern foothills of the Willapa Hills which is primarily privately owned timberlands. There is an impassable waterfall on the mainstem of Abernathy Creek at RK 22 (USFWS website: http://www.fws.gov/aftc/).

The Abernathy FTC was originally established as a National Fish Hatchery in 1960. In 1961, research activities at the Salmon Culture Laboratory in Entiat, Washington were transferred to Abernathy to expand the laboratory's research program to include tule fall Chinook. Currently the mission is to provide leadership in the scientifically based management of national fishery resources through development of new concepts and techniques to solve specific problems in aquatic restoration and recovery activities. The Applied Research Programs conduct cooperative studies developing, promoting, and supporting methodologies and technologies resulting in healthy populations of fish including Chinook, coho, and chum salmon, steelhead/ rainbow, cutthroat, and bull trout, Pacific lamprey, and white sturgeon (USFWS website: http://www.fws.gov/aftc/).

Survey Results

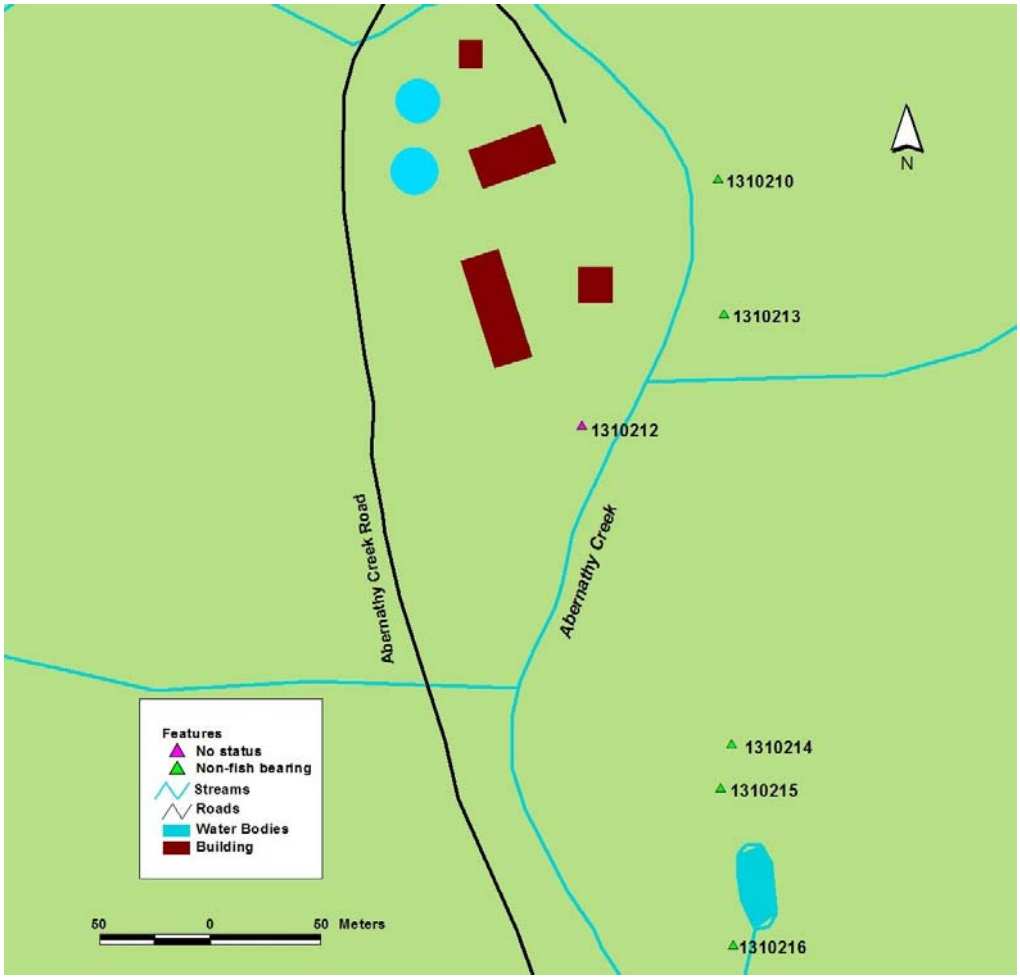
We conducted our survey, in cooperation with Abernathy FTC staff, on July 9, 2004. The Abernathy FTC includes one pond for adult holding, 12 concrete raceways, 92 circular starter tanks, six troughs, and incubation facilities (USFWS website: http://www.fws.gov/aftc/). Our survey identified a total of six sites of interest throughout the Abernathy FTC property. Hatchery infrastructure that was assessed for fish passage included: Abernathy Creek electric weir and fish ladder; Abernathy Creek water intake; spur road culvert; abandoned spawning channel culverts; and effluent pond culvert (Figure 2). Of these six structures, four were located on non-fish-bearing water and two (the hatchery fish ladder and intake structure) were rated as no status for passability.

Abernathy Creek electric weir and fish ladder The Abernathy FTC has an electrified/concrete weir that spans the entire channel of Abernathy Creek (Appendix A, 1310212). This weir is used to prevent returning adult salmon from passing the hatchery and to guide them into the hatchery's fish ladder. The electric weir had previously been surveyed by WDFW and was evaluated as 100 percent passable, if turned off.

On the right bank, adjacent to the electric weir, is the entrance to the fish ladder (Appendix A, 1310212). The fish ladder contains six pools and six weirs. During our survey the fish ladder was dry and there were no weirs in place; however, we estimated the approximate pool-head difference to be 0.3 m. There were no vertical slots in the tops of the wood weirs. The fish ladder is only intended to pass fish up into the hatchery and therefore was recorded as **no status for passability** for this assessment.

Abernathy Creek water intake Upstream of the electric weir and hatchery fish ladder is a WDFW-owned dam and the hatchery's water intake structure on the right bank (Appendix A, 1310210). WDFW evaluated the dam and associated fish ladder as 100 % passable. There is a debris gate and fish screen in front of the gravity diversion intake pipe with an alarm that warns of debris buildup. The intake pipe measures 0.9 m in diameter and routes water to a settling pond and then the hatchery, with excess water returned to the river by pipe. There is a 2-m drop at the end of this return pipe and therefore no unwanted fish access. The intake structure and screen were recorded as **no status for passability** for this assessment.

Figure 2. Abernathy Fish Technology Center.



Spur road culvert There is a small spur road located behind the hatchery buildings, with one small (0.2 m diameter) cross drain culvert that provides road drainage (Appendix A, 1310213). The upstream side of this culvert is crushed, creating a greater chance of becoming blocked with wood. The culvert was located on **non-fish-bearing** water.

Abandoned spawning channel culverts Two culverts (Appendix A, 1310214 and 1310215) are located at the hatchery spawning channels, which are part of a project that was never used. The spawning channel is overgrown and there is no water present. The culverts are about 15 m apart and are connected to the same ditch. Each culvert measures 0.8 m in diameter and has an outfall drop of 0.4 m to the ditch. Both of these culverts are located on **non-fish-bearing** water.

Effluent pond culvert There is a culvert (Appendix A, 1310216) that drains the hatchery's effluent pond, located near Abernathy Creek. The culvert drains effluent water into the abandoned spawning channel. There is a 2 m drop from the effluent pond to the culvert and the culvert measured 0.47 m in diameter. This culvert is located on **non-fish-bearing** water.

Carson National Fish Hatchery

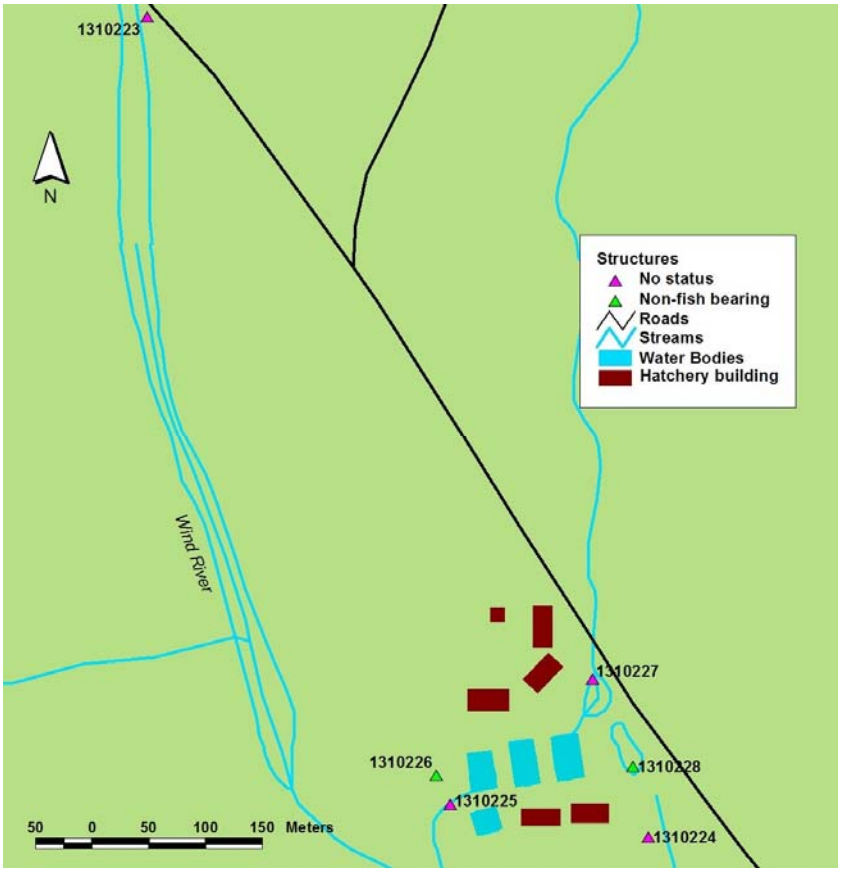
Introduction

The Carson NFH was built by the Civilian Conservation Corps in 1937. As a result of spawning habitat loss and degradation and the impact of dams on migration, spring Chinook were in rapid decline. During the 1950s, the hatchery began rearing spring Chinook and has helped spring Chinook populations recover in the lower Columbia River (USFWS website: http://www.fws.gov/gorgefish/carson/default.htm). The Carson NFH is located in Skamania County, Washington.

Survey Results

We conducted our survey, in cooperation with Carson NFH staff, on July 13, 2004. Our survey identified a total of six sites of interest throughout the Carson NFH property. The Carson NFH does not have a dam on the Wind River. Hatchery infrastructure that was assessed for fish passage included: hatchery fish ladder, Wind River water intake, Tyee Spring water intake, holding ponds culverts, holding ponds release structure, and pollution abatement pond culvert (Figure 3). Of these six structures, two were located on non-fish-bearing water and four were rated as no status for passability.

Figure 3. Carson National Fish Hatchery.



Hatchery fish ladder The hatchery fish ladder (Appendix A, 1310225) is located on the west side of the hatchery, on the left bank of the Wind River. The fish ladder contains 6 pools and 5 weirs that have a pool head difference of 0.3 m each. There were alternating notches at the top of each weir that measured about 0.2 m wide. The fish ladder is only intended to pass fish up into the hatchery, and was recorded as **no status for passability** for this assessment.

Wind River water intake The water intake structure (Appendix A, 1310223) is located on the left bank of the Wind River about 0.8 km above the hatchery, and about 10 m downstream of the Wind River Road bridge. There is a metal grate with 0.1 m wide gaps in front of the intake. The intake is not used very often but when water is diverted to the hatchery, screens are put in place to prevent fish from entering the structure. The intake structure and screen were recorded as **no status for passability** for this assessment.

There is a WDFW fish trap about 30 m upstream of the water intake structure that is currently not in use.

Tyee Springs water intake The main water intake structure (Appendix A, 1310227) is located at Tyee Springs, adjacent to the Wind River Road. Tyee Springs is not a fish bearing waterway. The intake structure is housed in a small building and has a rotary drum screen that is rotated by a water wheel. Tyee Spring water can be diverted into the holding ponds located on the left bank; however, this diversion was blocked with wood risers. The intake structure and screen were recorded as **no status for passability** for this assessment.

Holding ponds culverts The hatchery's earthen fish holding ponds are connected by three culverts (Appendix A, 1310228; 1.3, 2.3, and 3.3). There is a concrete structure that surrounds culverts 1.3 and 2.3, but the culverts are open to the upstream pond. Culvert 3.3 is not visible at the upstream side but there is a screen on the downstream end. There was water but no substrate present within culverts 1.3 and 2.3 and no water or substrate in culvert 3.3. Culverts 1.3, 2.3, and 3.3 had diameters of 1.4 m, 0.75 m, and 0.75 m, respectively. These culverts are within the hatchery holding ponds, therefore they are located on **non-fish-bearing** water.

Holding ponds release structure A cement box structure (Appendix A, 1310224) is located on the southern side of the hatchery property next to the Wind River Road. Water from Tyee Springs can fill the holding ponds when needed and allow release of the fish to the Wind River. There are slots in the cement box to place wood risers, however the risers were raised up, with about 0.2 m of water flowing out to the Wind River. The holding ponds release structure was recorded as **no status for passability** for this assessment.

Pollution abatement pond culvert A culvert (Appendix A, 1310226) located adjacent to the hatchery fish ladder returns water from the pollution abatement pond to the river. The culvert measured 0.38 m in diameter and has a high gradient slope with high velocity water flowing out. There is a concrete box and grating in front of the culvert that

prevents adult salmon from entering the culvert. The culvert is used to return hatchery water to the river, therefore it is located on **non-fish-bearing** water.

