# DESCHUTES BASIN HABITAT CONSERVATION PLAN

# FINAL STUDY REPORT

## Study 14-2: Evaluation of Fish Passage Options for Ochoco Dam

**Prepared for:**

**Deschutes Basin Board of Control, and City of Prineville, Oregon**

**Prepared by:**

**R2 Resource Consultant, Inc. and Biota Pacific Environmental Sciences, Inc.**

**December 2014**

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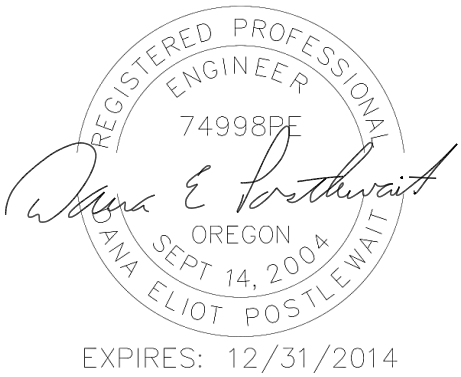


**December 2014**

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# 1.0 Introduction

## 1.1. Background

Seven central Oregon irrigation districts (Arnold, Central Oregon, North Unit, Ochoco, Swalley, Three Sisters, and Tumalo) and the City of Prineville, Oregon (City) are seeking Federal Endangered Species Act (ESA) incidental take permits for the Middle Columbia River steelhead (*Oncorhynchus mykiss*), Middle Columbia River spring Chinook salmon (*O. tshawytscha*), bull trout (*Salvelinus confluentus*), and up to 11 other listed and unlisted species inhabiting the Deschutes River basin. As required by Section 10 of the ESA, the City and the irrigation districts (collectively the Applicants) are preparing the Deschutes Basin Multi-species Habitat Conservation Plan (DBHCP) to minimize and mitigate the effects of the proposed incidental take on the covered species. The DBHCP is being prepared in cooperation with a multi-stakeholder Working Group representing the US Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), US Bureau of Reclamation (Reclamation), US Bureau of Land Management (BLM), Oregon Department of Fish and Wildlife (ODFW), Oregon Department of Environmental Quality (ODEQ), Oregon Water Resources Department (OWRD), the Confederated Tribes of the Warm Springs, Crook County, and several non-governmental entities.

This study has been completed to support development of the DBHCP. Drafts of this report were provided to the Working Group for review and comment, and the final report reflects their input.

## 1.2. Purpose and Scope

### 1.2.1. Purpose

The Deschutes Basin HCP Working Group has suggested the evaluation of installation and operation of fish passage facilities at Ochoco Dam as mitigation for irrigation activities to be covered by the DBHCP. This study identifies the various options available for providing fish passage at Ochoco Dam, and evaluates at a preliminary level the technical, financial, biological, and operational implications of each option. This study is preliminary in nature. Options that appear feasible based on this study will require additional detailed examination before they can be deemed practicable for consideration in the DBHCP.

Anadromous fish access to upper Ochoco Creek has been blocked since construction of the Ochoco Dam in 1920. There is no existing or planned program to reintroduce anadromous fish above the dam. However, the upper basin currently supports native redband trout, and is believed to be capable of supporting anadromous salmonid fishes as well. Ongoing efforts to re-establish steelhead trout and spring Chinook salmon above the Pelton Round Butte Project, if successful, will give both species access to Ochoco Creek upstream as far as Ochoco Dam. Fish passage at the dam could extend the ranges of both species into the upper Ochoco Creek watershed.

Ochoco Dam is a private facility owned and operated by Ochoco Irrigation District (OID). The dam consists of a 125-foot high earthen-filled structure that currently has no provisions for upstream fish passage. Some resident trout and other fish are known to move downstream through the outlet structure in the reservoir and into the upstream end of OID's Ochoco Main

Canal. From there, the fish can pass through a trashrack and continue downstream in the canal, or they can follow the spill that returns water to Ochoco Creek approximately 200 feet below the dam. There are currently no fish screens to prevent fish from moving downstream within the canal, although OID is proposing to install fish screens to prevent fish from remaining in the canal past the point where water is spilled back into the creek. The existing trashrack at the canal entrance likely discourages some fish from entering the canal, although it is not a full exclusionary device.

#### 1.2.2. Scope

This study is a preliminary examination of options to meet the stated goal of "utilizing habitat above Ochoco Dam to support reintroduced populations of steelhead trout and spring Chinook salmon." The Deschutes Basin HCP Working Group has an interest in assessing options for volitional passage, which is addressed. However, it is important to note volitional passage is viewed as one of several possible means to meet the stated goal of utilizing habitat upstream of Ochoco Dam. As such, both volitional and non-volitional methods to provide upstream and downstream passage past Ochoco Dam are among the options identified and developed as potential means to meet this goal.

This study provides a preliminary evaluation of the various options and implications of providing fish passage past Ochoco Dam, the ability of these options to function within the established operational regime for Ochoco Dam, and an initial planning level opinion of probable capital and operational cost for the alternatives. Technical considerations are based on: 1) limited examination of Ochoco Dam and the Ochoco Creek channel, 2) information provided by OID and 3) professional experience with similar fish passage systems in the region. Development of detailed cost estimates for the identified fish passage alternatives was not part of the scope; however, a likely range of costs based on experience and comparisons with similar scale fish passage facilities will provide reasonable estimates for comparison of the alternatives. The biological potential of the upper basin is derived from previous work, and from a brief field examination.

Options meeting the existing economic constraints and biological objectives for Ochoco Creek would require additional evaluation and design work prior to serious consideration in the DBHCP. None of these alternatives are approved or endorsed by the OID at this time, and this report is intended to facilitate ongoing discussions.

# 2.0 Methods

## 2.1. Review of Existing Information

### 2.1.1. Biological Information

Information and analyses of salmonid fish spawning and rearing habitats along with riparian assessments, water quality, water temperature, and hydrological data above Ochoco Dam were reviewed and summarized. To the extent supported by the existing information, a summary of: 1) total area of habitat, and 2) the relative quality of habitat to produce summer steelhead trout and spring Chinook salmon, was prepared. Existing limitations and/or impairments to habitat

described in the existing documents, such as unscreened diversions and blockages to fish movement, were also noted.

### 2.1.2. Engineering Information

OID staff facilitated a review of relevant technical information as a basis for this study, including an overview of the dam's physical characteristics, hydrologic regime, and operational characteristics. Additionally, OID provided a tour of the site, and a review of the dam design drawings and operational data to help facilitate this study.

## 2.2. Site Evaluations

### 2.2.1. Biological Potential of Upper Basin

R2 Resource Consultants, Inc. (R2) and Biota Pacific Environmental Sciences, Inc. (Biota Pacific) performed a 2-day site visit to the upper Ochoco Creek basin (Figure 2-1) along with representatives of the US Fish and Wildlife Service (USFWS), Oregon Department of Fish and Wildlife (ODFW), and the Crooked River Watershed Council (CRWC) to gain a general impression of available fish habitat conditions and to observe specific stream reaches of interest. The mainstems of Mill, Marks, Canyon, and upper Ochoco creeks were examined via pedestrian surveys. Information and photographs of riparian, stream channel, and substrate conditions along with estimates of active channel and wetted channel widths were noted. Fish passage conditions at potential migratory barriers along these and tributary channels were reviewed. Tours were conducted of restoration projects along Jim Bauersfeld's properties on Mill Creek and the Lesser's Ranch and CRWC's restoration sites on Marks Creek. Biological information relevant to this study is summarized in Section 3.0.

### 2.2.2. Engineering Feasibility

A basic understanding of the site was provided with a site tour led by OID personnel with a civil engineer from R2 who specializes in the design and construction of fish passage facilities. This tour included a thorough overview of the dam and reservoir, and a tour of other sites within the area that may accommodate features of various fish passage systems. Information and photographs of the sites were taken for further analysis. Following the tour, both parties reconvened at the OID offices and discussed the potential sites and agreed on a general approach for this study. Additional research was performed by R2 on the stream gaging and flow data for the potential sites to help understand dam operations and define fish passage design flows. Information relevant to this study is summarized in Section 4.0.