Little White Salmon and Willard National Fish Hatchery Complex

Introduction

The Little White Salmon NFH was a pioneer in the fledgling science of salmon propagation when it began rearing salmon in 1896. During the past 100 years, the facilities and the propagation methods have changed dramatically and research is on-going. Today, more than 9.4 million young salmon are released into the Columbia River or transferred to other sites for release each year. The Little White Salmon River provides a cold, clean source of water in which salmon are incubated and raised for 6 to 18 months. Spring and up-river bright fall Chinook salmon and coho salmon produced at the Little White Salmon NFH contribute significantly to the salmon harvested by sport fishers in the Columbia River, particularly in Drano Lake (USFWS website: http://www.fws.gov/gorgefish/littlewhite/).

The Willard NFH is part of the Little White Salmon/Willard NFH Complex with administrative offices located at the Little White Salmon NFH. It was built in 1952 and has been used primarily for raising coho salmon that are collected at the Little White Salmon NFH since the mid-1960s. Willard NFH is currently an integral component of the Yakama Nation Mid-Columbia coho salmon reintroduction effort aimed at reestablishing self sustaining populations of coho salmon in the Wenatchee River Basin of north central Washington (USFWS website: http://www.fws.gov/gorgefish/willard/). The hatchery complex is located in Skamania County, Washington.

Survey Results

We conducted our survey, in cooperation with Little White Salmon/Willard NFH Complex staff, on July 14, 2004. There is a natural barrier waterfall, Spirit Falls, about 0.8 km upstream of the Little White Salmon NFH, which prevents anadromous fish access upstream, including to the Willard NFH.

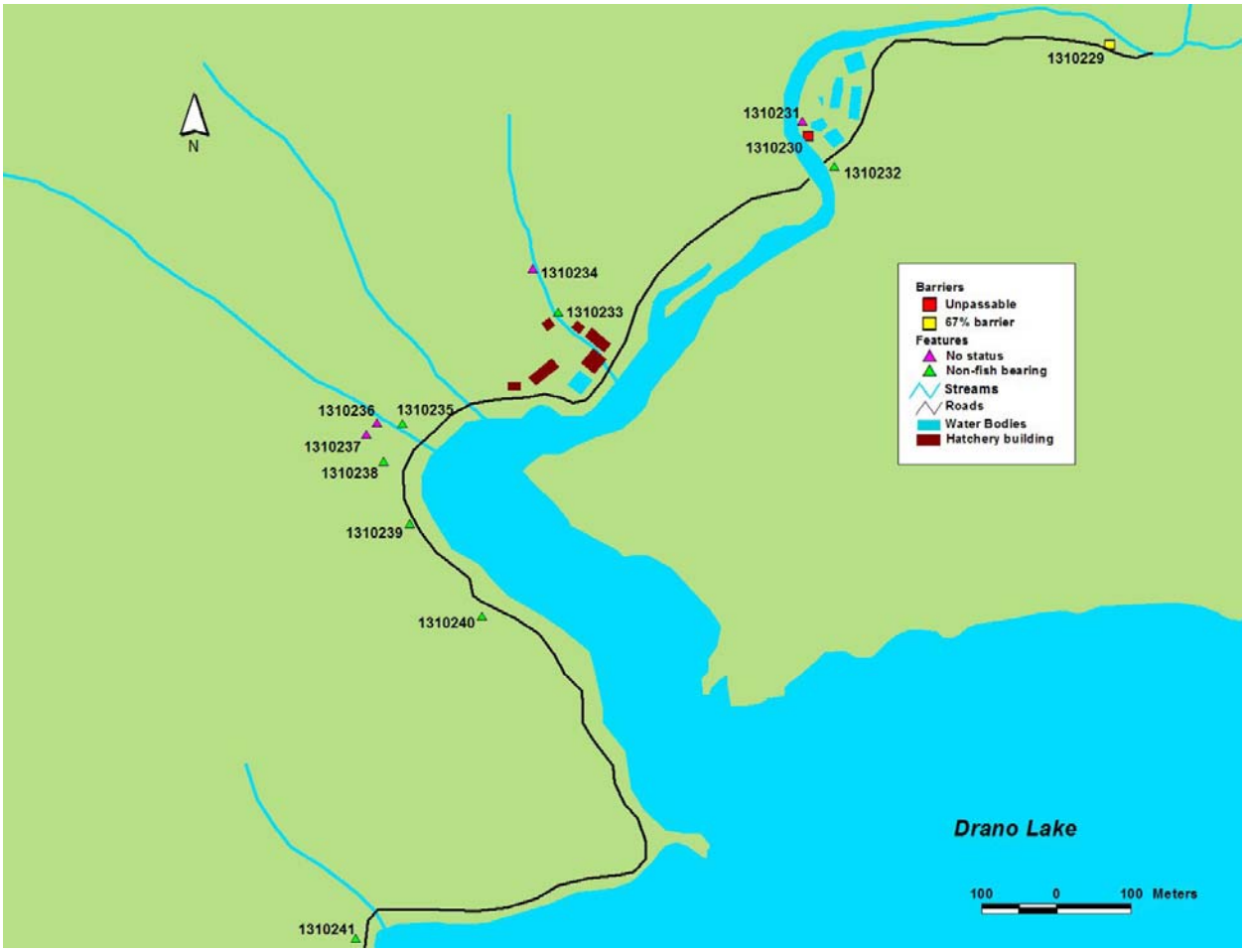
Our survey identified 14 sites of interest on Little White Salmon NFH property. Hatchery infrastructure that was assessed for fish passage included: Little White Salmon River barrier dam, hatchery fish ladder, Little White Salmon River dam and water intake, Hillside Spring water intake, Hillside Spring culvert, Roadside Spring water intakes, Roadside Spring culverts, unnamed springs culverts, and pollution abatement pond culvert (Figure 4). Of these 14 structures, seven were located on non-fish-bearing waters, two were fish passage barriers, and five were rated as no status for passability.

Little White Salmon River barrier dam and hatchery fish ladder The Little White Salmon NFH has a concrete dam that spans the entire channel of the Little White Salmon River (Appendix A, 1310230). The dam is 40 m long and 3 m high with two steps of 1.5

m each. The dam intentionally prevents returning adult salmon from passing the hatchery and guides them into the hatchery's fish ladder. There was a small closed gate on the left bank side of the dam that if opened, could potentially provide upstream fish passage. Also, fish could be manually transported upstream by hatchery personnel if desired. The dam was evaluated as a **100 percent barrier** to upstream fish passage.

On the left bank of the dam is the hatchery fish ladder (Appendix A, 1310231). The fish ladder is underground at the upper portion. We were not able to count all of the weirs, but there are at least seven pools and seven weirs with a pool-head difference of 0.2 to 0.3 m each. Excess water from the fish ladder flows out adjacent to the ladder. The fish ladder is only intended to pass fish up into the hatchery and was recorded as **no status for passability** for the purpose of this assessment.

Figure 4. Little White Salmon National Fish Hatchery.



Little White Salmon River dam and water intake Approximately 0.4 km upstream of the barrier dam and hatchery fish ladder is a diversion dam that spans the Little White Salmon River and a gravity water intake structure on the left bank (Appendix A, 1310229). The dam is 23 m long and 1 m high with two steps of 0.5 m each. There is a small water/debris release gate on the left bank side of the dam that was open about 0.3

m. The dam was evaluated as a **67 percent barrier** to upstream fish passage; however, at high flow fish passage at the dam increases.

The water intake structure (Appendix A, 1310229) connects to a rotary screen drum area through a rock tunnel that was dynamited in the early 1900's. There is a pipe that measures 0.9 m in diameter that routes excess water and fish to the river. The intake structure and screen were recorded as **no status for passability** for this assessment.

Hillside Spring water intake One of several water intake structures for the hatchery nursery water is located at Hillside Spring (Appendix A, 1310234), about 30 m upstream of culvert number 1310233. Bailey Spring stream is small and steep and is not a fish bearing waterway. The intake structure consists of a mesh screen within a concrete box that spans the stream and forms a small backwatered pool. There were some active rock slides in the area at the time of the assessment. The intake structure and screen were recorded as **no status for passability** for this assessment.

Hillside Spring culvert A culvert (Appendix A, 1310233) is located about 30 m downstream of water intake number 1310234. This culvert measured 1 m in diameter and transports Hillside Spring water under the main hatchery road. The upstream side of this culvert is enclosed in cement with a metal grate on top and is located on **non-fish-bearing** water.

Roadside Spring water intake I One of several water intake structures for the hatchery lower raceway water is located at Roadside Spring (Appendix A, 1310236), upstream of culverts number 1310235. Roadside Spring and stream is small and steep and is not a fish bearing waterway. The intake structure consists of a mesh screen on top of a concrete box that spans the stream and forms a small backwatered pool. The intake structure and screen were recorded as **no status for passability** for this assessment.

Roadside Spring water intake II One of several water intake structures for the hatchery lower raceway water is located at a second roadside spring (Appendix A, 1310237), about 30 m away from water intake number 1310236. Unnamed spring is small and steep and is not a fish bearing waterway. The intake structure consists of a mesh screen on top of a concrete box that spans the stream and forms a small backwatered pool. The intake structure and screen were recorded as **no status for passability** for this assessment.

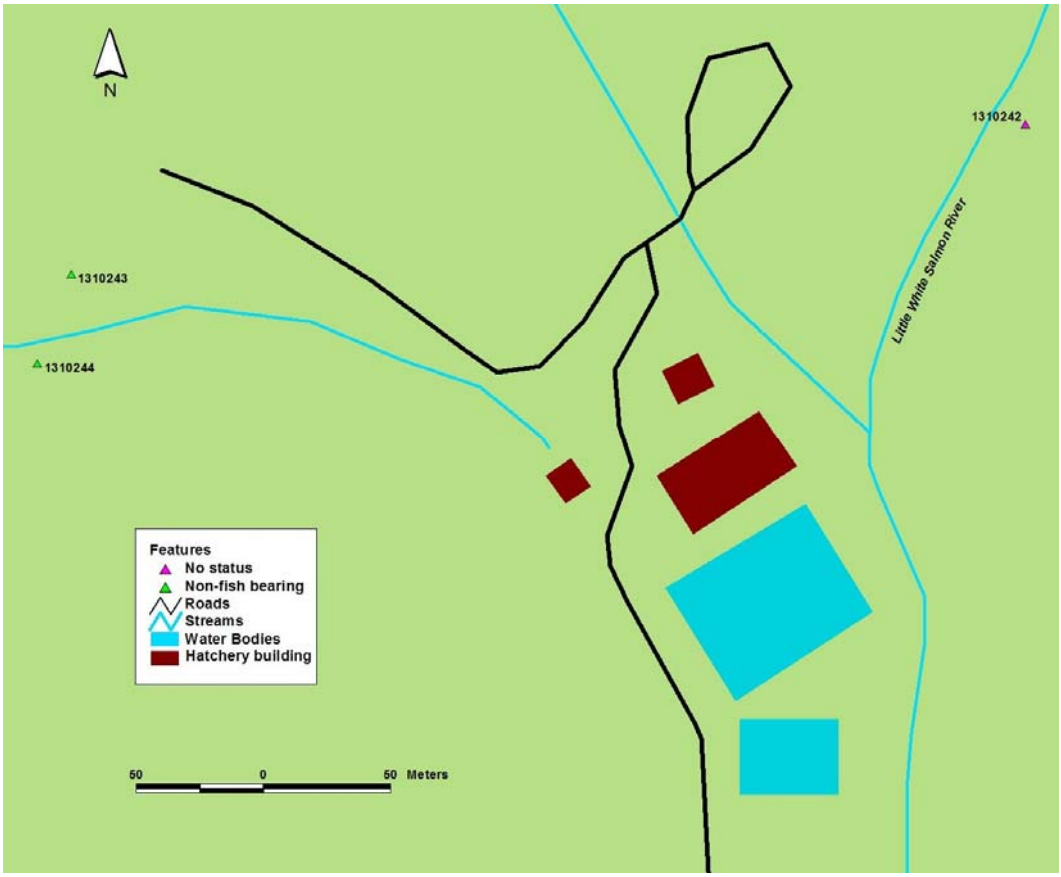
Roadside Spring culverts Two culverts (Appendix A, 1310235; 1.2 and 2.2) are located downstream of water intake number 1310236. These culverts measured 0.9 m and 0.4 m in diameter and transport Roadside Spring water under the main hatchery road. At the time of the survey most stream flow went subsurface above these culverts. The upstream side of these culverts are covered with a metal debris grate and they are located on **non-fish-bearing** water.

Unnamed Springs culverts A series of four cross drain culverts (Appendix A, 1310238, 1310239, 1310240, 1310241) are located on the main hatchery road. These culverts measured 0.5 m, 0.3 m, 0.2 m, and 0.2 m in diameter, respectively. All four culverts are located on **non-fish-bearing** water.

Pollution abatement pond culvert A culvert (Appendix A, 1310232) located downstream of the hatchery barrier dam, returns water from the pollution abatement pond to the river. The culvert measured 0.4 m in diameter and has a two step outfall drop of 0.4 m. The culvert is used to return pollution abatement pond water to the river, therefore it is located on **non-fish-bearing** water.

Our survey identified three sites of interest on Willard NFH property. There is no anadromous fish access to the Willard NFH due to the presence of a natural barrier waterfall downstream. Hatchery infrastructure that was assessed for resident fish passage included: Little White Salmon River water intake; drainage ditch culvert; and intermittent stream culvert (Figure 5). Of these three structures, two were located on non-anadromous fish-bearing waters and one was rated as no status for passability.

Figure 5. Willard National Fish Hatchery.