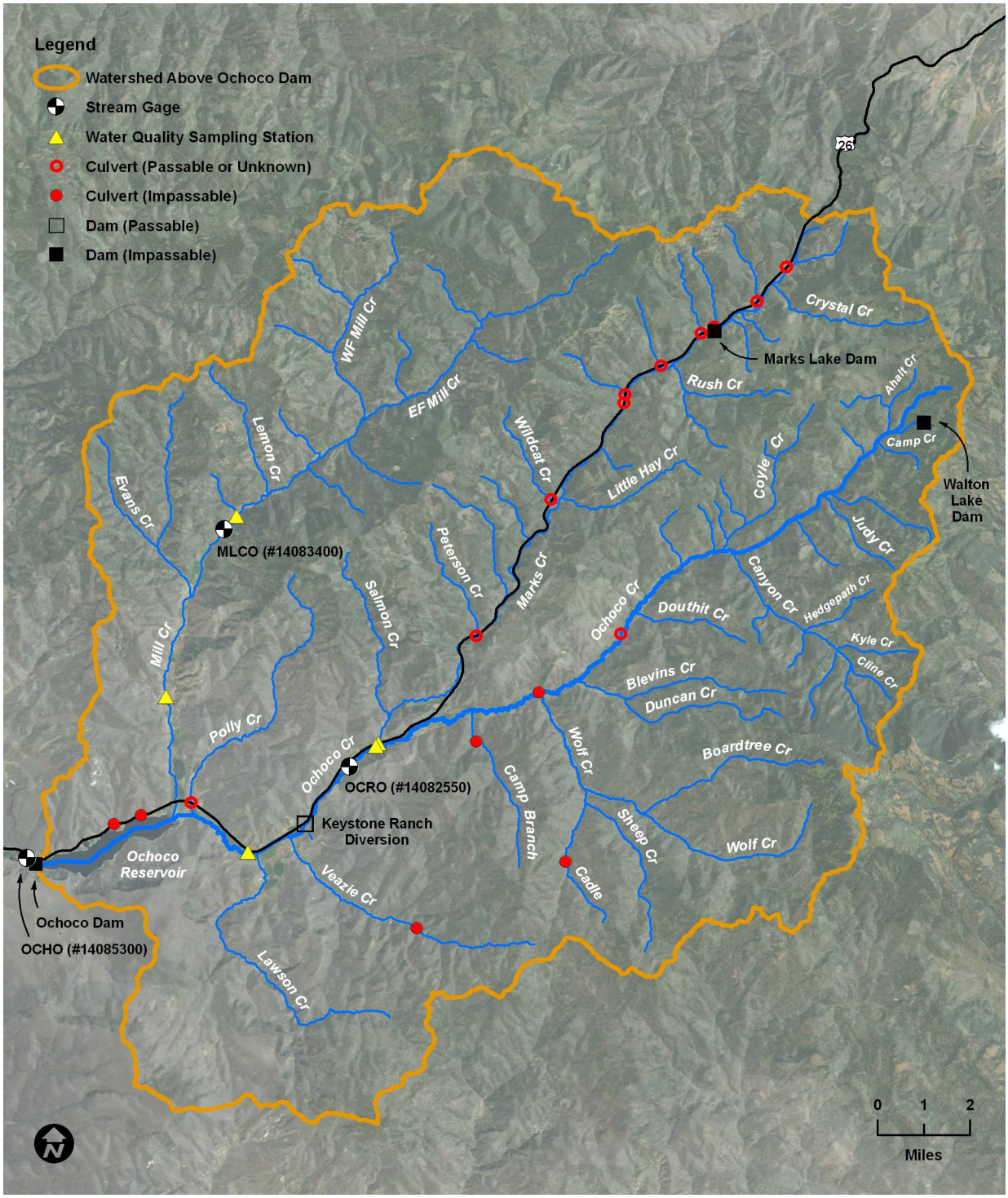


**Figure 2-1. Ochoco Creek watershed area and channel network upstream of Ochoco Dam.**

# 3.0 Biological Considerations

## 3.1. Biological Potential of the Upper Watershed

### 3.1.1. Sources of Information

This review relies on available Federal, State, and local resource agency information and reports of habitat conditions for flowing waters upstream of Ochoco Reservoir. Habitat assessments conducted by the USFS in the late 1970s (USFS 1977 and 1979), by ODFW for their Deschutes River and Crooked River Fish Management Planning efforts (Lyndsay et al. 1989; Fies et al. 1996; Stuart et al 1996; Marx 2003; Stuart et al. 2007), by the Northwest Power and Conservation Council in preparation of the Deschutes Subbasin Plan (NPCC 2004); watershed assessments performed by the Crooked River Watershed Council (CRWC) (Whitman 2002; Nielsen-Pincus 2008), and a University of Oregon MS thesis (Walters 2000) were reviewed and summarized in appropriate sections below. Other water quality, streamflow, water temperature, and fish passage data were gathered from ODEQ (2002, 2012), OWRB 2012), ODFW, the CRWC (2012), US Geological Survey (2012), Watershed Sciences (2006), and Portland General Electric (PGE 2012; Quesada et al. 2012; Spateholts 2012).

### 3.1.2. Upper Ochoco Creek Watershed Habitat Conditions

Headwaters and tributaries of Ochoco Creek begin on the forested hills of the Ochoco National Forest, and flow through narrow valleys and steep canyons. Lower elevations in the watershed consist of broad valleys generally in private ownership, with agricultural lands primarily used for livestock grazing and hay production.

#### 3.1.2.1. Quantity

None of the existing sources of information quantified the abundance of habitats available to salmonid fishes above Ochoco Reservoir. With the findings of the site visit, in conjunction with GIS data layers for the available channel network and ODFW passage barriers, the distance and surface area of waters potentially available to anadromous species were estimated. A total of 81 miles of streams for accessible mainstem and tributary habitats with surface areas ranging between 377,000 $m^2$ and 708,000 $m^2$ (93 and 175 acres) under relatively dry and wet conditions, respectively, was estimated to be available to large-bodied migratory species (Appendix A). The quantity of accessible habitats specific to steelhead trout and spring Chinook salmon are considered below in Sections 3.1.3 and 3.1.4.

#### 3.1.2.2. Quality

The quality of habitats to support salmonid fishes was addressed in many of the existing data sources as recapped in this subsection. Some of the information is dated, and given the amount of habitat restoration that has occurred in the basin in recent years, may no longer fit the current situation. Habitat conditions are summarized in the following sections related to natural and man-made limitations.

### Natural Limitations

Ochoco Creek is similar to many of the Deschutes Basin east-side tributaries with natural limitations of low seasonal stream flows, occasional early summer dry streambed conditions, and heavy sediment loads from naturally erosive soils and channel banks. Except in the extreme headwater locations, no natural migratory barriers were noted along the mainstems of Ochoco Creek, Mill Creek, Marks Creek, and other large tributary waters. Summer steelhead trout and spring Chinook salmon were known to use the Ochoco Creek basin prior to development of Ochoco Dam in 1920 and the subsequent exclusion of upstream passage at the Pelton-Round Butte complex (Frey 1942 as cited in Nehlsen 1995).

### Man-made Limitations

Water diversions diminish low flows and can generate passage barriers. Land uses including agriculture and ranching have reduced habitat conditions through loss of riparian vegetation. Cattle in many locations have direct access to creeks, which further degrades channels. Most summer live flow in Ochoco, Marks and Mill creeks between the National Forest boundary and Ochoco reservoir is diverted for irrigation, and Ochoco and Mill creeks are frequently dry above the reservoir in July, August and September. Further, flood intensity, such as during the 1964 flood, has increased in much of the upper drainage because of the loss of natural water storage (NPCC 2004). Many tributary streams were channelized following the 1964 flood, disconnecting the streams from their floodplains and increasing the energy of the streams on the channel banks (Whitman 2002). Such channels do not connect with their floodplains and water moves quickly through the system.

The Northwest Power and Conservation Council (NPCC 2004) listed the following habitat limitations for the upper Ochoco Creek basin:

- Seasonally low stream flows are common in most stream reaches.
- Lower reaches and lower tributary reaches have low or intermittent summer flow associated with water withdrawals.
- High summer water temperatures from the upper end of Ochoco Reservoir to RM 36.4 fail to meet State water quality standards.
- Channel manipulation and lack of stability have affected fish habitat quality.
- There are a number of seasonal and permanent artificial barriers without fish screening or passage.
- There is a general lack of large wood or other instream structure.
- Most riparian corridors have been degraded.
- Sedimentation from stream bank and upland erosion affects the quality of the stream substrate.

Riparian assessments conducted in 2000 in the Mill, Marks and Ochoco creek drainages indicated riparian recruitment of wood to streams was generally inadequate along Mill Creek, West Fork Mill Creek, Marks Creek and Ochoco Creek (Whitman 2002). Some riparian areas along upper Mill Creek continue to recover from the 2000 Hash Rock forest fire. The riparian corridor along lower Ochoco Creek has been damaged by livestock grazing, channel simplification, and agricultural practices. Tributaries Canyon, Fisher, and Judy creeks have been

impacted by inactive mercury (cinnabar) mines located at the headwaters of Canyon Creek. ODFW survey results for Marks Creek indicated overgrazing, irrigation structures, and stream channelization had adverse impacts on fish habitat, streamside cover, and bank condition. Up to 80 percent of the stream banks were observed to be eroding. Average shade levels ranged between 10-30 percent on Ochoco Forest lands and 0-20 percent on private lands. The USFS and ODFW surveys for the upper Ochoco Creek drainage in 1979, and for Marks and Mill creeks in 1977, showed the best riparian conditions were found in the upper reaches of Canyon and Ochoco creeks (Stuart et al. 1996).

Habitat complexity has been reduced along Ochoco Creek through stream channelization and berming. Several reaches are isolated from their floodplains, and large wood is in low abundance. Channel assessments indicated sensitivity to erosion is high for 84 percent of the Ochoco Creek, and the potential for large wood recruitment is low for roughly two-thirds of stream reaches (Walter 2000; Whitman 2002; NPCC 2004). Channel erosion sensitivity for Marks and Mill creeks was rated as high for the entire channels (Walter 2000). Lack of instream habitat complexity and large wood contribute to reduced fish production in many reaches. Fish populations have also been fragmented by irrigation diversion dams and small impoundments that lack fish passage facilities or protection screens (Marx 2003).

Water quality in Marks, Mill, and Ochoco creeks also surpasses State water temperature criteria for salmonid spawning and rearing (ODEQ 2002). Stream reaches that exceed Oregon's water quality criterion of 17.8°C (64°F) for summer rearing include:

- Ochoco Creek (RM 0.0 - RM 36.4
- Marks Creek (RM 0-17.1)
- Mill Creek (RM 0-11.5)
- East Fork Mill Creek (RM 0-7.6)
- West Fork Mill Creek (RM 0-4.9)

Stream reaches that also exceed Oregon's water quality criterion of 12.8°C (55°F) at times during the spawning and incubation between October 1 and June 30 include:

- Marks Creek (RM 0-17.1)
- Mill Creek (RM 0-11.5)

Water temperatures have been recorded as high as 25.6°C (78°F) on Mill Creek and 26.7°C (80°F) on the West Fork of Mill Creek (Stuart et al. 1996). The spawning criterion (12.8°C; 55°F) has also been exceeded in Marks Creek and Mill Creek. An example of a longitudinal temperature profile using thermal infrared (TIR) imaging and water temperature measurements for a 4-day period in August 2005 is shown in Figure 3-1.

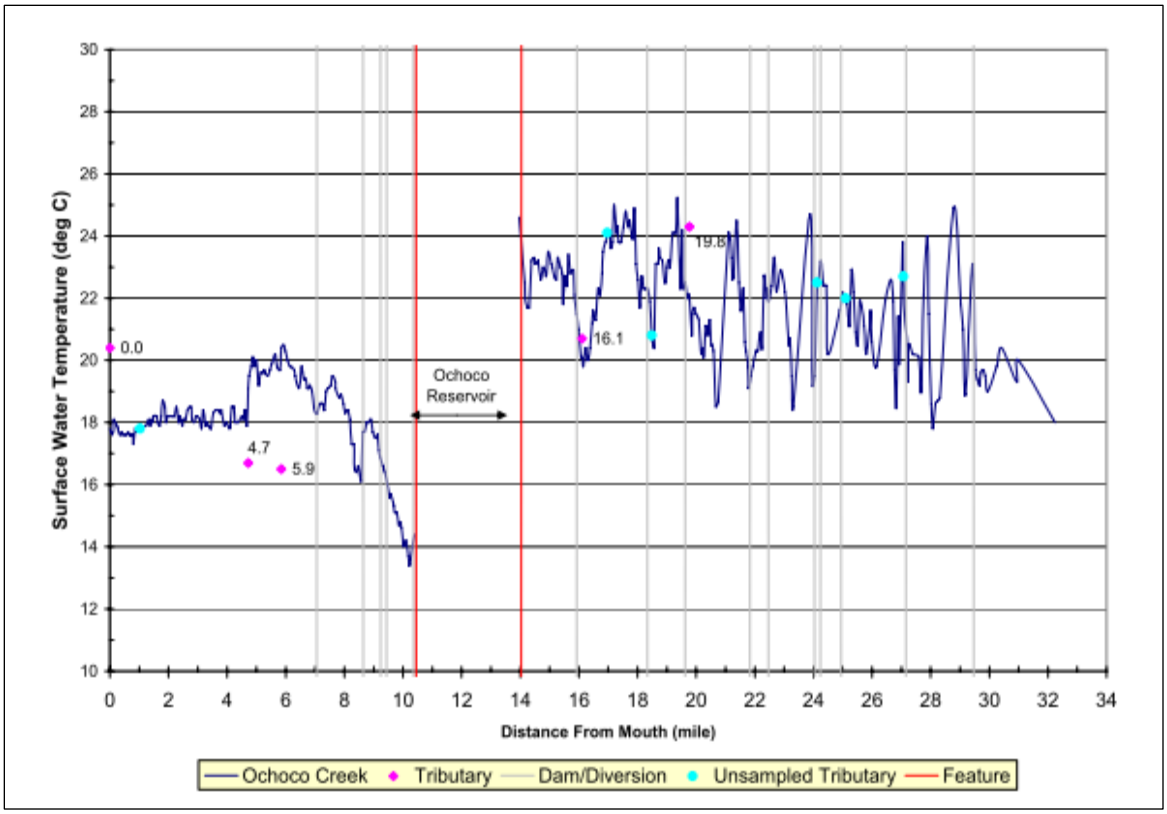


**Figure 3-1. Thermal infrared temperature data and median sampled temperatures plotted by river mile for Ochoco Creek. Source:** Watershed Sciences 2006

Peak summer temperatures recorded as 7-day averages of the daily maximum values at various continuous gage sites in the basin as reported by the Crooked River Watershed Council (CRWC 2012) are shown in Table 3-1.

**Table 3-1. Seven-day maximum temperatures (°C) reported for upper Ochoco Creek and tributaries.**

| Station | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|
| Ochoco @ Lawson Cr. | - | - | - | - | - | - | - | 22.0 | - |
| Ochoco @ USGS Gage | - | - | 23.3 | - | - | 19.9 | 20.8 | 21.8 | 23.7 |
| Mill Cr. @ Coffer Div. | - | - | 25.7 | 24.2 | - | - | 21.9 | 22.2 | - |
| Mill Cr. @ OWRD Gage | - | - | - | - | - | - | 22.4 | 21.3 | - |
| Marks Cr. @ Hwy. 26 | 24.3 | 25.0 | 25.1 | - | - | - | - | - | - |

**Source:** Crooked River Watershed Council (2012)

In addition, elevated mercury levels have been documented in fish collected in Ochoco Creek and Ochoco Reservoir, likely from inactive mercury (cinnabar) mines located at the headwaters of Canyon Creek. A 2-year-old fish collected from Ochoco Reservoir had mercury levels exceeding 0.5 mg/L (Stuart et al. 1996). Older age fish typically have greater levels of bio-accumulated mercury, suggesting that 3- to 4-year-old fish may reach or exceed the State health standard of 1.0 mg/L.

Reintroduced salmonid fishes could use Ochoco Reservoir for rearing and foraging opportunities and perhaps as thermal refuge from warm summer stream temperatures. Habitat limitations for fish in Ochoco Reservoir include seasonal and annual water level fluctuations and drawdown, high suspended sediments which limit photosynthesis, moderate to low concentrations of nutrients in the water, very low abundance of aquatic vegetation, a lack of structural complexity, and water that is too warm for optimal year-round salmonid fish production (Fies et al. 1996).

Stream fencing to exclude livestock, riparian plantings, and stream restoration activities especially on Mill and Marks creeks have contributed to riparian vegetation and streambank recovery in recent years. The CRWC, OWEB, and ODFW are working with landowners in the subbasin to protect and enhance riparian areas with exclusionary fencing, planting of trees and shrubs, providing passage at barriers, coordinating stream restoration, and improved livestock management. Fencing to exclude livestock from streams has had a rapid improvement in willow growth, shade levels, and channel stability. Extensive stream areas have recently been fenced and the resulting habitat conditions are likely better than reported in the documents cited above.

### 3.1.3. Summer Steelhead Trout Spawning and Rearing Habitat

ODFW believes reintroduced steelhead trout could occupy flowing water habitats in the upper Ochoco Creek basin anywhere the channel network currently supports the production of resident rainbow trout (Hodgson, pers. comm. September 2012). Resident rainbow trout were observed in surface waters at numerous locations during the 2-day site visit in September 2012 (Photo 3-1).

Give the widespread distribution capabilities of steelhead trout, all of the estimated 81 miles of accessible streams and surface areas reported above in Section 3.1.2.1 *Quantity* are assumed to be available to this migratory species. Water runoff is at the highest levels during the spring spawning season for steelhead trout (March through May). As a result, access to spawning, incubation, and early rearing habitats is maximized. As water levels decrease and temperatures warm during summer and early fall, the fish may move to lower stream elevations or the reservoir if stream flows will not support year-round rearing.

**Photo 3-1. Resident rainbow trout observed during low flow conditions in Canyon Creek near RM 1 on September 20, 2012.**

### 3.1.4. Spring Chinook Salmon Spawning and Rearing Habitat

Chinook salmon were reported to use Ochoco Creek extensively before Ochoco Dam was built (Frey 1942). However, the upstream distribution of the use was unknown. Since Chinook salmon are primarily mainstem spawners, their potential distribution is more limited than for steelhead trout. As Frey (1942) pointed out, the spawning period for spring Chinook salmon would occur during the lowest water period of the year, further limiting the available waters and appropriate spawning and incubation temperatures for the species. For the purposes of this preliminary assessment, the Chinook distribution and quantity of available habitats were limited arbitrarily to active channel widths greater than 15 feet. This approach produced a total estimate of 40 miles of mainstem and tributary habitats, with surface areas ranging between 218,000 $m^2$ and 471,000 $m^2$ (54 and 116 acres) under relatively dry and wet conditions, respectively. The habitat is categorized as relatively low quality given low flows and high water temperatures during the late summer and early fall spawning period.

### 3.1.5. Existing Salmonid Fish Populations

Redband trout were native to the upper Ochoco Creek basin. A number of indigenous redband trout were eliminated during rotenone projects in the past, and the genetic integrity of the native populations has been diluted by multiple releases of hatchery rainbow trout stocks. As described in Stuart et al. (1996; 2007), Ochoco, Marks, and Canyon creeks have the highest rates of hatchery introgression in the Crooked River basin, ranging from 10 to 30 percent. ODFW acknowledged this percentage of introgression was plausible due to the long-term hatchery stocking and the multiple rotenone projects (Stuart et al. 1996).

Numerous chemical treatment projects using rotenone were conducted from the 1950s to the late 1980s to rid some flowing and standing water bodies of large populations of non-game fish species such as bridgelip and largescale sucker, and northern pike minnow. These species were thought to compete with trout for food and space, and in some cases prey on eggs or juvenile trout. Eradication of the non-game fish also resulted in loss of the remnant redband populations in some of these streams. The location of streams and stream reaches impacted by this management practice in the Crooked River Basin are depicted in Figure 3-2.