Little White Salmon River water intake The water intake structure (Appendix A, 1310242) is located on the right bank of the Little White Salmon River at the northern edge of the hatchery property. A concrete wall forms a large, deep, backwatered pool, with a debris grate on the upstream end of the intake. Water is gravity piped to a screened intake area where excess water and fish are returned to the river about 100 m downstream. The intake structure and screen were recorded as **no status for passability** for this assessment.

Drainage ditch culvert A cross drain culvert (Appendix A, 1310243) is located on an old logging road to the north of the hatchery buildings. This culvert measured 0.25 m in diameter and was located on **non-fish-bearing** water.

Intermittent stream culvert A culvert (Appendix A, 1310244) is located on an old logging road to the north of the hatchery buildings. This culvert measured 0.75 m in diameter and transports the intermittent creek water under the logging road. The downstream end of this culvert had an outfall drop of 0.35 m and there was no bed material present inside. This culvert was determined to be located on **non-fish-bearing** water (anadromous fish) for the purpose of this assessment; however, it is a **barrier to resident fish passage** due to the outfall drop.

Spring Creek National Fish Hatchery and Lower Columbia River Fish Health Center

Introduction

Established in 1901, Spring Creek NFH was one of several egg collection stations for the Bureau of Commercial Fisheries Clackamas Hatchery, near Portland, Oregon. As the human population of the Columbia River Gorge increased, heavy fishing pressure and destruction of habitat resulted in the U.S. government establishing a fish hatchery at this site. The original hatchery was flooded when the Bonneville Dam was completed in 1938. The hatchery was redesigned and rebuilt by the U.S. Army Corps of Engineers in 1972. The hatchery was expanded to partially compensate for the loss of fall Chinook spawning grounds due to dam construction along the Columbia River (USFWS website: http://www.fws.gov/gorgefish/springcreek/Default.htm).

Today the hatchery raises more than 15 million tule fall Chinook salmon annually. The hatchery uses water from several springs located at the base of the adjacent basalt cliffs. Ninety percent of the water used in the hatchery's rearing ponds is recycled through an oyster shell filtration system to conserve water and reduce pollution (USFWS website: http://www.fws.gov/gorgefish/springcreek/Default.htm).

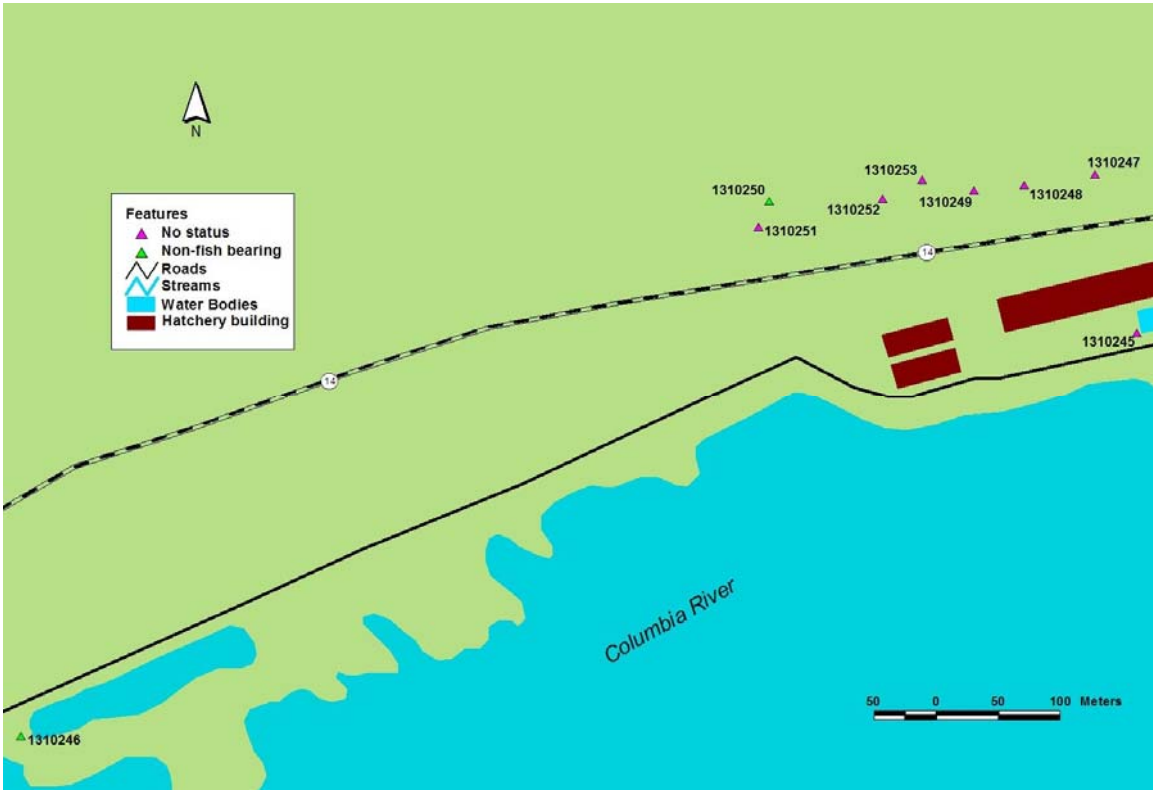
The Lower Columbia River FHC (Center) originated in 1953 as the first of the federal fish health centers in the northwestern states. The Center provides services to seven lower Columbia River NFH's, to three tribes, and as requested, to state and private facilities. The primary purposes of the Center are to inspect hatchery fish for pathogens, diagnose disease, recommend remedial treatments to maintain good health management, and to monitor the health of wild fish (USFWS website: (http://www.fws.gov/gorgefish/fishhealth/Default.htm). In May 2005, the Center moved from its location at Spring Creek NFH to a U.S. Forest Service site in Willard, WA (Gutenberger, Susan, U.S. Fish and Wildlife Service, Pers. Comm., 2006).

The Spring Creek NFH and Lower Columbia River FHC are located in Skamania County, Washington.

Survey Results

We conducted our survey, in cooperation with Spring Creek NFH staff, on July 14, 2004. Our survey identified nine sites of interest on Spring Creek NFH property. Hatchery infrastructure that was assessed for fish passage included: hatchery fish ladder, Spring Creek water intake structures, road drainage culvert, and a pollution abatement pond culvert (Figure 6). Of these nine structures, two were located on non-fish-bearing waters and seven were rated as no status for passability.

Figure 6. Spring Creek National Fish Hatchery.



Hatchery fish ladder On the right bank of the Columbia River is the hatchery fish ladder (Appendix A, 1310245). Water from several spring fed water intake structures is routed through the fish ladder. The fish ladder has 14 pools and 14 weirs and is only intended to pass fish up into the hatchery. It was recorded as **no status for passability** for this assessment.

Spring Creek water intake structures A total of six gravity water intake structures divert spring water to the hatchery fish ladder. Five of these structures (Appendix A, 1310248, 1310249, 1310251, 1310252, 1310253) divert water to a main diversion (Appendix A, 1310247), which then routes the water to the hatchery fish ladder. These intake structures either have open slots to route water downstream or have screened concrete boxes that pipe water to the main diversion structure. The intake structures and screens were recorded as **no status for passability** for this assessment.

Road drainage culvert A cross drain culvert (Appendix A, 1310250) provides spring water drainage for a hatchery road that is located on the north side of Highway 14. This culvert measured 0.32 m in diameter and was located on **non-fish-bearing** water.

Pollution abatement pond culvert A culvert (Appendix A, 1310246) located on the south side of Highway 14, off the hatchery entrance road, returns water from the pollution abatement pond to the river. The culvert measured 0.7 m in diameter and has a gate on the inlet. At the time of the assessment the gate was closed and the pollution abatement pond was dry. The culvert is used to return pollution abatement pond water to the river, therefore it is located on **non-fish-bearing** water.

Refuge Facilities

Willapa National Wildlife Refuge Complex

Introduction

Willapa NWR is located in Pacific County, Washington. The refuge consists of 27,500 acres on Willapa Bay, one of the most pristine estuaries in the United States and the second largest estuary on the Pacific Coast (USFWS 2005).

The refuge was established in 1937 to protect migrating and wintering populations of brant, waterfowl, shorebirds, and other migratory birds (USFWS website: http://www.fws.gov/willapa/WillapaNWR/Index.html). Primary fish species that occur on the refuge are Chinook salmon, coho salmon, chum salmon, steelhead trout, coastal cutthroat trout, and lamprey. The refuge preserves a number of ecosystems including sand dune, old growth forest, second growth forest, grassland, estuarine mudflats and saltmarsh, fresh water wetlands and all or part of 19 streams or rivers with resident and anadromous fish species (USFWS 2005).

Willapa NWR consists of several management units which are commonly referred to as: Lewis and Reikkola units at the southern end of Willapa Bay, Tarlatt Slough, Porter Point, Black River, Pickering, Teal Slough, Omera Point, Leadbetter Point at the very northern end of the Long Beach peninsula, and Long Island in Willapa Bay.

Long Island is the Pacific Coast's largest estuarine island. The island is 5,640 acres and includes a rare 274-acre old growth lowland coastal forest. The rain-drenched forests on the island grow rapidly and densely with salal, huckleberry, western hemlock, and Sitka spruce. A network of old logging roads converted to trails provides well over 10 miles of hiking opportunities (USFWS website: http://www.fws.gov/willapa/WillapaNWR/Index.html).

Willapa NWR has recently identified and implemented several fish passage and other aquatic restoration projects, including the following: dam removal, fish ladder construction, bridge installation, tide gate removal, and tidal restoration (USFWS 2005).

Survey Results

We conducted our survey, in cooperation with Willapa NWR staff, on June 21, 22, 23, 24, 28, 29, 30, and July 1, 2004. Our survey identified 97 sites of interest on Willapa NWR property. Refuge infrastructure that was assessed for fish passage included: road culverts, fishways, a log bridge, and tide gate culverts (Figure 7 and 8). Of these 97 structures, 75 were located on non-fish-bearing water, eight were barriers to fish passage, one was passable to fish, nine were unknown passability, and four were rated as no status for passability.

Figure 7. Willapa National Wildlife Refuge (North).