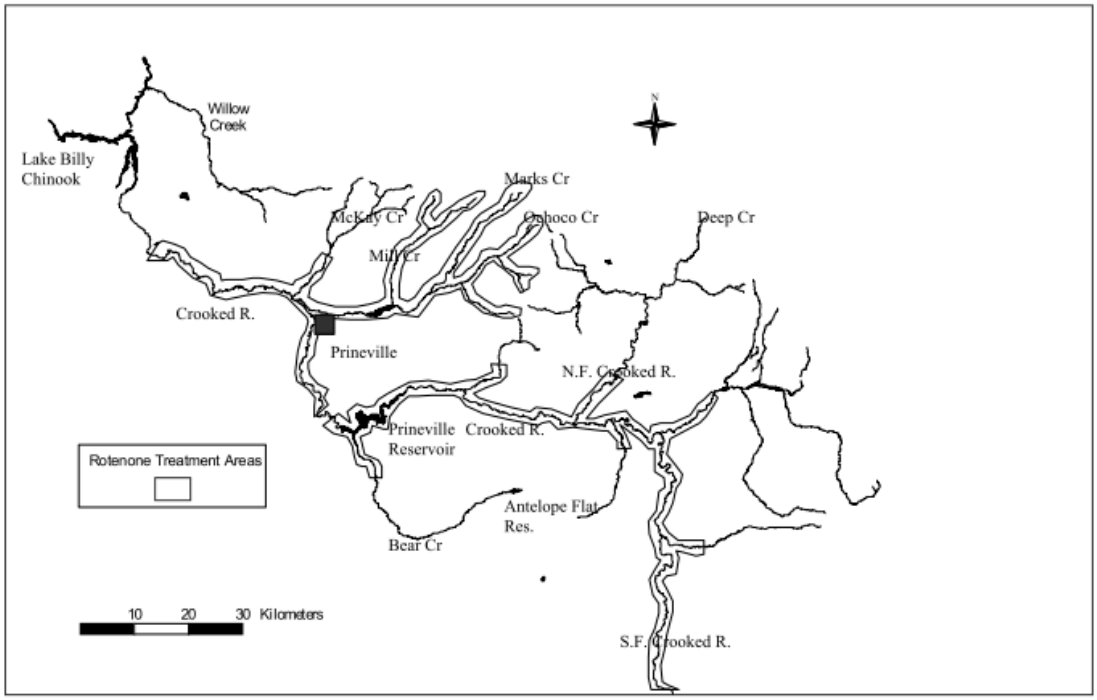


**Figure 3-2. Map of past chemical treatment projects in the Crooked River Basin.**
**Source:** Stuart et al. 1996; 2007; NPCC 2004.

For the purposes of this study, the resident trout in the Upper Ochoco Creek basin are referred to simply as rainbow trout to avoid distinction between the native redband and hatchery rainbow trout stocks. Resident life history forms in the basin may also include adfluvial life histories, where fish migrate downstream from the tributary creeks to rear and mature in Ochoco Reservoir and return to the tributaries for spawning and incubation.

#### 3.1.5.1. Overview of Rainbow Trout Habitat and Populations

During trout density surveys conducted in the drought years of 1991 and 1992, surveyors found good numbers of trout in Canyon Creek and in Ochoco creeks, and moderate numbers in Marks and in Mill creeks (Stuart et al. 1996). Trout densities from a number of streams in the upper Ochoco Creek drainage are shown in Table 3-2.

**Table 3-2. Relative densities of rainbow trout, all age classes, in tributary stream of the Ochoco National Forest lands.**

| Subbasin | Stream | Date | Fish/m$^2$ |
|---|---|---|---|
| Ochoco | Canyon | 8/92 | 2.64 |
| Ochoco | Ochoco | 8/92 | 2.66 |
| Ochoco | Marks | 8/92 | 0.31 – 0.77 |
| Ochoco | Mill | 7/91 | 0.34 – 0.69 |

**Source:** Stuart et al. 1996**.**

#### 3.1.5.2. Implications of Restoring Anadromy to Resident Rainbow Trout

Competition between rainbow and juvenile steelhead trout may occur in areas currently occupied by populations of resident rainbow trout. Cramer and Beamesderfer (2006) note larger resident trout will displace steelhead parr where stable habitat conditions are favorable for year-round rearing. Where stream flow and habitat conditions are unstable, the seasonal use by steelhead trout may be a more successful strategy than the resident life history form (Cramer and Beamesderfer 2006; Ackerman et al. 2007; Courter 2011). Seasonal use of streams by the adfluvial life history form of resident rainbow trout that migrate between Ochoco Reservoir and tributary waters may be comparable to the seasonal approach of anadromous species. Since the spawning, incubation, and emergence timing overlap between these life history strategies, young-of-the-year fry and summer parr likely would compete for limited resources, reducing the production potential of both resident rainbow and steelhead trout.

## 3.2. Periodicity of Fish Runs

The following information was developed to assist with the analysis of potential fish passage facilities.

### 3.2.1. Adult Upstream Migration Timing

The run timing and an initial estimate of the number of adults that may have access to a passage system are helpful to develop conceptual fish passage concepts. Since fish have not had access to the upper Ochoco Creek basin for quite some time, the best available data to provide an initial estimate of returning adult abundance and migration timing can be found at the Pelton Reregulating Dam, as summarized in Table 3-3. Table 3-4 was prepared based on the observed data and frequencies shown in Table 3-3. Based on these data, continuous upstream fish

passage activity is anticipated year-round at Ochoco Dam for planning purposes, with peaks in January – March, and again in June –July.

**Table 3-3. Adult fish counts at Pelton Reregulating Dam**

| Month | Summer Steelhead Trout | | | | Spring Chinook Salmon | | | |
|---|---|---|---|---|---|---|---|---|
| | 2012 | 2011 | Total | Percent | 2012 | 2011 | Total | Percent |
| Jan | 665 | 981 | 1,646 | 32% | 0 | 0 | 0 | 0% |
| Feb | 927 | 317 | 1,244 | 24% | 0 | 0 | 0 | 0% |
| Mar | 567 | 289 | 856 | 17% | 0 | 0 | 0 | 0% |
| Apr | 73 | 87 | 160 | 3% | 1 | 0 | 1 | 0% |
| May | 3 | 3 | 6 | 0% | 64 | 580 | 644 | 15% |
| Jun | 0 | 0 | 0 | 0% | 935 | 1,220 | 2,155 | 50% |
| Jul | 0 | 0 | 0 | 0% | 362 | 748 | 1,110 | 26% |
| Aug | 3 | 1 | 4 | 0% | 81 | 272 | 353 | 8% |
| Sep | 31 | 3 | 34 | 1% | 0 | 12 | 12 | 0% |
| Oct | 0 | 121 | 242 | 5% | 0 | 0 | 0 | 0% |
| Nov | 0 | 186 | 372 | 7% | 0 | 0 | 0 | 0% |
| Dec | 0 | 297 | 594 | 12% | 0 | 0 | 0 | 0% |
| Total | 2,269 | 2,285 | 5,158 | 100% | 1,443 | 2,832 | 4,275 | 100% |

**Source:** PGE (2012) Fish Counts at Pelton Dam

**Table 3-4. Assumed adult upstream migration timing for summer steelhead and spring Chinook in Ochoco Creek.**

| Species | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D |
| Summer Steelhead | + | + | + | - | | | | | - | - | - | - |
| Spring Chinook | | | - | - | - | + | + | - | | | | |

**Legend**: - denotes months where fish are running, and + denotes months with peak runs

### 3.2.2. Smolt Downstream Migration

Estimated run timing for outmigrants is summarized in Table 3-5 for summer steelhead trout and spring Chinook salmon. Summer steelhead smolt sizes during the outmigration period are estimated at 120-180 mm fork length (Quesada et al. 2012). Steelhead fry (0+-age) may also move out of the upper watershed in the fall if conditions are not good upstream. Similarly, spring Chinook smolt sizes are estimated at 80-130 mm fork length (Quesada et al. 2012). Peak

smolt outmigration would likely occur in April and May, with collection facilities operating from February through June of each season. If there was a desire to collect summer steelhead fry, a collection system would need to also operate in October through December.

**Table 3-5. Assumed juvenile outmigration timing for summer steelhead and spring Chinook in Ochoco Creek.**

| Species | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D |
| Summer Steelhead | | | - | - | + | - | | | | F | F | F |
| Spring Chinook | | - | - | + | - | | | | | | | |

**Legend:** - denotes months where fish are running
+ denotes months with peak runs
F denotes possible fry outmigration (0+ age) if conditions are not good upstream

# 4.0 Facility Information and Relevant Fish Passage Data

## 4.1. Ochoco Dam and Associated Facilities

Descriptions of Ochoco Dam, Ochoco Reservoir and the associated facilities are provided in DBHCP Chapter 3 – *Scope of the HCP*. The information is not repeated in this report, however, material pertinent to this study is provided below for reference. An overview of the covered lands is provided in Figure 4-1, showing an overview of map of the Deschutes Basin and the irrigation districts covered by the DBHCP.

### 4.1.1. OID Overview

Ochoco Irrigation District provides water to approximately 850 patrons on 20,062 acres mostly north and east of the Crooked River in Crook County. An overview map of the OID is provided as Figure 4-2. OID owns and operates Ochoco Dam and Reservoir, and operates Bowman Dam and Prineville Reservoir under contract with Reclamation. The OID conveyance system is comprised of four main canals (Crooked River Diversion Canal, Crooked River Distribution Canal, Ochoco Main Canal, and Ryegrass Canal) and roughly 99 miles of smaller canals and associated laterals illustrated in Figure 4-3. Water is diverted from the Crooked River at the Crooked River Diversion, and 34 downstream pumps are operated by individual OID patrons. Water is diverted from Ochoco Creek at Ochoco Dam, three small diversions operated by OID downstream of Ochoco Dam, two infiltration galleries operated by OID, and 33 pumps operated by individual patrons. OID also diverts water from multiple locations on Johnson Creek, Dry Creek, McKay Creek, and Lytle Creek. Some of the diversions and portions of the canal systems are Federally-owned, with operation and maintenance transferred to OID. The remaining structures are owned and operated by OID.

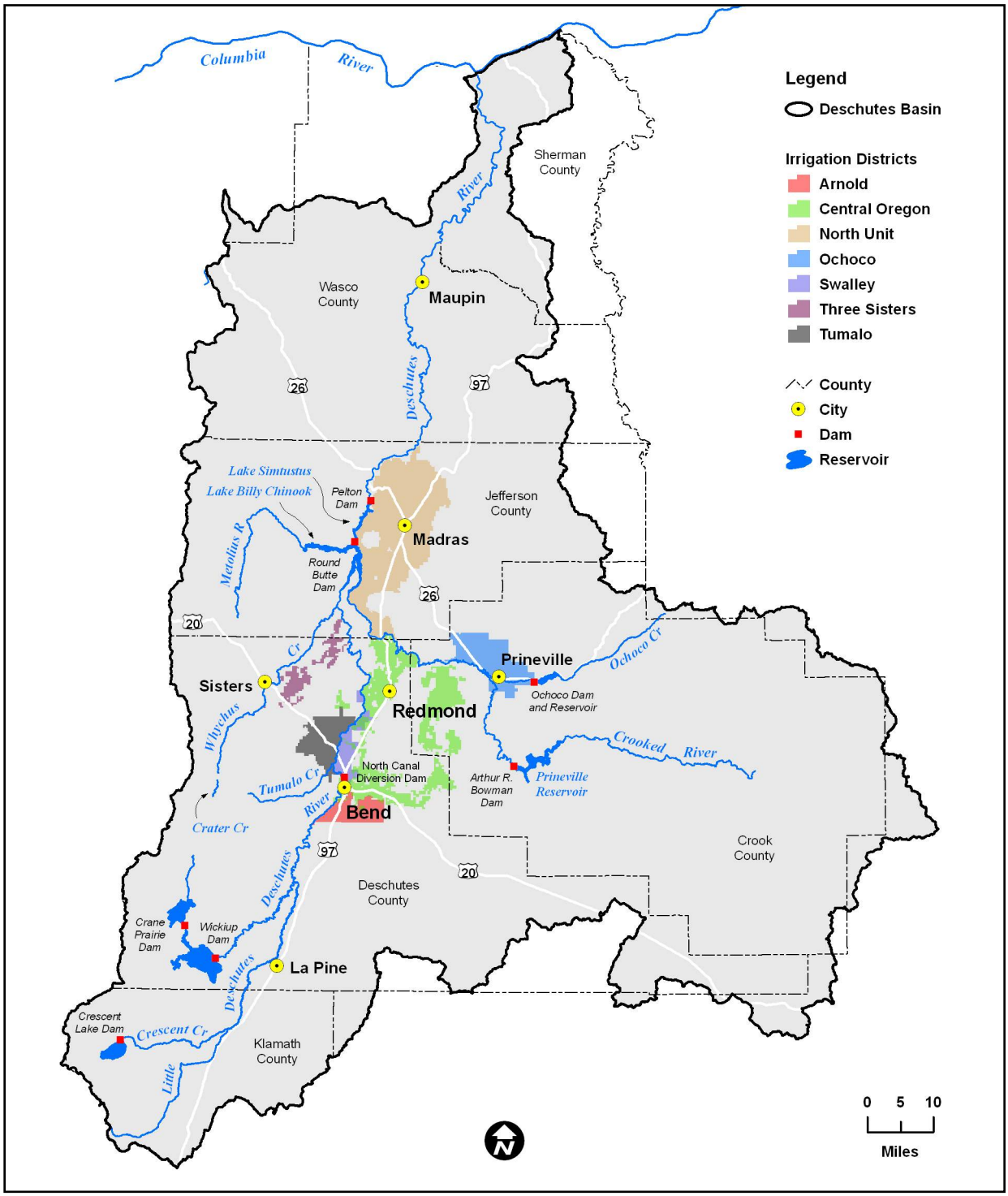


**Figure 4-1. Map of the Deschutes Basin showing irrigation districts covered by the Deschutes Basin HCP.**

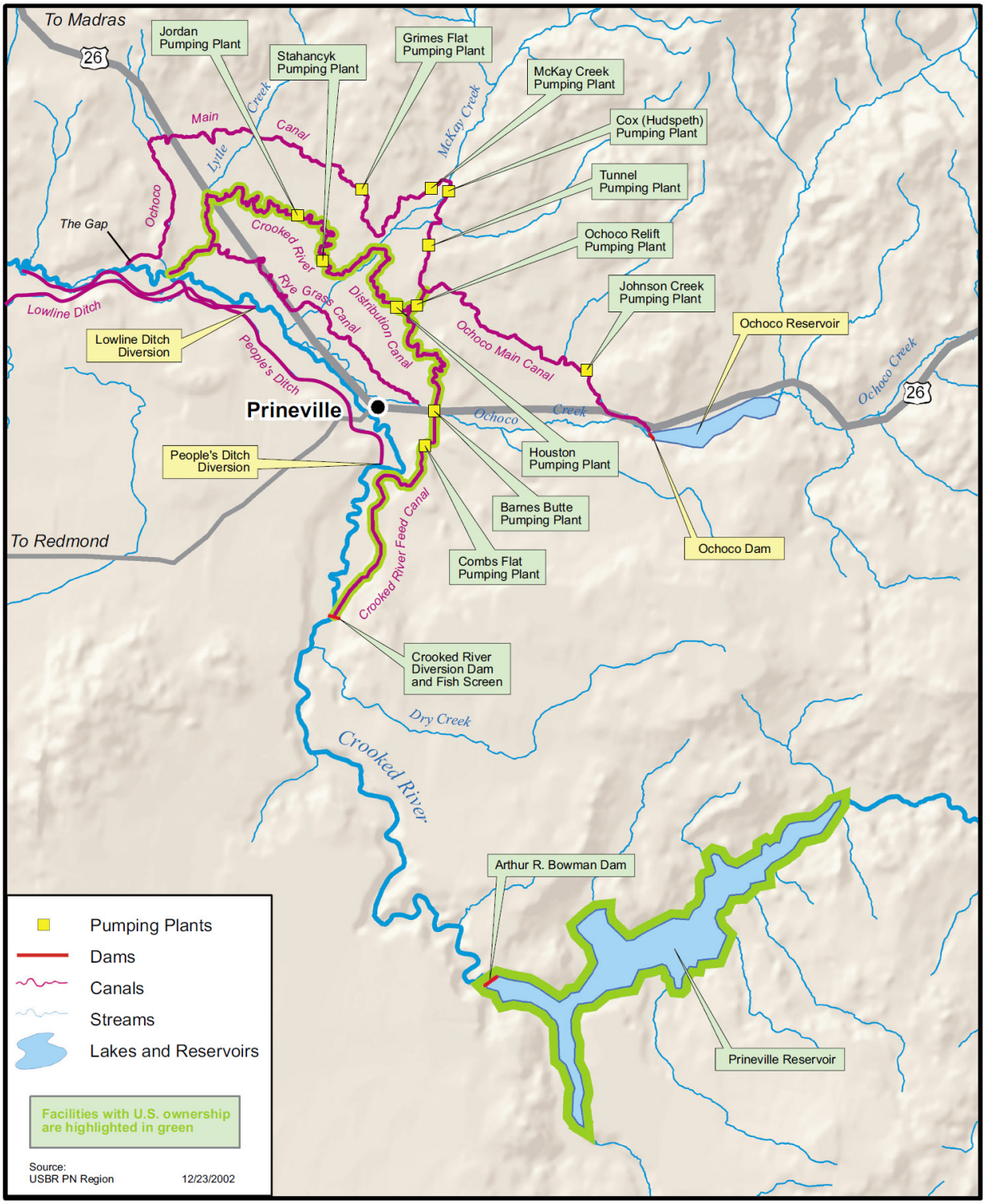


**Figure 4-2. Overview map of the Ochoco Irrigation District and Crooked River Project.**

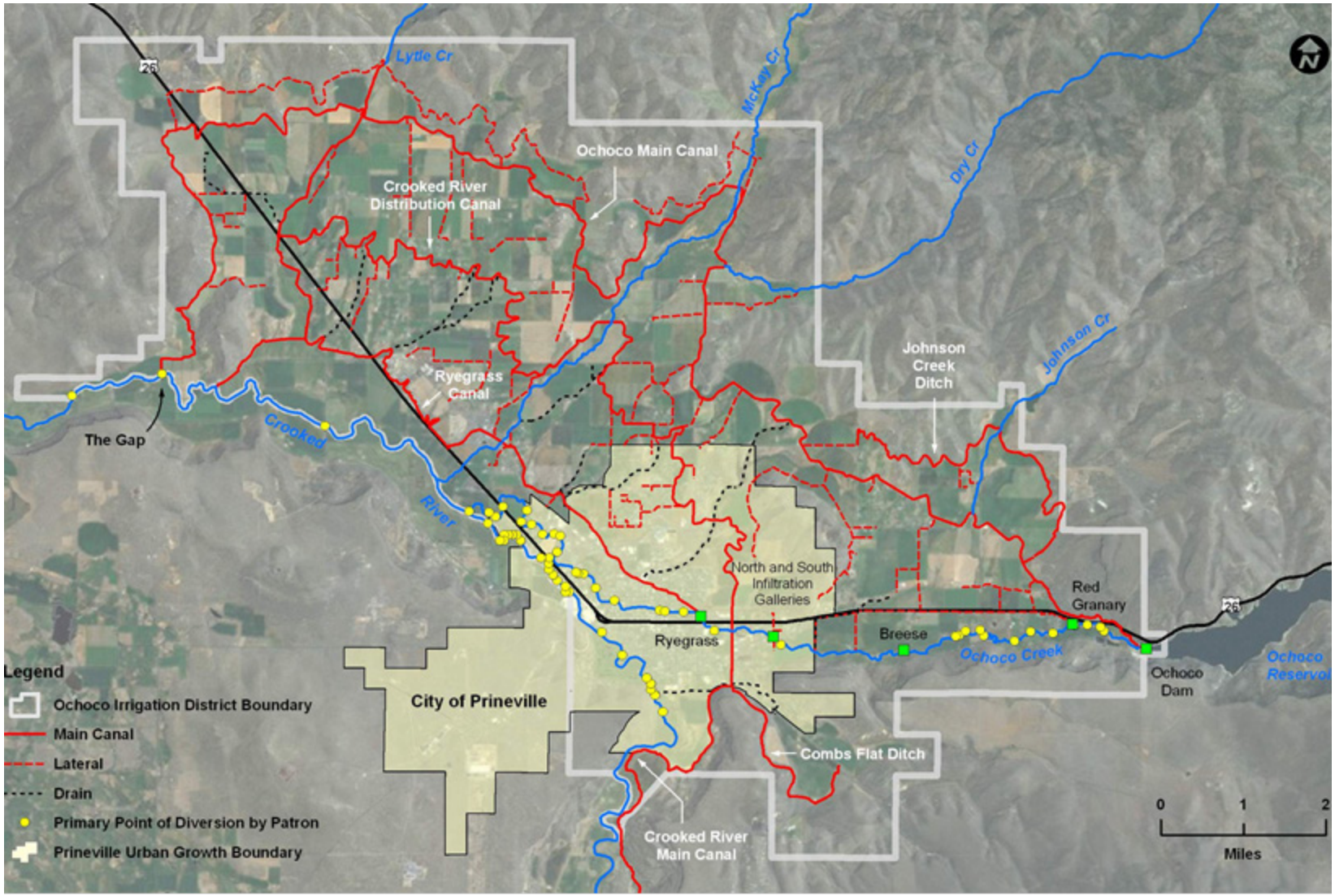


**Figure 4-3. Detail map of the Ochoco Irrigation District.**

### 4.1.2. Ochoco Dam Description

The Ochoco Dam is a zoned, earthfilled dam with a structural height of 125 feet above its foundation, located along Ochoco Creek. The purpose of the dam is for water storage, distribution for irrigation and industrial water, and for flood control to help protect the City of Prineville. An overview of the dam is provided in Photo 4-1, showing the primary features. An aerial view is provided in Photo 4-2.

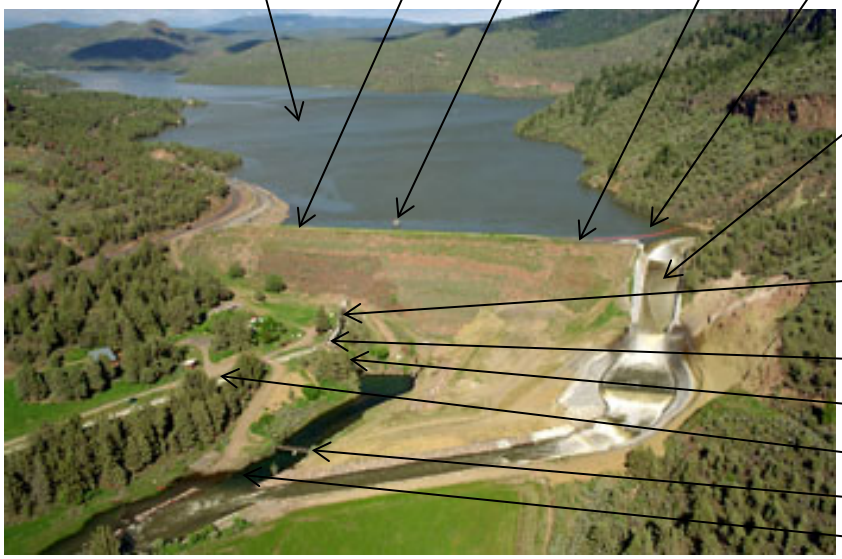


**Photo 4-1. Ochoco Dam and Reservoir, looking upstream with features labeled.**

**Photo 4-2. Aerial view of Ochoco Dam, Reservoir, Ochoco Creek and Ochoco Main Canal.**

Features of the dam that are important for the consideration of fish passage include the following (additional photographs of these features are provided at the end of this section, organized from upstream to downstream):

- Dam Crest. The dam crest is about 1,300 feet long, and varies in top elevation from EL 3,154 near the right bank, to EL 3,143 near the spillway. The top of the dam is approximately 25 feet wide. See Photo 4-3.
- Dam Base. The maximum base width is 700 feet.
- Outlet works. The outlet works currently has a maximum capacity of 430 cfs at the normal reservoir level of 3,130.7 feet, and historically had a capacity of 1,100 cfs (prior to improvements in 1948). OID anticipates a future capacity increase to 1,100 cfs, associated with dam improvements under consideration for additional flood control capability. Controlled flow is released from the dam through an outlet works consisting of the following:
    - Control Tower. Located in the reservoir, provides an inlet transition at EL 3,074.94 feet (centerline EL 3,076.5 feet), consisting of a 60-inch I.D. steel pipe constructed integral with the tower with a trashrack. The tower is a vertical 8.0-foot I.D. concrete cylinder, founded on the base of the reservoir. Water flows in from the entrance, down through the vertical shaft of the tower, and enters the 44-inch diameter outlet pipe. The centerline elevation of the 60-inch diameter inlet pipe is approximately 54 feet below the full pool elevation of 3,130.7 feet. The top of the Control Tower is shown in Photo 4-1 through Photo 4-3, with a close-up view in Photo 4-3.

- Trashrack. The trashrack on the upstream end of the inlet pipe is a box shaped steel structure that protrudes from the circular opening. The box is 7' -8" tall, by 7' -6" wide by 5' -0" deep, fabricated from steel ½" thick bars spaced at 4 ½" on centers (creating an open space between bar faces of 4"). There are no formal cleaning provisions for the trashrack, and typically the intake is not cleaned (pers. comm., OID).
- Bulkhead Gate. The inlet has provisions to accommodate a bulkhead gate that can be transported to the intake by barge, and manually lowered over the intake opening to close off the intake into the tower. This gate is stored by the Dam Tender's residence.