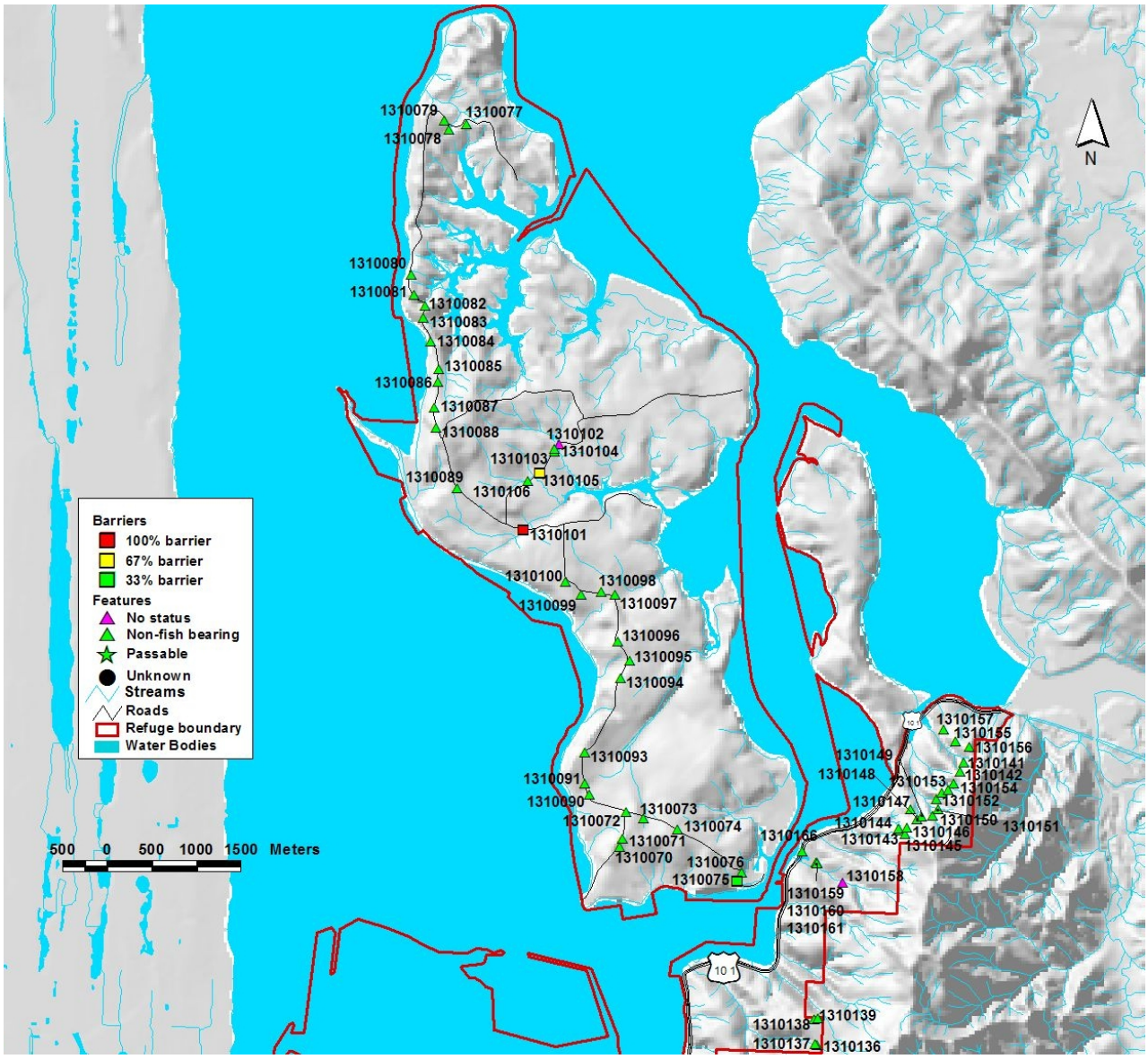
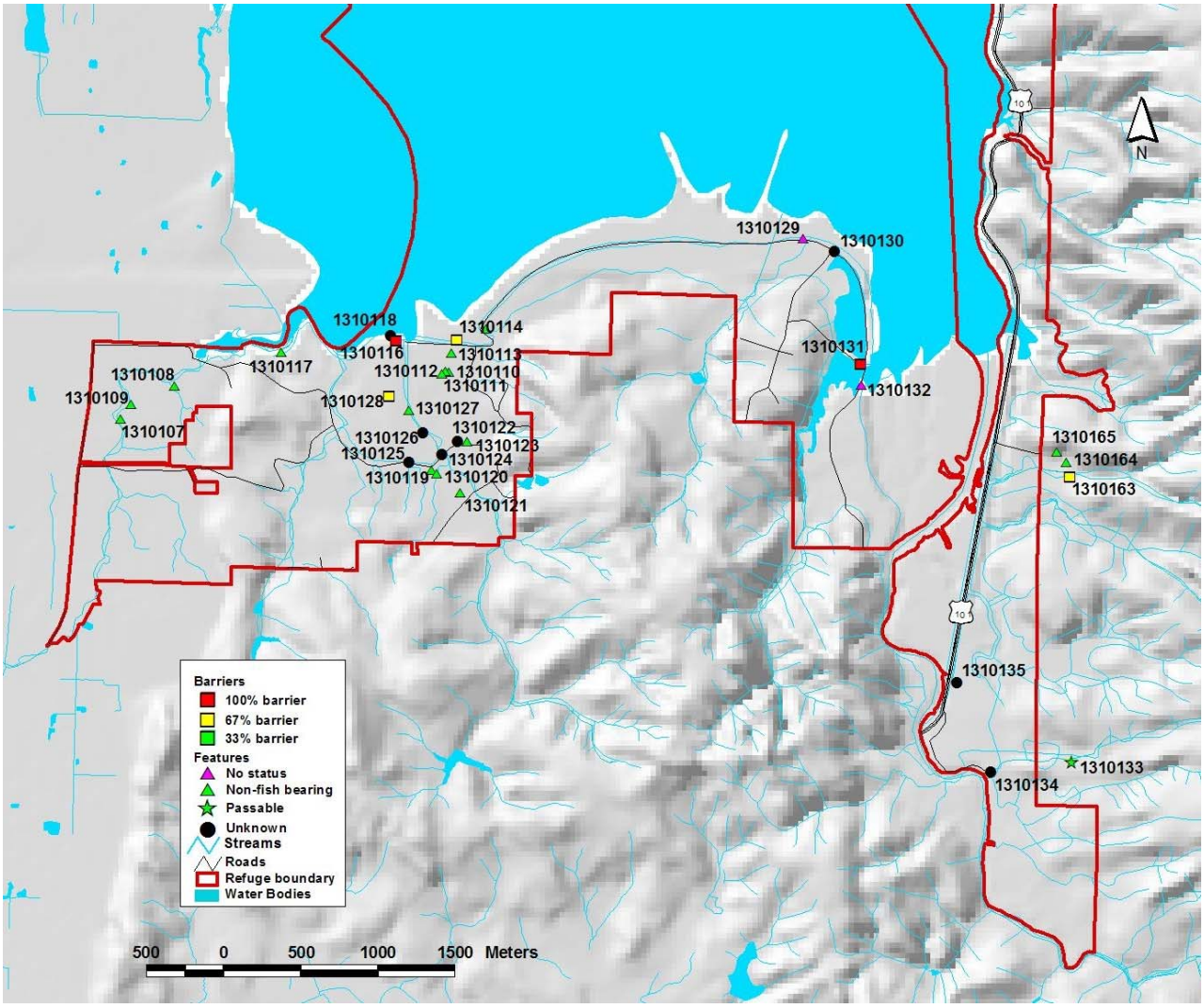


Figure 8. Willapa National Wildlife Refuge (South).



Long Island Unit We conducted surveys on Long Island by bicycle on June 21, 22, and 23, 2004. We identified a total of 37 sites, of which, 33 culverts were located on non-fish-bearing water, three culverts were barriers to fish passage, and one structure was evaluated as a fishway.

The 33 culverts located on **non-fish-bearing water** (Appendix A, 1310070 - 1310074, 1310076 - 1310100, 1310103, 1310104, and 1310106) serve mainly as cross drains for road drainage. Many of these culverts are in disrepair and are located on overgrown roads. These culverts range in diameter from 0.30 to 0.65 m.

The first of the three culverts that were determined to be fish passage barriers is located on the main road on Long Island. This culvert (Appendix A, 1310075) consists of two side by side round culverts that measured 0.65 m in diameter each. The culverts are located at the confluence of a small stream and Long Island Slough and are tidally

influenced. The culverts were at slopes of 2.2 % and 2.6 % and neither had streambed material present inside. The side by side culverts were evaluated as a **33 percent barrier** to upstream fish passage.

The second barrier culvert is located on the main road on a stream that flows into Baldwin Slough. This culvert (Appendix A, 1310101) has a water control structure and trash rack on the upstream end. There was grass and wood debris covering the front of the trash rack at the time of survey. The culvert measured 1.25 m in diameter and had a 0.7 m drop at the outlet. The culvert was evaluated as a **67 percent barrier** to upstream fish passage.

The third barrier culvert is located on a spur road on a stream that flows into Baldwin Slough. This culvert (Appendix A, 1310105) is located adjacent to a rusted out and completely blocked culvert. The culvert measured 0.61 m in diameter and had a 0.4 m drop at the outlet. The culvert was evaluated as a **67 percent barrier** to upstream fish passage.

There is a fishway (Appendix A, 1310102) located on the Baldwin Slough spur road. In 1999, the Willapa NWR removed a culvert at this location and installed log weirs to maintain the water surface elevation in an upstream wetland and to provide improved upstream fish passage. Two weirs were visible at the time of the survey; however, there is a large beaver dam that may be covering additional logs. The fishway was recorded as **no status for passability** for this assessment.

Tarlatt Slough Unit We conducted surveys of the Tarlatt Slough Unit on June 24, 2004. We identified a total of three sites, of which, two culverts were located on non-fish-bearing water, and one culvert was rated as unknown passability to fish passage.

The two **non-fish-bearing water** culverts (Appendix A, 1310107 and 1310108) are located on Lone Fir Cemetery Road and provide drainage for seasonal wetland and pasture land.

The third culvert (Appendix A, 1310109) is located on 95th Street and has a wetland on the upstream side and a tidal slough on the downstream side. Due to the presence of the wetland and slough, we were unable to perform a Level B analysis on this structure (see Level A and Level B flow chart, Appendix B). Therefore, this structure was evaluated as **unknown passability**. The culvert diameter measured 0.65 m and had a drop of 0.1 m at the outlet. No streambed material was present inside.

Riekkola Unit We conducted surveys of the Riekkola Unit on June 24 and 28, 2004. We identified a total of 19 sites, of which, 11 culverts were located on non-fish-bearing water, five culverts were rated as unknown passability to fish passage, and three culverts, including one with a tide gate, were barriers to upstream fish passage.

The 11 culverts located on **non-fish-bearing water** (Appendix A, 1310110 - 1310113, 1310115, 13101117, 1310119 - 1310121, 1310123, and 1310127) serve mainly as road

cross drains and are located in pasture land drainage ditches. These culverts range in diameter from 0.30 to 0.65 m.

The five culverts (Appendix A, 1310118, 1310122, 1310124, 1310125, 1310126) determined to be **unknown passability** were located in areas influenced by wetlands and/or tidal sloughs. Due to the presence of these wetlands and sloughs, we were unable to perform a Level B analysis on these structures (see Level A and Level B flow chart, Appendix B) to determine passability. Most of these culverts were located on ditches that drain to Domon Creek, however one culvert was located on the mainstem of Domon Creek (Appendix A, 1310124). No streambed material was present inside any of the culverts.

The first of the three culverts that were determined to be fish passage barriers is located on the main road in the northeast corner of the Riekkola Unit. The culvert (Appendix A, 1310114) measured 0.65 m in diameter and is in a stream with a bed width of 1.0 m. There is a rusted culvert that is buried adjacent to this one. The culvert was at a slope of 1.03 percent and had an outfall drop of 0.25 m. The culvert was evaluated as a **33 percent barrier** to upstream fish passage.

The second barrier culvert is located at the outlet of Domon Creek at Tarlatt Slough. This culvert (Appendix A, 1310116) consists of two side by side culverts with tide gates on each one. For tidally influenced culverts, an analysis of tidal influence and streamflow is needed (TAPPS 2000), however, WDFW considers this type of tide gate to be a barrier to fish passage since the gates rarely open completely to allow fish passage (Collins, Dave, WDFW, Pers. Comm., 2003). Each culvert also has a wood slat water control structure on the upstream end that prohibits saltwater exchange to the interior wetlands. The two culverts each measured 1.3 m in diameter and had a 0.5 m and 0.6 m drop at the outlet. However, at high tide there would not be an outfall drop. The culvert was evaluated as a **100 percent barrier** to upstream fish passage due to the presence of the tide gates and the water control structures.

The third barrier culvert is located on a tributary to Domon Creek. The tributary is ditched in the vicinity of the culvert and is overgrown with aquatic vegetation. This culvert (Appendix A, 1310128) measured 0.60 m in diameter and had a 1.17 percent slope with no streambed material inside. The culvert was evaluated as a **33 percent barrier** to upstream fish passage.

<u>Porter Point Unit</u> We conducted surveys of the Porter Point Unit on June 28, 2004. We identified a total of two sites, of which, one was evaluated as a fishway with an attached tide gate culvert and one culvert was rated as unknown passability to fish passage.

There is a fishway (Appendix A, 1310129) located on the Porter Point Dike. The fishway modifies a 1 m in diameter tide gate culvert that is used to manage upstream water levels. The fishway has 12 pools and 12 weirs with a pool to head difference ranging from 0.0 m to 0.4 m. The fishway weirs are submerged at high tide. The fishway was recorded as **no status for passability** for this assessment.

A culvert (Appendix A, 1310130) is located on the Porters Point Dike upstream of fishway number 1310129. Due to the presence of a wetland, we were unable to perform a Level B analysis on this structure (see Level A and Level B flow chart, Appendix B). Therefore this structure was evaluated as **unknown passability**. The culvert diameter measured 0.60 m and had a 0.13 percent slope with no streambed material present inside.

Lewis Unit We conducted surveys of the Lewis Unit on June 28, 2004. We identified a total of two sites, of which, one culvert was evaluated as a barrier to fish passage and one was evaluated as a fishway with an attached tide gate culvert.

A culvert (Appendix A, 1310131) is located on an interior dike of the Lewis Unit. The culvert was submerged at the downstream end and had a wood slat water control structure on the upstream end. The water control structure was evaluated as a **100 percent barrier** to upstream fish passage.

There is a fishway (Appendix A, 1310132) located on a dike in the Lewis Unit. The fishway modifies a 1 m diameter tide gate culvert that is used to manage upstream water levels. The fishway has 13 pools and 13 weirs with a pool to head difference of 0.3 m. At the time of the survey there was no water flowing from the upstream wetland into the fishway. The fishway was recorded as **no status for passability** for this assessment.

Bear River Unit We conducted surveys of the Bear River Unit on June 29, 2004. We identified a total of three sites, of which, one bridge was evaluated as passable to fish and two culverts were rated as unknown passability to fish passage.

The bridge (Appendix A, 1310133) is located on an overgrown road at the edge of the Bear River Unit property line. The bridge was constructed of several logs and measured 4.7 m long. The wetted width under the bridge was 3 m and the wetted width of the slough channel was 4.2 m. The bridge was evaluated as **passable to fish**.

The first of the two culverts (Appendix A, 1310134) is located on the road to the Willapa NWR house approximately 20 m upstream of the confluence with the Bear River. Due to the presence of a tidal slough, we were unable to perform a Level B analysis on this structure (see Level A and Level B flow chart, Appendix B). Therefore this structure was evaluated as **unknown passability**. The culvert diameter measured 1.25 m and had a 0.42 percent slope with no streambed material present inside.

The second culvert (Appendix A, 1310135) is located on a spur road approximately 15 m east of Highway 101. Due to the presence of a tidal slough and a grade break within the culvert, we were unable to perform a Level B analysis on this structure (see Level A and Level B flow chart, Appendix B). Therefore this structure was evaluated as **unknown passability**. The culvert diameter measured 0.95 m and had an outfall drop of 0.12 m with no streambed material present inside.

Omera Point Area We conducted surveys of the Omera Point Area on June 29, 2004. We identified a total of four culverts which were located on **non-fish-bearing water**

(Appendix A, 1310136 - 1310139). These culverts range in diameter from 0.30 to 1.25 m. Two of these culverts are located about 20 m apart on the same stream. The other two culverts serve mainly as road cross drains and are located on the road above the gravel quarry.

Teal Slough Unit We conducted surveys of the Teal Slough Unit on June 29 and 30, 2004. We identified a total of 18 sites which were located on **non-fish-bearing water** (Appendix A, 1310140 - 1310157). These culverts serve mainly as road cross drains for seepage or small streams. These culverts ranged in diameter from 0.45 to 0.60 m. Most of the culverts were in a state of disrepair and only partially functioning as intended. We noted water seeping through the road next to culverts number 1310141, 1310151, and 1310154. The road is starting to fail and there is an increased potential for mass failure of the road at these locations.

Refuge Headquarters We conducted surveys near the Willapa NWR headquarters on June 30 and July 1, 2004. We identified a total of five sites, of which, one was evaluated as a fishway and four were located on non-fish-bearing water.

There is a fishway (Appendix A, 1310158) located on Headquarter Creek. In 2000, the Willapa NWR removed a dam and a culvert at this location and installed log structures to provide habitat and improved upstream fish passage. There are seven log structures with a pool to head difference of 0.2 to 0.4 m each over a distance of 40 m of stream length. The fishway was recorded as **no status for passability** for this assessment.

The four culverts located on **non-fish-bearing water** (Appendix A, 1310159 – 1310161 and 1310166) serve mainly as road or parking lot cross drains for seepage or small streams. These culverts measured 0.45 m in diameter each.

Pickering Unit We conducted surveys of the Pickering Unit on July 1, 2004. We identified a total of four sites, three of which are owned and maintained by Willapa NWR. Of these three structures, one culvert was evaluated as a barrier to fish passage and two culverts were located on non-fish-bearing water.

A culvert (Appendix A, 1310162) is located near the entrance gate to the Pickering Unit, about 5 m from Highway 101. This culvert measured 1.0 m in diameter and was located in a 2.0 m wetted width stream channel, measured at low tide. This culvert is maintained by the Washington Department of Transportation, therefore, there was **no fish passage determination** made through this assessment. Funds are in place and design work is underway for the replacement of this culvert with a 22 m long bridge in 2007 (Stenvall, Charlie, U.S. Fish and Wildlife Service, Pers. Comm., 2006).

A culvert (Appendix A, 1310163) is located on a road at the boundary of the Pickering Unit. This culvert measured 2.3 m span by 1.5 m rise and had an outfall drop of 0.5 m with no streambed material inside. The culvert was evaluated as a **67 percent barrier** to upstream fish passage. This culvert was replaced with the 12 m bridge in 2005. Adult

chum and coho salmon were observed above the bridge in the fall of 2005 (Stenvall, Charlie, U.S. Fish and Wildlife Service, Pers. Comm., 2006).

The two culverts located on **non-fish-bearing water** (Appendix A, 1310164 and 1310165) serve mainly as road cross drains for seepage or small streams. These culverts measured 0.30 m and 0.40 m in diameter.

Wheaton Unit We conducted surveys of the Wheaton Unit on July 1, 2004. We identified one culvert (Appendix A, 1310167) that was located on **non-fish-bearing water**. This culvert provides road drainage and measured 0.30 m in diameter.

Julia Butler Hansen Refuge for the Columbia White Tail Deer

Introduction

The Julia Butler Hansen Refuge for the Columbian White-tailed Deer was established in 1972 specifically to protect and manage the endangered Columbian white-tailed deer (USFWS website: http://www.fws.gov/willapa/JuliaButlerHansen/Index.html). Julia Butler Hansen NWR is located along the Columbia River in Wahkiakum County, Washington and Columbia and Clatsop County, Oregon.

The refuge contains over 6,000 acres of pastures, forested tidal swamps, brushy woodlots, marshes and sloughs along the Columbia River in both Washington and Oregon. The mainland refuge unit, the Hunting Islands and Price Island are in Washington. Tenasillahe Island, Crims Island, Wallace Island are in Oregon (USFWS website: http://www.fws.gov/willapa/JuliaButlerHansen/Index.html).

Habitats at Julia Butler Hansen NWR consist of tidally influenced wetlands and sloughs, forested Columbia River islands, and grasslands. Four streams or rivers are part of the refuge. More than 3,000 acres on both mainland and island portions of the refuge are enclosed by dikes and tide gates for protection of Columbia white-tail deer. Primary fish species present are all Columbia River stocks of anadromous salmonids (USFWS 2005).

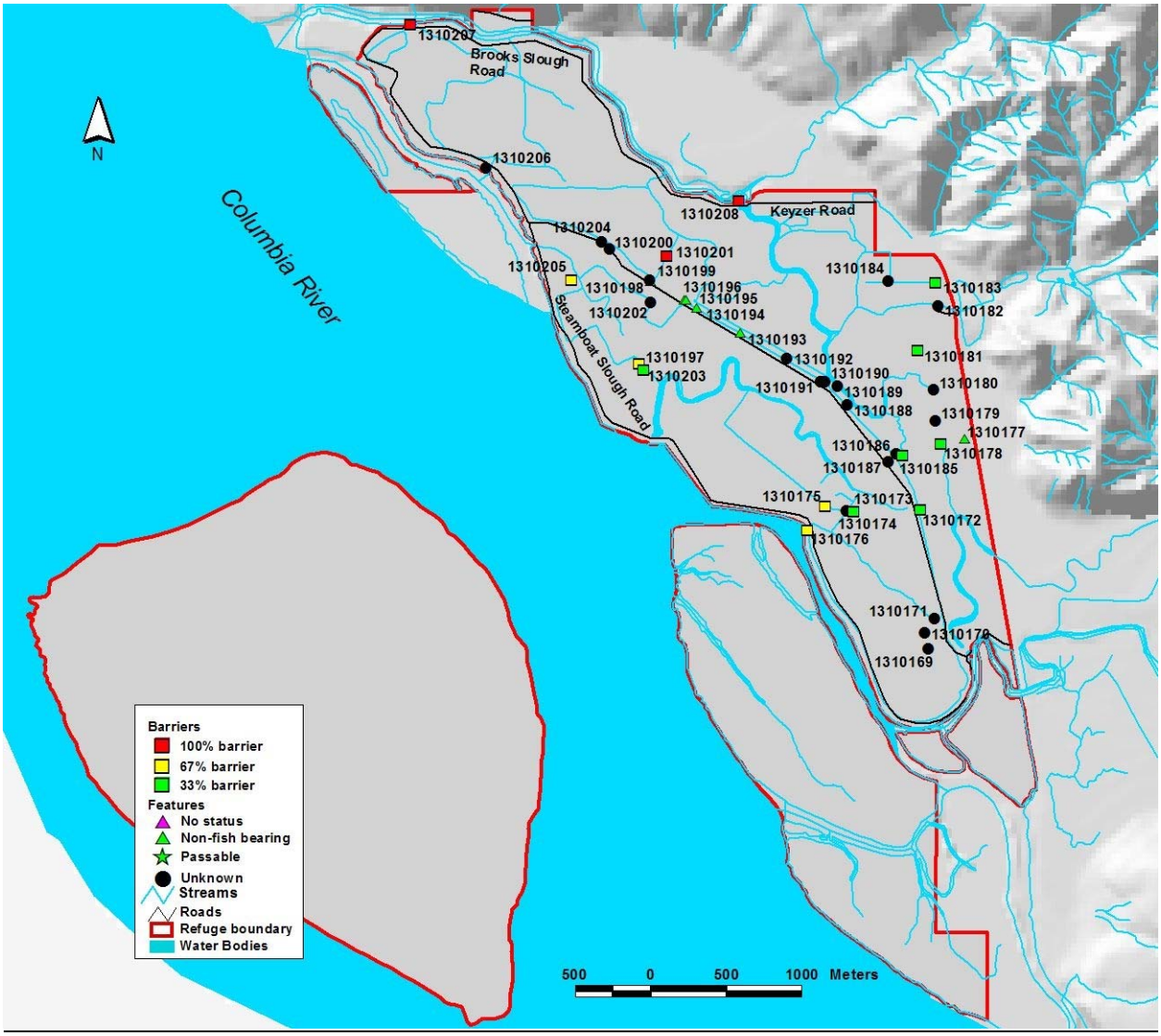
Aquatic resource issues include improving potential rearing habitat for juvenile salmonids without affecting habitat for Columbia white-tail deer, and reestablishment and restoration of streams which traverse refuge and private ownerships. Potential projects include the following: replace failing tidegates with fish friendly, improving intertidal marsh-stream/slough habitat for salmonids within dikes, improving water quality, dike removal, re-establishing bathymetry, and controlling invasive species (USFWS 2005).

Survey Results

We conducted our survey in cooperation with refuge staff on July 7 and 8, 2004. Our survey identified 40 sites of interest on refuge property. Infrastructure that was assessed for fish passage included road and tide gate culverts (Figure 9). The tide gate culverts are

under a county road that forms the refuge dike, therefore they are owned by the county. The refuge strongly influences the management of these tide gate culverts, so we included them in this survey. Of the 40 structures, 6 were located on non-fish-bearing water, 14 were barriers to fish passage, and 20 were unknown passability. We did not survey refuge islands located in Oregon.

Figure 9. Julia Butler Hansen Refuge for the Columbian White-tailed Deer.



Tide Gate Culverts The first of the four tide gate culverts is located under Steamboat Slough Road near the Elochoman River. This culvert (Appendix A, 1310176) measured 1.7 m in diameter with a tide gate that was open 0.2 m at the time of the survey. For tidally influenced culverts, an analysis of tidal influence and streamflow is needed (TAPPS 2000); however, WDFW considers this type of tide gate to be a barrier to fish passage since the gates rarely open completely to allow fish passage (Collins, Dave,

WDFW, Pers. Comm., 2003). The culvert was evaluated as a **67 percent barrier** to upstream fish passage due to the presence of the tide gates.

The second tide gate culvert is located under Center Road near the Columbia River. This tide gate culvert (Appendix A, 1310206) was recently installed and has been approved by the National Marine Fisheries Service to provide some fish passage. This culvert measured 1.2 m in diameter with a tide gate that was open 0.3 m at the time of the survey. There was a 0.20 m outfall drop that was measured at low tide. There would not be an outfall drop at high tide. For tidally influenced culverts, an analysis of tidal influence and streamflow is needed (TAPPS 2000); however, WDFW considers this type of tide gate to be a barrier to fish passage since the gates rarely open completely to allow fish passage (Collins, Dave, WDFW, Pers. Comm., 2003). The culvert was evaluated as **unknown passability** due to the presence of the tidal slough downstream.

The third tide gate culvert is located under Brooks Slough Road near Brooks Slough. This culvert (Appendix A, 1310207) measured 2 m in diameter with a tide gate on the downstream end and a trash rack on the upstream end. The downstream end of the culvert was completely submerged at the time of the survey. For tidally influenced culverts, an analysis of tidal influence and streamflow is needed (TAPPS 2000); however, WDFW considers this type of tide gate to be a barrier to fish passage since the gates rarely open completely to allow fish passage (Collins, Dave, WDFW, Pers. Comm., 2003). The culvert was evaluated as a **100 percent barrier** to upstream fish passage due to the presence of the tide gate.

The fourth tide gate culvert is located under Brooks Slough Road near Brooks Slough. This structure consisted of three side by side culverts (Appendix A, 1310208) with tide gates on the downstream side and trash racks on the upstream side. Each culvert measured 2 m in diameter. For tidally influenced culverts, an analysis of tidal influence and streamflow is needed (TAPPS 2000), however, WDFW considers this type of tide gate to be a barrier to fish passage since the gates rarely open completely to allow fish passage (Collins, Dave, WDFW, Pers. Comm., 2003). The culvert was evaluated as a **100 percent barrier** to upstream fish passage due to the presence of the tide gate.

<u>Barrier Culverts</u> We identified eleven barrier culverts throughout the refuge:
A culvert (Appendix A, 1310172) is located on Center Road on an unnamed ditch. This culvert measured 0.9 m in diameter and had a slope of 1.5 percent with no streambed material inside. The culvert was evaluated as a **33 percent barrier** to upstream fish passage.

A culvert (Appendix A, 1310173) is located on a small road southwest of Center Road on an unnamed ditch. This culvert measured 0.9 m in diameter and had a slope of 1.2 percent with no streambed material inside. The upstream end of this culvert was slightly crushed. The culvert was evaluated as a **33 percent barrier** to upstream fish passage.

Another culvert (Appendix A, 1310175) is located on the small road southwest of Center Road on an unnamed ditch. This culvert measured 0.5 m in diameter and had a slope of

3.07 percent with no streambed material inside. The upstream end of this culvert was slightly crushed and the downstream end was rusted out. The culvert was evaluated as a **67 percent barrier** to upstream fish passage.

A side by side culvert (Appendix A, 1310178) is located in a field on an unnamed tributary to Brooks Slough. Both culverts measured 1.2 m in diameter and had slopes of 0.62 and 1.3 percent with no streambed material inside. These culverts were evaluated as a **33 percent barrier** to upstream fish passage.

A culvert (Appendix A, 1310181) is located at the entrance to the Swan wetland. This culvert measured 0.6 m in diameter and had a slope of 0.22 percent with no streambed material inside. The culvert had a wood slat water control structure on the upstream end. The water control structure was evaluated as a **100 percent barrier** to upstream fish passage.

A culvert (Appendix A, 1310183) is located near the Highway 4 refuge viewing platform. This culvert measured 0.9 m in diameter and had a slope of 1.5 percent with no streambed material inside. The culvert was evaluated as a **33 percent barrier** to upstream fish passage.

A culvert (Appendix A, 1310185) is located at the downstream end of the Peregrine wetland. This culvert measured 0.6 m in diameter and had an outfall drop of 0.25 m with no streambed material inside. The culvert had a water control structure, however there were no wood slats in place at the time of the survey. The culvert was evaluated as a **33 percent barrier** to upstream fish passage.

A culvert (Appendix A, 1310197) is located on an unnamed ditch about 20 m downstream of culvert number 1310203. The culvert measured 0.9 m in diameter and had a slope of 2.13 percent with no streambed material inside. The culvert was evaluated as a **67 percent barrier** to upstream fish passage.

A culvert (Appendix A, 1310201) is located on an unnamed ditch in a pasture. This culvert measured 0.65 m in diameter and had an outfall drop of 0.05 m with no streambed material inside. The culvert had a 0.55 m high wood slat water control structure on the upstream end. The water control structure was evaluated as a **100 percent barrier** to upstream fish passage.