- Guard Gate. The Control Tower contains a 5-foot square guard gate located on the upstream end of the outlet pipe (inside the tower), with a centerline elevation of approximately 3,050.5 feet. This fabricated gate is operated by a hydraulic hoist power unit. The power unit is located in a water proof enclosure at the top of the tower, approximate EL 3,137.5 feet.
- Outlet/Conveyance Pipe. A 44-inch I.D. circular steel pipe runs through the original horseshoe conduit with a centerline elevation of 3,050.38 feet (Invert EL 3,048.55 feet) at the upstream end, and 3,050.68 feet (Invert EL 3,048.85 feet) at the downstream end. The Outlet Pipe is approximately 472 feet long. The upstream end of the pipe was grouted into the original horseshoe shaped tunnel in 1948 to create a water tight seal. The 44-inch pipe creates the 430-cfs capacity, and prior to the 1948 retrofit, the horseshoe tunnel capacity was 1,100 cfs.
- Control House and Regulating Gate. The Outlet Pipe terminates at a 3' -3" square hydraulically operated high pressure regulating slide gate, located in the control house at the downstream side of the dam. This gate regulates flow through the conveyance pipe. The Regulating Gate cannot be operated at less than a 2-inch opening. See Photo 4-6.
- Bypass Pipe. A 14" Bypass Pipe controlled by two 14" high pressure butterfly valves provides a bypass around the 3' -3" regulating gate. This system is typically used for low flows (less than 20 cfs) during the non-irrigation season, and provides for a fire protection tap for the dam-tender residence, along with irrigation water for the dam-tender's residence.
- Stilling Basin. Flow passing through the Regulating Gate and/or the Bypass Pipe enters a stilling basin at the upstream end of the Ochoco Canal, to help dissipate energy from the discharge prior to flow entering the canal. See Photo 4-6.
- Ochoco Canal. The Ochoco Canal leads from the Stilling Basin to the OID Canal System to convey irrigation releases. The canal capacity is about 160 cfs. See Photo 4-7.
- Canal Spill. A Canal Spill feature is provided at the end of the concrete flume about 230 feet downstream from the Control House to allow flows greater than desired in the Ochoco Canal to spill directly back to Ochoco Creek. This facility is fitted with a trash rack, has a check structure in the canal, and consists of a reinforced concrete weir, chute, and flip bucket. Flashboards at the top of the

weir provide control of releases to the Ochoco Creek from the outlet works, when flow capacity through the dam exceeds the canal needs. See Photo 4-7 through Photo 4-9. Canal Spill flows range from a minimum of 0 cfs to a maximum of the full outlet capacity of 430 cfs, but typically the spill flows vary during the irrigation season from about 3 cfs to 20 cfs to provide for leased flow in the creek, and for irrigation diversions from the creek by OID downstream during the irrigation season. Additional information on flows is provided in Section 4.1.4.

  - Barge Supported Pump System. Because the original intake was located below the current intake lip EL 3,074.94 feet, there is usable storage in the reservoir below the intake structure that must be pumped to utilize for the canal (there are also 5,266 acre feet of inactive storage). A system supported by a floating barge can be deployed to pump water from the lower pool elevations into the Control Tower. The pump motors are electric powered.