A culvert (Appendix A, 1310203) is located on an unnamed ditch about 20 m upstream of culvert number 1310197. The culvert measured 0.6 m in diameter and had an outfall drop of 0.15 m with no streambed material inside. The culvert had a water control structure, however there were no wood slats in place at the time of the survey. The culvert was evaluated as a **33 percent barrier** to upstream fish passage.

A culvert (Appendix A, 1310205) is located on an unnamed ditch east of Steamboat Slough Road. This culvert measured 0.6 m in diameter and had an outfall drop of 0.15 m with no streambed material inside. The culvert had a 0.38 m high wood slat water control

structure on the upstream end. The water control structure was evaluated as a **67 percent barrier** to upstream fish passage.

Unknown Passability Culverts We located 20 culverts (Appendix A, 1310169 - 1310171, 1310174, 1310179, 1310180, 1310182, 1310184, 1310186 - 1310192, 1310199, 1310200, 1310202, 1310204, 1310206) throughout the refuge. Due to the presence of wetland sloughs or grade breaks within the culverts, we were unable to perform a Level B analysis on these structures (see Level A and Level B flow chart, Appendix B). Therefore these structures were evaluated as **unknown passability**. Culvert diameters ranged from 0.5 m to 2.4 m.

Several of these culverts (Appendix A, 1310180, 1310182, 1310189, 1310192, 1310199, 1310200, and 13101204) were in various states of disrepair, such as rusted, blocked by debris, crushed, or bent. These culverts have a higher likelihood of failing, potentially leading to erosion of the road.

Non-Fish-Bearing Water Culverts The six culverts located on **non-fish-bearing water** (Appendix A, 1310177, 1310193 - 1310196, 1310198) serve mainly as road cross drains for seepage, ditches, or small streams. These culverts ranged from 0.45 m to 0.61 m in diameter.

Ridgefield National Wildlife Refuge Complex

Introduction

The refuge was established (along with 3 other refuges in the Willamette Valley of Oregon) in 1965, in response to a need to establish vital winter habitat for wintering waterfowl with an emphasis on the dusky Canada goose whose nesting areas in Alaska were severely impacted by a violent earthquake in 1964 (USFWS website: http://www.fws.gov/ridgefieldrefuges/RNWRHome.htm). The primary habitat management objectives for the refuge are to: provide wintering habitat for dusky Canada geese and other migratory waterfowl; protect, restore, and enhance populations of threatened and endangered species; maintain habitats for indigenous species and perpetuate natural diversity; and provide for environmental education, research, and wildlife oriented recreation (USFWS 2005). Ridgefield NWR is located along the Columbia River in Clark County, Washington.

Ridgefield NWR has a total of 5,150 acres of riverine wetlands, floodplain lakes, sloughs, streams, grasslands, and woodlands. Main watercourses are the Columbia River and three small tributaries to the Columbia River. Lake River, Gee Creek, Campbell Slough and Bachelor Slough are all found within, or bordering the refuge (USFWS 2005). Primary fish species present are all Columbia River stocks of anadromous salmonids, and coastal cutthroat trout (USFWS website: http://www.fws.gov/ridgefieldrefuges/RNWRHome.htm).

Ridgefield NWR consists of the following management units: Carty, Roth, Ridgeport Dairy, River S, and Bachelor Island. Two of the five management units are not directly affected by dikes, whereas the majority of the other three units are affected by dikes (USFWS 2005). Preservation of the natural Columbia River floodplain is the management objective of the Carty (2-mile self guided hiking trail), Roth and Ridgeport Dairy units. The River 'S' (4.2 mile auto tour route and 1.2 mile seasonal hiking trail) and Bachelor Island units are managed to maximize habitat for waterfowl and other wetland wildlife (USFWS website: http://www.fws.gov/ridgefieldrefuges/RNWRHome.htm).

Aquatic resource issues include fish surveys and habitat assessments of areas open to the Columbia River; assessment of fish passage at the mouth of Gee Creek; and technical assistance concerning mosquito control, fish presence, invasive species, and contaminants monitoring (USFWS 2005).

The flow through the mouth of Gee Creek seems to continue to slow due to an increase of silt build up. The creek is also being choked by reed canarygrass. Both of these issues could potentially become barriers to cutthroat and coho and reduce juvenile rearing habitat for anadromous salmonids. Evaluation of the silt build up and a comprehensive plan to reduce the amount of silt is needed. This plan may need to look at short term Refuge removal of silt and canarygrass, and a long term plan of reducing silt deposits from off-refuge (USFWS 2005).

Survey Results

We conducted our survey on July 12 and 13, 2004 and identified four sites of interest on Ridgefield NWR property. Refuge infrastructure that was assessed for fish passage included: dike culverts, a bridge, and a tide gate culvert (Figure 10 and 11). Of these four structures, one was located on non-fish-bearing water, one was a barrier to fish passage, one was passable to fish, and one was unknown passability.

Carty Unit We identified one culvert that was located on **non-fish-bearing water** (Appendix A, 1310168). This culvert measured 0.30 m in diameter. The culvert was not functioning as there was a channel cut through the road adjacent to this culvert.

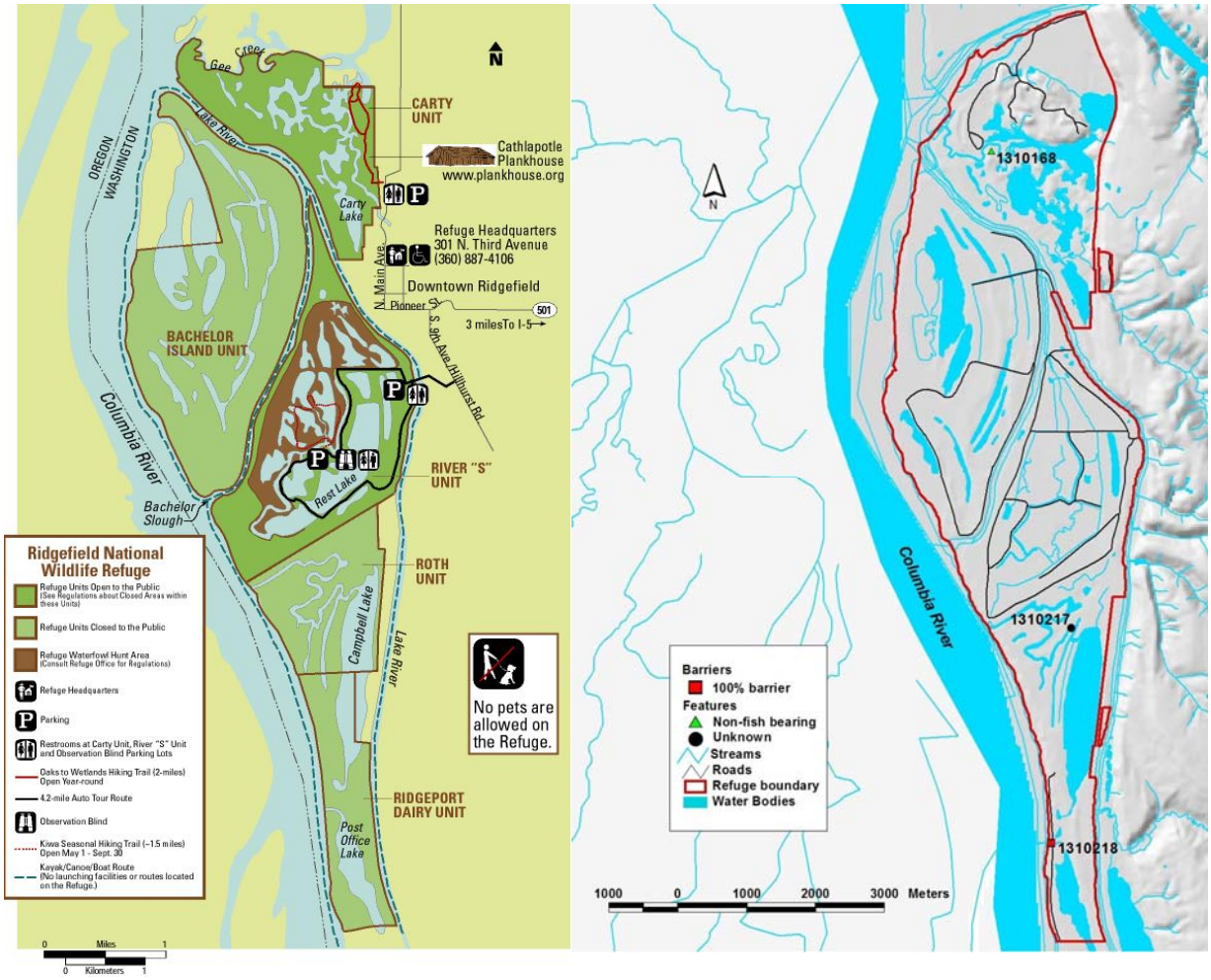
A bridge (Appendix A, 1310209) is located on a wetland slough that flows to Gee Creek. The bridge measured 10 m long. The wetted width under the bridge was 7.7 m and the wetted width of the slough channel was 10.0 m. The bridge was evaluated as **passable to fish**.

Roth Unit We identified one tide gate culvert (Appendix A, 1310218) located at the confluence of a slough to Post Office Lake and the Columbia River. This culvert has a tide gate on the downstream side and a wood slat water control structure on the upstream side that measured 1.5 m high at the time of the survey. For tidally or flooding influenced culverts, an analysis of tidal or flooding influence and streamflow is needed (TAPPS 2000), however, WDFW considers this type of tide gate to be a barrier to fish passage since the gates rarely open completely to allow fish passage (Collins, Dave, WDFW, Pers. Comm., 2003). The culvert had a 1.3 m span and 0.9 m rise. The culvert

was evaluated as a **100 percent barrier** to upstream fish passage due to the presence of the tide gate and of the water control structure.

A side by side culvert (Appendix A, 1310217) is located on a dike within the unit. Due to the presence of wetlands upstream and downstream, we were unable to perform a Level B analysis on this structure (see Level A and Level B flow chart, Appendix B). Therefore this structure was evaluated as **unknown passability**. The culvert diameters measured 1.8 m each with slopes of 0 percent and 1 percent. The right bank culvert was slightly squashed. No streambed material was present inside either culvert.

Figures 10 and 11. Ridgefield National Wildlife Refuge.



<u>River S and Bachelor Island Units</u> These units are completely contained within dikes, with the only means for water exchange through several pumps on the outer dike. These pumps are screened, and are used to maintain freshwater levels in the wetlands and sloughs inside the dike. The screen openings are either 3/16 inch or 1/4 inch.

We did not survey the internal wetlands and sloughs of these units; however, there are numerous culverts with attached water control structures. These culverts are maintained by the Ridgefield NWR in order to provide habitat for waterbirds and amphibians. Currently there are no fish passage structures through the outer dike. If fish passable structures are installed in the outer dike in the future, then a fish passage assessment of the interior water control structures would need to be completed.

Pierce Lake National Wildlife Refuge

Introduction

The USFWS acquired Pierce NWR in 1983 through a land donation of 319 acres made by the previous landowner Mrs. Lena Pierce. Today, the refuge has a total of 391 acres of habitat that provide sanctuary for wintering waterfowl such as Canada geese, ducks, and other aquatic birds. Habitats present on the refuge include stream channels, sloughs, and impoundments. Hardy Creek supports one of the last chum salmon runs along the Columbia River. Small numbers of coho salmon also spawn in Hardy Creek (USFWS website: http://www.fws.gov/ridgefieldrefuges/PNWRHome.htm). Pierce NWR is located along the Columbia River in Skamania County, Washington.

Pierce NWR has no public roads or walking trails leading into the refuge. With the exception of special guided tours and educational activities allowed by special permit, the refuge remains closed to the public (USFWS website: http://www.fws.gov/ridgefieldrefuges/PNWRHome.htm).

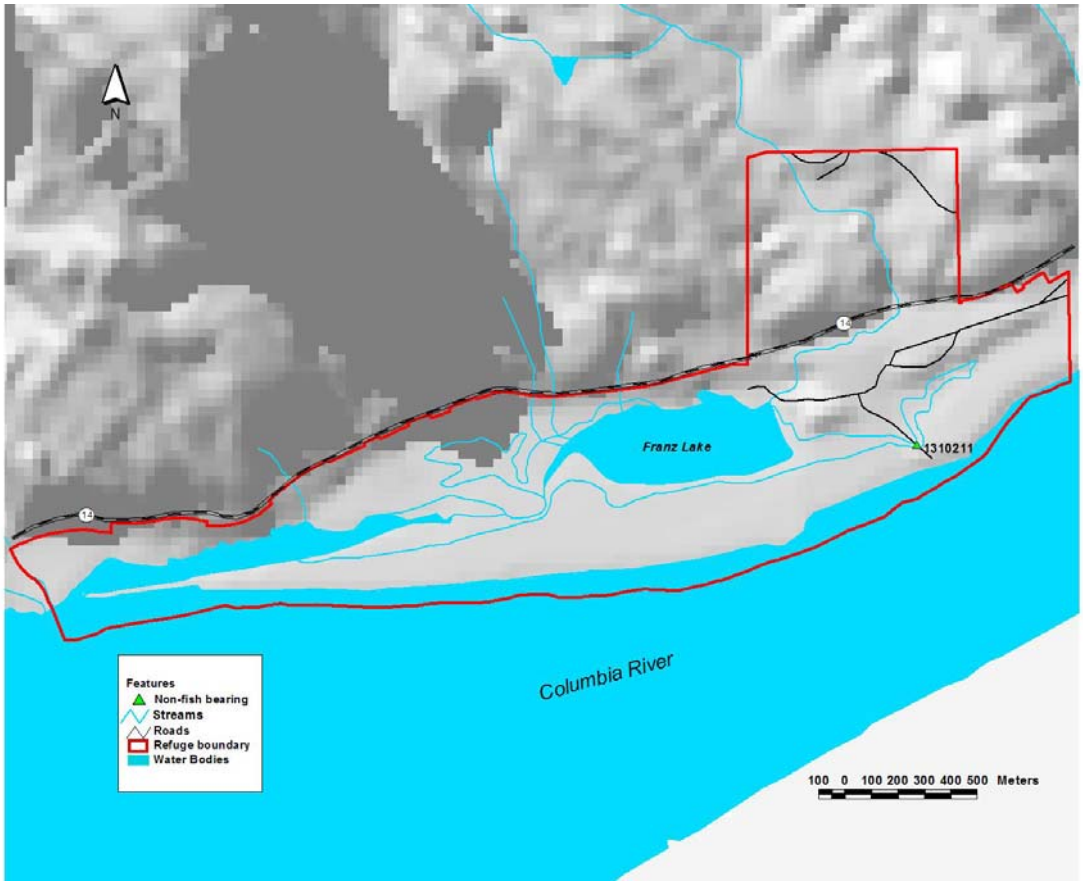
Aquatic resource issues and potential restoration projects include the following: assess man-made migration barriers (road and railroad culverts) to anadromous fish within the Hardy Creek watershed for subsequent removal or modification (USFWS 2005).

Survey Results

We conducted our survey on July 12 and 13, 2004 and identified seven sites of interest on Pierce NWR property. Refuge infrastructure that was assessed for fish passage included several road culverts and a bridge (Figure 12). Of these seven structures, one was located on non-fish-bearing water, four were fish passage barriers, one was passable to fish, and one was unknown passability.

A culvert (Appendix A, 1310255) is located on an unnamed tributary to Hardy Creek off of the main refuge road. This culvert measured 0.9 m in diameter and had a slope of 5.6 percent with no streambed material inside. The culvert had a gated water control structure on the upstream end. The culvert and water control structure was evaluated as a **100 percent barrier** to upstream fish passage.

Figure 12. Pierce National Wildlife Refuge.



A culvert (Appendix A, 1310256) is located on an unnamed tributary to Hardy Creek off of the main refuge road. This culvert measured 0.6 m in diameter and had an outfall drop of 0.23 m with no streambed material inside. The culvert had a 0.5 m high wood slat water control structure on the upstream end. The water control structure was evaluated as a **100 percent barrier** to upstream fish passage. If the wood slat water control structure was removed, the culvert would be a 67 percent barrier to upstream fish passage.

A culvert (Appendix A, 1310258) is located on an unnamed tributary to Hardy Creek in the western section of the refuge. This culvert measured 1.28 m in diameter and had an outfall drop of 1.1 m with no streambed material inside. The culvert had a 0.6 m high wood slat water control structure on the upstream end. The culvert and water control structure was evaluated as a **100 percent barrier** to upstream fish passage.

A culvert (Appendix A, 1310259) is located on an unnamed tributary to Hardy Creek in the western section of the refuge. This culvert measured 0.8 m in diameter and had an outfall drop of 0.5 m with no streambed material inside. The culvert had a 1.01 m high wood slat water control structure on the upstream end. The culvert and water control structure was evaluated as a **100 percent barrier** to upstream fish passage.

A bridge (Appendix A, 1310257) is located on the main refuge road upstream of Pierce Lake. The bridge measured 14.2 m long. The wetted width under the bridge was 3.6 m and the wetted width of the adjacent stream channel was 4.5 m. The bridge was evaluated as **passable to fish**.

A culvert (Appendix A, 1310254) is located within a manmade U-shaped channel. Due to the presence of wetlands upstream and downstream, we were unable to perform a Level B analysis on this structure (see Level A and Level B flow chart, Appendix B). Therefore this structure was evaluated as **unknown passability**. The culvert diameter had a 2.8 m span by 2.4 m rise with a slope of 0.63 percent. There was streambed material present inside the culvert.

We identified one culvert (Appendix A, 1310260) that was located on **non-fish-bearing water**. This culvert provides road drainage for a small spring that enters Pierce Lake and measured 0.5 m in diameter.

Franz Lake National Wildlife Refuge

Introduction

Franz Lake NWR was established in 1990, and contains a total of 590 acres. The refuge is one of the last remaining undeveloped habitat areas open to the Columbia River. Franz Lake's system of rivers, streams, and wetlands provides habitat for breeding, migrating, and wintering waterfowl such as wintering tundra swans, and other aquatic migratory birds and raptors such as American bald eagles. Primary species present are coho salmon, Chinook salmon, steelhead, and cutthroat trout (USFWS website: http://www.fws.gov/ridgefieldrefuges/FLNWRHome.htm). Franz Lake NWR is located along the Columbia River in Skamania County, Washington.

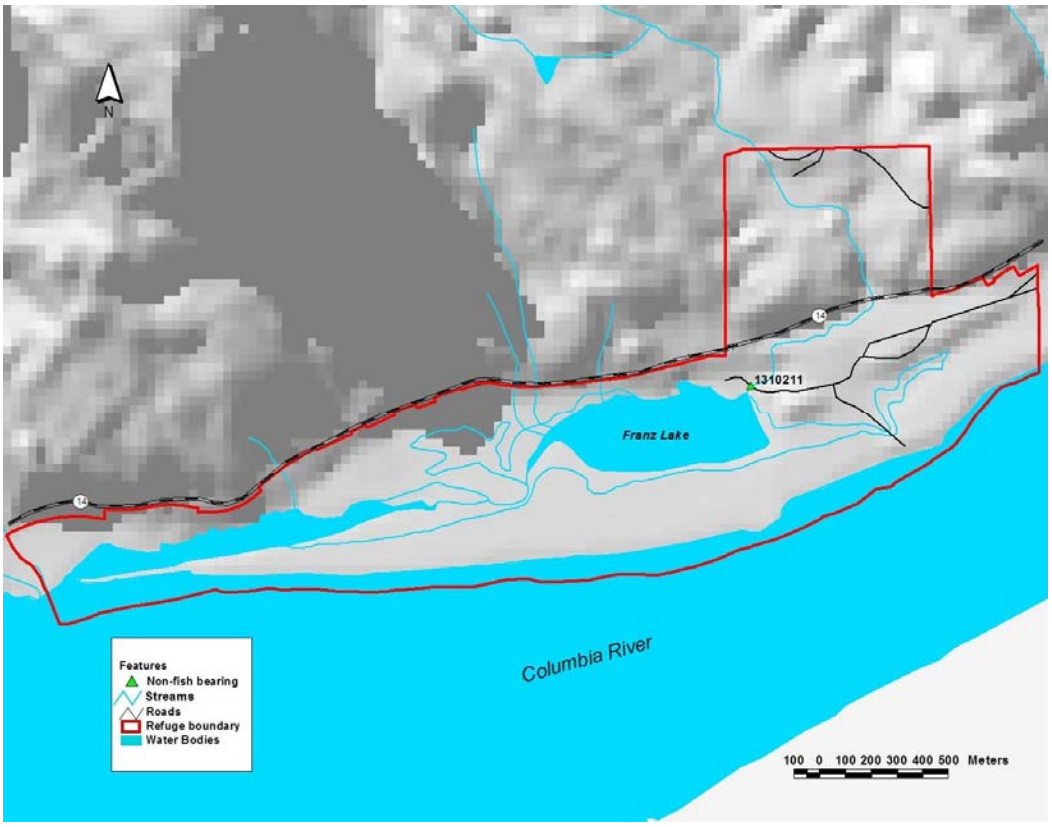
There are no public roads or walking trails leading into the refuge. This allows refuge staff to manage this refuge as a true wildlife sanctuary where wildlife and plants remain undisturbed by human activities (USFWS website: http://www.fws.gov/ridgefieldrefuges/FLNWRHome.htm).

Aquatic resource issues and potential restoration projects include the following: determine fish species presence, distribution, and diets of salmonids; investigate effects of mosquito control treatment on aquatic invertebrates; assess man-made migration barriers (road and railroad culverts) to anadromous fish within the Indian Mary Creek watershed for subsequent removal or modification (USFWS 2005).

Survey Results

We conducted our survey on July 13, 2004 and identified one culvert of interest on Franz Lake NWR property (Figure 13). The culvert (Appendix A, 1310211) was located on **non-fish-bearing water**. This culvert had a 0.67 m high wood slat water control structure in place and measured 0.47 m in diameter with no streambed material inside.

Figure 13. Franz Lake National Wildlife Refuge



Steigerwald Lake National Wildlife Refuge

Introduction

Steigerwald Lake NWR was established in 1984 as mitigation from the impacts resulting from construction of the second powerhouse at the Bonneville Lock and Dam by the U.S. Army Corps of Engineers (USFWS 2005). The refuge contains 1,062 acres of floodplain lake-wetlands and river bottomland habitat that supports anadromous fish, breeding neotropical birds, and migrating and wintering ducks, geese, and other birds (USFWS website: http://www.fws.gov/ridgefieldrefuges/SLNWRHome.htm). Steigerwald Lake is approximately 300 acres in size, and much of its shallow water shoreline consists of invasive non-native reed canarygrass. There is a ditch which runs from east to west through the lake and its wetlands, left over from historical attempts to drain the lake for agricultural purposes. There is a water treatment facility run by the city of Washougal which regulates some of the water in the refuge. The city pumps out water through an underground pipe to prevent flooding at their facilities.

Steigerwald Lake NWR is located just inside of Washington's western boundary of the Columbia River Gorge National Scenic Area. Visitors may enjoy viewing refuge wildlife

and scenes of the Columbia River by accessing the Columbia River Dike Trail at nearby Captain William Clark Park, just west of the refuge on Port of Camas-Washougal property. Refuge lands off of the dike trail are not open to the public; however, plans exist to construct the Steigerwald Lake NWR Gateway Center and a refuge trail system pending future budget appropriations and partnerships (USFWS website: http://www.fws.gov/ridgefieldrefuges/SLNWRHome.htm).

Current management emphasis is to provide green grass pastures as forage areas for wintering Canada geese. Primary fish species present are coho salmon, Chinook salmon, steelhead, and cutthroat trout. Chum salmon were documented using Gibbons Creek prior to the construction of the Columbia River dike in 1965 (USFWS 2005). Steigerwald Lake NWR is located along the Columbia River in Clark County, Washington.

Steigerwald Lake refuge is surrounded by dikes. There is one entrance point for potential fish passage through a WDFW fish ladder (Figure 14) on Gibbons Creek at the confluence with the Columbia River. Historically, the creek flowed into Steigerwald Lake. In 1992, the U.S. Army Corps of Engineers constructed a channel in an elevated dike to transport Gibbons Creek directly into the Columbia River, bypassing Steigerwald Lake. WDFW installed a flow control structure that diverts flows up to 70 cfs into the elevated channel. Flows exceeding 70 cfs flow over a concrete spillway into the original Gibbons Creek channel (USFWS 2005).

Aquatic resource issues and potential restoration projects include: re-establishing the connection between Gibbons Creek and the Columbia River though Steigerwald Lake, restoring its function as an off-river rearing area for juvenile salmonids, and conducting a follow up habitat survey to determine changes in conditions in Gibbons Creek since the previous survey, including: (1) habitat fragmentation, especially by road culverts; (2) riparian vegetation removal; (3) in stream habitat simplification by large woody debris input reduction and removal; and (4) spawning habitat degradation by heavy inputs of fine sediment (USFWS 2005).

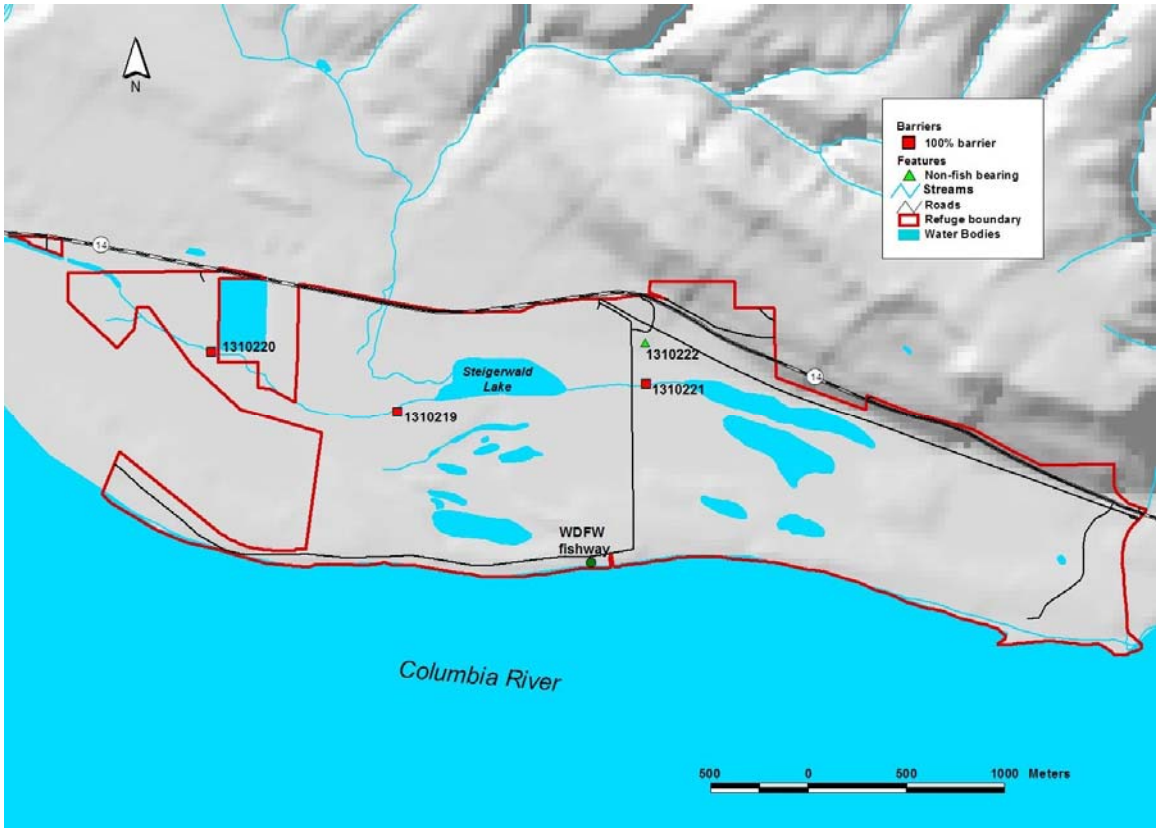
Survey Results

We conducted our survey on July 12 and 13, 2004 and identified four sites of interest on Steigerwald Lake NWR property (Figure 14). Of these four structures, one was located on non-fish-bearing water and three were fish passage barriers.