- Spillway. A concrete spillway is located along the left bank of the dam crest, consisting of a three-level uncontrolled overflow crest (see Photo 4-4). The overall width of the spillway is 275 feet. Water going over the crest flows into a 3-stage stilling basin leading back to Ochoco Creek. The three crest section, from left to right (looking downstream) are:
  - 54 feet long at EL 3,131.8 feet
  - 71 feet long at EL 3,131.3 feet
  - 150 feet long at EL 3,130.7 feet
- Spillway Logboom. A floating logboom is maintained upstream of the approach to the spillway (see Photo 4-4).
- Measurement Weir. A flow Measurement Weir is located downstream of the Canal Spill to measure flow from the Canal Spillway and any leakage through the dam. See Photo 4-7. This weir is tied into Reclamation's Hydromet gauge system, and with the identifier OCHO. Note that this weir and gauge are located upstream of the dam's spillway channel, so it does not record spill events (other than some apparent backwater affect).

**Photo 4-3. Ochoco Dam control tower (from dam crest looking upstream).**

**Photo 4-4. Ochoco Dam multi-level spillway crest and logboom (looking upstream).**

**Photo 4-5. Ochoco Dam spillway and Ochoco Creek (looking downstream from dam crest).**

**Photo 4-6. Ochoco Dam outlet works, Ochoco Canal, and spill to Ochoco Creek (looking downstream).**

**Photo 4-7. Ochoco Canal, spill to Ochoco Creek, and measurement weir (looking downstream).**

**Photo 4-8. Ochoco Dam outlet works stilling basin (looking upstream).**

**Photo 4-9. Ochoco Dam outlet works stilling basin (looking downstream toward canal check structure).**

**Photo 4-10. Flow measurement weir (contains Reclamation's Hydromet Gage ID "OCHO").**

### 4.1.3. Diversion of Water at Ochoco Dam - General

OID utilizes a combination of in-channel reservoir storage and live flow to meet its irrigation needs. The amount of water diverted at any time is determined by the amount available (storage and live flow combined), the surface water rights to which the district delivers water, the operational constraints of the conveyance system, and patron demand.

The irrigation season typically begins in April and runs through mid-October. Maximum diversion rates to the Ochoco Canal and Canal Spill occur between May 15 and September 15 (summer irrigation diversions), with minimum diversion rates in April and October. This schedule is highly dependent on weather conditions and availability of water, and can vary considerably. Additional information on flows is provided in Section 4.1.4.

OID delivers water on a demand ("as needed") basis, through the use of the Regulating Gate in the Outlet Works leading to the Ochoco Canal for irrigation use. A portion of the flow exiting the Outlet Works is spilled to Ochoco Creek. All other covered diversions from Ochoco Creek occur downstream of Ochoco Dam including one small dam (Red Granary), two inverted weirs, infiltration galleries and pumps. The Red Granary dam, the inverted weirs, and some of the pumps are operated by OID. The remaining pumps are operated by district patrons. Diversion structures typically create small impoundments to raise water levels and facilitate gravity flow out of stream channels. Such impoundments are not managed for active water storage. Pumps may also require small impoundments.

### 4.1.4. Flows and System Operations

Flows relevant to fish passage needs are typically summarized for the 5 percent and 95 percent exceedence flows during the period when fish would be migrating through the system (NMFS 2011). Additional information on fish passage criteria is provided in Section 4.2.

The following sections summarize flow data from available gages, at locations to be examined for fish passage facilities. There are two sources of flow data: 1) the Reclamation Hydromet system, and 2) the OWRD stream gaging system. These two sources are interrelated, and each has their own designation with the OWRD gage number and the Reclamation letter designation. Flow data were synthesized for the gages of interest based on the longest duration gage in the system.

#### 4.1.4.1. Flows in Mill Creek Upstream of Evans Creek

Table 4-1 provides monthly flow data from the Reclamation Hydromet System, Gage ID "MLCO" (OWRD #14083400), which recorded flows in Mill Creek just upstream of Evans Creek from 1999 - 2012. The gauge location is shown on Figure 2-1. Additional data were synthesized from 1941 to 1998 based on monthly inflows to Ochoco Reservoir.

**Table 4-1. Flow data in Mill Creek, upstream of Evans Creek and Mill Creek confluence.**

| Exceedence Level | Flow (cfs) by Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 0% (Max) | 131 | 231 | 342 | 330 | 184 | 72 | 11 | 6.7 | 5.4 | 10 | 66 | 185 |
| 5% | 99 | 140 | 253 | 243 | 130 | 52 | 7.9 | 2.6 | 2.7 | 5.1 | 11 | 61 |
| 50% | 15 | 29 | 55 | 79 | 48 | 14 | 3.2 | 1.1 | 1.2 | 1.9 | 3.7 | 7.1 |
| 95% | 2.7 | 5.5 | 14 | 17 | 14 | 7.2 | 1.7 | 0.7 | 0.6 | 1.1 | 2.1 | 2.3 |
| 100% (Min) | 2.3 | 3.5 | 4.9 | 6.2 | 10 | 5.5 | 1.4 | 0.2 | 0.1 | 0.3 | 1.5 | 1.3 |

**Source:** Data from Gage MLCO (OWRD #14083400) from 1999 – 2012, and synthesized flows from 1941 to 1998. Note that values above 10 cfs have been rounded to one significant digit.

#### 4.1.4.2. Flows in Ochoco Creek Downstream of Marks Creek

Table 4-2 provides flow data from the Reclamation Hydromet System, Gage ID "OCRO" (OWRD #14082550), which recorded flows in Ochoco Creek just downstream of Marks Creek from 1999 - 2012. The gauge location is shown on Figure 2-1. Additional data were synthesized from 1941 to 1998 based on monthly inflows to Prineville Reservoir.

**Table 4-2. Flow data in Ochoco Creek, downstream of Marks Creek.**

| Exceedence Level | Flow (cfs) by Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 0% (Max) | 186 | 328 | 485 | 468 | 261 | 123 | 29 | 9.5 | 7.7 | 14 | 93 | 262 |
| 5% | 143 | 198 | 359 | 344 | 194 | 73 | 12 | 4.1 | 3.8 | 7.3 | 15 | 86 |
| 50% | 20 | 41 | 85 | 112 | 61 | 19 | 4.3 | 1.4 | 1.6 | 2.6 | 5.1 | 9.4 |
| 95% | 4.1 | 7.8 | 17 | 25 | 19 | 10 | 1.4 | 0.5 | 0.3 | 0.4 | 2.2 | 3.1 |
| 100% (Min) | 3.3 | 5.4 | 4.4 | 8.8 | 14 | 3.1 | 0.2 | 0.0 | 0.1 | 0.3 | 0.5 | 1.2 |

**Source:** Data from Gage OCRO (OWRD #14082550) from 1999 – 2012, with synthesized flows from 1941 to 1998. Note that values above 10 cfs have been rounded to one significant digit.

#### 4.1.4.3. Inflows to Ochoco Reservoir

Table 4-3 provides an estimate of inflows to Ochoco Reservoir based on the synthesis of the two upstream gauges. As noted above, the reservoir is managed to fill during the wet, winter months between November through early March, so the inflows to the reservoir will not match the outflows of the regulated system, which are presented in the next section.

**Table 4-3. Estimated inflows to Ochoco Reservoir.**

| Exceedence Level | Flow (cfs) by Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 0% (Max) | 335 | 591 | 875 | 845 | 472 | 184 | 26 | 17 | 14 | 26 | 168 | 472 |
| 5% | 258 | 366 | 653 | 625 | 328 | 129 | 19 | 6.8 | 7.0 | 13 | 27 | 157 |
| 50% | 36 | 74 | 152 | 202 | 111 | 35 | 7.9 | 2.6 | 3.0 | 4.9 | 9.2 | 18 |
| 95% | 7.4 | 14 | 33 | 43 | 36 | 18 | 3.3 | 1.3 | 1.1 | 1.9 | 6.0 | 5.6 |
| 100% (Min) | 6.0 | 9.8 | 12 | 16 | 27 | 10 | 1.6 | 1.0 | 0.8 | 0.7 | 2.1 | 3.3 |

**Source:** Data developed by adding flow from Gages MLCO and OCRO (OWRD #14083400 and #14082550) from 1999 – 2012, with synthesized data from 1941 to 1998, and estimated additional flows to Ochoco Reservoir. Note that values above 10 cfs have been rounded to one significant digit.

#### 4.1.4.4. Flow releases from Ochoco Dam

A complete understanding of Ochoco Creek flows and operations is necessary to help analyze any type of fish ladder or fish trap entrance below the dam. Table 4-4 provides an overview of the typical flows released below Ochoco Dam, along with the reservoir capacity information. Additionally,

Table 4-5 provides a summary of actual average monthly flows released based on average daily values below Ochoco Dam derived from Reclamation's Hydromet data, with the inclusion of spill amounts derived from the Hydromet reservoir level data converted to spill based on the spillway rating curve.