A side by side culvert (Appendix A, 1310219; 1.2 and 2.2) is located on a dike with a wetland upstream and a slough channel downstream. These side by side culverts measured 1.1 m span by 1.2 m rise each with no streambed material inside. The culverts had 1.8 m and 1.4 m high wood slat water control structures on the upstream end. The water control structures were evaluated as a **100 percent barrier** to upstream fish passage.

Three side by side culverts (Appendix A, 1310220; 1.3, 2.3, and 3.3) are located on a slough that connects with Steigerwald Lake. These side by side culverts measured 1.35 m span by 1.1 m rise each with no streambed material inside. The culverts had 0.35 m, 0.53 m, and 0.6 m high wood slat water control structures on the upstream end. The water control structures were evaluated as a **100 percent barrier** to upstream fish passage.

Figure 14. Steigerwald Lake National Wildlife Refuge.



A culvert (Appendix A, 1310221) is located on a dike east of Steigerwald Lake. This culvert measured 0.8 m in diameter with no streambed material inside. The culvert had a 0.45 m high wood slat water control structure on the upstream end. The water control structure was evaluated as a **100 percent barrier** to upstream fish passage.

We identified one culvert (Appendix A, 1310222) that was located on **non-fish-bearing water**. This culvert provides road drainage for a spring and measured 0.3 m in diameter.

Recommendations and Summary

We were able to make several general and specific recommendations in regards to providing fish passage at the following structures. For the purposes of these recommendations, “adequately sized culverts” are culverts that meet either WDFW’s

stream simulation or no-slope design criteria as described in Bates *et al.* (2003). In addition, the potential for channel incision should be assessed at each site using the methodology described in Castro (2003). Where appropriate, fish friendly grade control structures should be installed as part of the fish passage project.

General Recommendations

1) For barrier culverts without water control structures (wcs) or tidegates – remove when feasible or replace with a bridge or adequately sized culvert.

2) For tidegate barrier culverts – assess potential to provide fish passage while considering water control needs (water surface elevation and saltwater exclusion). Consider tidegate removal, replacement with a self-regulating tidegate, or construction of a fish ladder.

3) For barrier culverts with wcs – evaluate the need for the wcs, if not needed, remove the wcs and remove or replace the culvert with a bridge or adequately sized culvert. If the wcs is needed, construct a fish ladder.

4) For unknown status culverts with or without wcs, conduct an additional evaluation to determine the functionality of the structure and the potential fish passage impacts. Culverts without streambed material inside, as recorded through this assessment, are probably undersized and therefore partial or complete fish passage barriers. The lack of streambed material inside of the culvert is an indicator of high velocities during high flow events that scour the streambed material from the culvert. Remove those structures that are not needed, and replace with a bridge or adequately sized culvert or construct a fish ladder for those that are needed.

5) For culverts located on non-fish-bearing streams – non-fish-bearing for this assessment means non-anadromous and therefore these structures may impact resident fish passage. In addition, these structures may be a potential hazard for a mass wasting event, negatively impacting downstream habitat. Remove when feasible or replace with a bridge or adequately sized culvert.

In addition to the general recommendations the following specific activities should be implemented.

Little White Salmon NFH There is a small gate on the left bank side of the dam that was closed at the time of the assessment. Investigate the potential and effectiveness of opening this gate to improve fish passage. Also, investigate the potential of trapping and transporting fish upstream of the dam.

Willapa NWR Install bridges on Highway 101 to reconnect streams (USFWS 2005).

Julia Butler Hansen NWR Assess habitat conditions and species composition in sloughs and evaluate strategies for modifying existing tidegates (USFWS 2005).

Ridgefield NWR Assess fish passage at the mouth of Gee Creek (USFWS 2005).

Steigerwald Lake Remove fish passage barriers on Gibbons Creek which would provide anadromous fish access to 10.2 miles of upstream potential spawning and rearing habitat (USFWS 2005).

Summary

In summary, culvert assessments were completed on Service owned lands in WRIA's 24-29, with the exception of the interior culverts at Ridgefield NWR. If it is determined that the refuges are responsible for fish passage on the conservation easement properties, then the Service would need to conduct an assessment of these properties.

The fish passage barrier assessment identified a total of 32 barriers (Table 3). Of these barriers, 30 were culverts and 2 were hatchery dams. In addition there were 3 passable structures, all classified as other. A total of 31 culverts had an unknown passability status. In general, this unknown barrier status was because many were connected to wetlands, so a downstream control was inaccessible. There were 102 culverts that were on non-fish-bearing drainages that were not evaluated for fish passage. There were 23 structures with no status: 8 fishways, 14 gravity diversions, and 1 classified as other. According to the TAPPS manual protocols, fishways and screened water diversions are not evaluated for barrier status.

In addition to this fish passage assessment, the Service anticipates continued discussion of policies and legislated mandates pertaining to Region 1 hatcheries and refuges. These policies and mandates include the following: intentional barriers to fish passage to provide water that is free of regulated pathogens for hatchery purposes; and, maintenance of freshwater wetlands for migratory bird habitat which can prohibit fish passage. In locations where it is decided that fish passage should be provided, additional data would be necessary in order to design an appropriate fix; and then finally remove the barrier or replace it with a fish passable structure.

Table 3. Fish passage barriers (n=32), categorized by percent barrier and then by structure type.

Site Identification	Service Facility	Structure Type	Stream Name	Percent Barrier	Year Fixed
1310230	Little White Salmon NFH	Dam	Little White Salmon River	100	
1310116	Willapa NWR	Culvert - Tidegate	Domon Creek	100	
1310207	Julia Butler Hansen NWR	Culvert - Tidegate	Unnamed Stream	100	
1310208	Julia Butler Hansen NWR	Culvert - Tidegate	Brooks Slough	100	
1310218	Ridgefield NWR	Culvert - Tidegate	Post Office Lake	100	
1310131	Willapa NWR	Culvert - Water Control Structure	Unnamed Stream	100	
1310181	Julia Butler Hansen NWR	Culvert - Water Control Structure	Unnamed Stream	100	
1310201	Julia Butler Hansen NWR	Culvert - Water Control Structure	Unnamed Stream	100	
1310219	Steigerwald Lake NWR	Culvert - Water Control Structure	Steigerwald Lake	100	
1310220	Steigerwald Lake NWR	Culvert - Water Control Structure	Unnamed Stream	100	
1310221	Steigerwald Lake NWR	Culvert - Water Control Structure	Unnamed Stream	100	
1310255	Pierce Lake NWR	Culvert - Water Control Structure	Unnamed Stream	100	
1310256	Pierce Lake NWR	Culvert - Water Control Structure	Unnamed Stream	100	
1310258	Pierce Lake NWR	Culvert - Water Control Structure	Unnamed Stream	100	
1310259	Pierce Lake NWR	Culvert - Water Control Structure	Unnamed Stream	100	
1310229	Little White Salmon NFH	Dam	Little White Salmon River	67	
1310176	Julia Butler Hansen NWR	Culvert - Tidegate	Unnamed Stream	67	
1310101	Willapa NWR	Culvert	Unnamed Stream	67	
1310105	Willapa NWR	Culvert	Unnamed Stream	67	

1310163	Willapa NWR	Culvert	Unnamed Stream	67	2005
1310175	Julia Butler Hansen NWR	Culvert	Unnamed Stream	67	
1310197	Julia Butler Hansen NWR	Culvert	Unnamed Stream	67	
1310205	Julia Butler Hansen NWR	Culvert - Water Control Structure	Unnamed Stream	67	

1310075	Willapa NWR	Culvert	Unnamed Stream	33	
1310114	Willapa NWR	Culvert	Unnamed Stream	33	
1310128	Willapa NWR	Culvert	Unnamed Stream	33	
1310172	Julia Butler Hansen NWR	Culvert	Unnamed Stream	33	
1310173	Julia Butler Hansen NWR	Culvert	Unnamed Stream	33	
1310178	Julia Butler Hansen NWR	Culvert	Unnamed Stream	33	
1310183	Julia Butler Hansen NWR	Culvert	Unnamed Stream	33	
1310185	Julia Butler Hansen NWR	Culvert - Water Control Structure	Unnamed Stream	33	
1310203	Julia Butler Hansen NWR	Culvert - Water Control Structure	Unnamed Stream	33	

Acknowledgements

Special thanks to Linda Moore of the USFWS WWFWO for providing ARCView GIS support in map-making, and Dan Lantz, Howard Gearns, and Dan Butler of the USFWS WWFWO for field assistance. Thanks also to the hatchery and refuge personnel who provided access to Service owned lands, as well as assistance with on-site information.

Literature Cited

Bates, K., B. Barnard, B. Heiner, J.P. Klavas, and P.D. Powers. 2003. Design of Road Culverts for Fish Passage. Washington Department of Fish and Wildlife.

Castro, J. 2003. Geomorphologic Impacts of Culvert Replacement and Removal: Avoiding Channel Incision. U.S. Fish and Wildlife Service, Oregon Fish and Wildlife Office. Portland, OR.

Phinney, L.A., and P. Bucknell. 1975. A Catalog of Washington Streams and Salmon Utilization: Coastal Region, volume 1. Washington Department of Fisheries.

TAPPS (Technical Applications Division). 2000. Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual. Washington Department of Fish and Wildlife Habitat Program, Environmental Restoration Division.

Tschaekofske, H.J., D.W. Lantz, and B.J. Peck. 2004. Fish Passage Inventory and Barrier Assessment on U.S. Fish and Wildlife Service Lands: Watershed Inventory Areas 1-23. U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office.

USFWS (U.S. Fish and Wildlife Service). 2005. A report on a workshop between National Wildlife Refuges in Region 1 and the Columbia River Fisheries Program Office and Appendices, July 20, 2005, Vancouver, Washington. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office.

Websites

USFWS (U.S. Fish and Wildlife Service). Abernathy Fish Technology Center. Last updated March 2005. http://www.fws.gov/aftc/ (Date accessed December 8, 2005)

USFWS (U.S. Fish and Wildlife Service). Little White Salmon National Fish Hatchery Complex. Last updated February 2005. http://www.fws.gov/gorgefish/littlewhite/ (Date accessed December 8, 2005)

USFWS (U.S. Fish and Wildlife Service). Willard National Fish Hatchery. Last updated February 2005. http://www.fws.gov/gorgefish/willard/ (Date accessed December 8, 2005)

USFWS (U.S. Fish and Wildlife Service). Carson National Fish Hatchery. Last updated July 2005. http://www.fws.gov/gorgefish/carson/default.htm (Date accessed December 8, 2005)

USFWS (U.S. Fish and Wildlife Service). Spring Creek National Fish Hatchery. Last updated February 2005. http://www.fws.gov/gorgefish/springcreek/Default.htm (Date accessed December 8, 2005)

USFWS (U.S. Fish and Wildlife Service). Lower Columbia River Fish Health Center. Last updated June 2005. http://www.fws.gov/gorgefish/fishhealth/Default.htm (Date accessed December 8, 2005)

USFWS (U.S. Fish and Wildlife Service). Willapa National Wildlife Refuge. Last updated November 2005. http://www.fws.gov/willapa/WillapaNWR/Index.html (Date accessed December 8, 2005)

USFWS (U.S. Fish and Wildlife Service). Julia Butler Hansen Refuge for the Columbian White-tailed Deer. Last updated April 2005. http://www.fws.gov/willapa/JuliaButlerHansen/Index.html (Date accessed December 8, 2005)

USFWS (U.S. Fish and Wildlife Service). Ridgefield National Wildlife Refuge. Last updated August 2005. http://www.fws.gov/ridgefieldrefuges/RNWRHome.htm (Date accessed December 8, 2005)

USFWS (U.S. Fish and Wildlife Service). Franz Lake National Wildlife Refuge. Last updated August 2005. http://www.fws.gov/ridgefieldrefuges/FLNWRHome.htm (Date accessed December 8, 2005)

USFWS (U.S. Fish and Wildlife Service). Pierce National Wildlife Refuge. Last updated August 2005. http://www.fws.gov/ridgefieldrefuges/PNWRHome.htm (Date accessed December 8, 2005)

USFWS (U.S. Fish and Wildlife Service). Steigerwald Lake National Wildlife Refuge. Last updated August 2005. http://www.fws.gov/ridgefieldrefuges/SLNWRHome.htm (Date accessed December 8, 2005)