**Table 4-4. Summary of Ochoco Dam and Reservoir operations.**

| Item | Comment |
|---|---|
| **Releases** | |
| Minimum Release | No formal minimum release has been established. Seepage from below the dam supplies about 2 cfs. OID attempts to provide a release to bring flows up to about 5 cfs. |
| 15-45 cfs | Typical irrigation flow in Ochoco Creek below the dam. |
| 60-120 cfs | Typical total release from the dam for irrigation; includes flows into canal and release to creek. |
| 415 cfs | Approximate maximum release through outlet works. |
| 750 cfs | Approximate channel capacity |
| 1,100 cfs | Maximum flood control target, with some areas of inundation. |
| Rate of change (maximum) | None. |
| **Reservoir Content** | |
| Minimum Pool | None. 810 acre-feet of dead pool exists when all irrigation water is used. |
| 5,266 acre-feet | Remaining pool at invert of outlet works. OID must install and operate pumps to access irrigation water below this point which has not yet occurred since outlet works were modified in 1995. |
| 14,750 acre-feet | Average end of October carryover storage. |
| 39,000 acre-feet | Total active capacity at full pool. |
| 44,266 acre-feet | Total available storage. This includes 39,000 acre-feet of active capacity and 5,266 acre-feet that can be pumped from the dead pool. Achieved about 50 percent of the years on average. |

**Source:** 2003 Reclamation Report

**Table 4-5. Flows in Ochoco Creek below the Ochoco Reservoir.**

| Exceedence Level | Flow (cfs) by Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 0% (Max) | 415 | 293 | 353 | 441 | 264 | 230 | 47 | 34 | 34 | 23 | 40 | 110 |
| 5% | 241 | 158 | 284 | 341 | 165 | 97 | 34 | 33 | 26 | 18 | 10 | 51 |
| 50% | 3.5 | 3.8 | 6.6 | 21 | 30 | 22 | 19 | 17 | 12 | 7.5 | 3.6 | 3.0 |
| 90% | 0.6 | 1.5 | 2.1 | 4.8 | 11 | 10 | 12 | 11 | 8.6 | 2.5 | 0.2 | 0.1 |
| 95% | 0.1 | 0.8 | 1.9 | 3.0 | 10 | 8.9 | 9.6 | 9.4 | 7.3 | 1.1 | 0.1 | 0.0 |
| 100% (Min) | 0.0 | 0.0 | 0.0 | 0.1 | 1.3 | 0.4 | 0.3 | 0.4 | 0.0 | 0.2 | 0.0 | 0.0 |

**Source:** Data developed by adding flow from Gage OCHO (OWRD #14085300) from 1984 – 2012, combined with calculated flow from Spillway Rating Curve. Note that values above 10 cfs have been rounded to one significant digit.

Typically, flows between 60 -120 cfs are released from the Outlet Works to meet the District's irrigation needs in Ochoco Canal. The flow is also managed to provide an informal minimum 5 cfs flow into the creek when flows allow, which is composed of about 2 cfs of seepage (at the fuller pool elevations) and 3 cfs from the Canal Spill. During the irrigation season, about 15 cfs are maintained in the creek directly below the Measurement Weir to meet creek conveyance needs for pumping downstream and an annual leased-water agreement with OWRD.

The three main operating seasons for the Ochoco Reservoir and flow characteristics are summarized below:

- Fall and Winter Operations (October/November to early March). The reservoir is refilled during the fall and winter, with no releases for irrigation. Releases are made during this time only to maintain river flows and to achieve or maintain reservoir space for winter/spring flood events. The average monthly 95 percent exceedence flows during this period range from 0 to about 2 cfs, and the 50 percent exceedence flows range from 3 to 7 cfs.
- Spring Operations (March to June). Reservoir releases for irrigation can begin as early as April, although natural flow (live flow) may be available to supplement irrigation demand until mid-summer. Because Ochoco Reservoir has flood control needs, releases are maintained to help control runoff, with releases dependent on forecast runoff volume and timing. The average monthly 95 percent exceedence flows during this period range from 2 to 10 cfs, and the 50 percent exceedence flows range from 7 to 30 cfs.
- Summer Operations (approximately June to October). Summer operations begin when live flow is insufficient to meet irrigation demand. Storage water is released from the reservoir as necessary to meet demands. The average monthly 95 percent exceedence flows during this period range from 7 to about 9 cfs, and the 50 percent exceedence flows range from 8 to 22 cfs.

The reservoir is managed to the extent possible to avoid spills. The ability to control spill is limited by the current 430-cfs Outlet Works capacity. It is anticipated that future modifications to the dam for safety improvements will increase the Outlet Works capacity back to its original 1,100-cfs flow (*channel capacity according to SOP*), which would provide better spill control and would reduce spill flows from the data provided herein. As a point of reference, excerpts from the dam's spillway rating curve are provided in Table 4-6 to assist with understanding potential spills that could occur during the fish migration season, and for consideration of extreme high flows for any fish passage facility durability and flood design elevations.

**Table 4-6. Excerpts from Ochoco Dam estimated spillway discharges table.**

| Reservoir Elevation (feet) | Depth of Flow over Crest (feet) | Spillway Discharge (cfs) | Notes |
|---|---|---|---|
| 3,130.7 | 0 | 0 | Lowest Spillway Crest Elevation |
| 3,130.8 | 0.1 | 23 | - |
| 3,130.9 | 0.2 | 54 | - |
| 3,131.0 | 0.3 | 92 | - |
| 3,131.1 | 0.4 | 133 | - |
| 3,131.2 | 0.5 | 180 | - |
| 3,131.7 | 1.0 | 556 | Typical managed spill level, 1' max over crest |
| 3,132.2 | 1.5 | 1,220 | - |
| 3,132.7 | 2.0 | 1,914 | Max Spill of Record |
| 3,134.3 | 3.6 | 5,227 | - |

**Source:** Reclamation (1988 memorandum)

### 4.1.5. Reservoir Operations and Pool Elevations

#### 4.1.5.1. Pool Elevations and Annual Fluctuation

This operational scenario and the resulting pool fluctuations are important to understand for the review of applicable fish passage facilities. Key elevations include:

- The normal full pool elevation is at the spillway crest, EL 3,130.7 feet, which provides a total storage capacity of 44,266 ac-ft. Typically, the reservoir is filled only 4 out of 10 years due to inflow limitations. The reservoir is managed to achieve the maximum storage available for irrigation water.
- The gravity intake invert, at EL 3,074.94 feet, is the minimum elevation water can be withdrawn without pumping to the intake.
- The top of the dead pool, which is the minimum pool elevation determined for dam safety requirements for the earthfilled dam, is EL 3,049.0 feet. No water can be withdrawn below this elevation. The OID typically operates to a minimum pool elevation of 3,050 feet.

Table 4-7 provides a summary of the pool elevations useful for the examination of fish passage facilities at the dam, and Figure 4-4 provides an overview of monthly reservoir elevations.

**Table 4-7. Reservoir pool annual average elevations.**

| Reference Elevation | Elevation (feet) |
|---|---|
| Top of Dead Pool | 3,049.0 |
| Minimum Elevation of Record | 3,049.7 |
| 95% Exceedence Elevation | 3,055.4 |
| 75% Exceedence Elevation | 3,094.2 |
| Mean Elevation of Record | 3,103.4 |
| 50% Exceedence Elevation | 3,107.8 |
| 25% Exceedence Elevation | 3,117.7 |
| 5% Exceedence Elevation | 3,129.2 |
| Spillway Crest Elevation | 3,130.7 |
| Maximum Elevation of Record | 3,132.7 |

**Source**: Based on average daily data from Reclamation Pacific Northwest Region Hydromet system Data; 1984 through 2012.

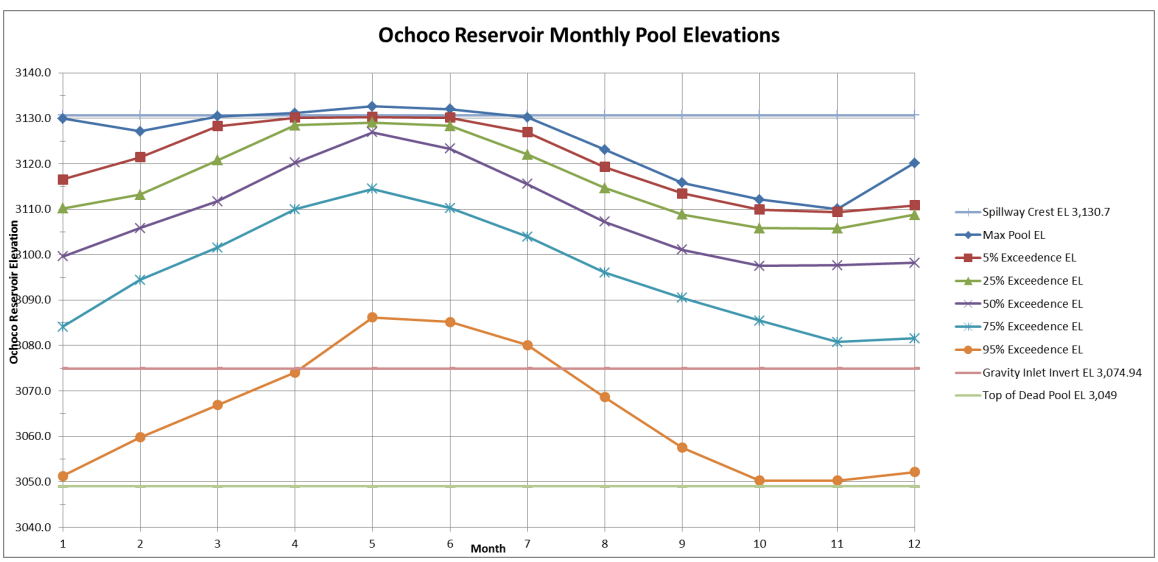


**Figure 4-4. Monthly Reservoir Elevations in Feet.**

**Source**: (based on average daily data from Reclamation Pacific Northwest Region Hydromet system Data, 1984 through 2012).

Typical fish passage design elevations range from the full pool elevation, to the 95 percent exceedence elevation during the period of fish passage. For this facility, the reservoir fluctuation that would need to be accommodated by fish passage facilities would be the difference between the crest elevation and the Dead Pool elevation, or 81.7 feet (3,130.7 – 3,049.0) as fish could be migrating any time during the year.

### 4.1.6. Fish Run Preliminary Estimates to Assess Passage Facilities

Assessing smolt production capacities in the upper Ochoco Creek watershed was beyond the scope of this document. Nevertheless, cursory daily peak run estimates were provided for the engineering assessment to assist with fish passage facility analysis and planning. Steelhead trout are anticipated to be more abundant than spring Chinook salmon in the Ochoco basin, and steelhead abundance and timing may be the driving factor for sizing and costing the passage facilities. Since there are no fish in the basin above Ochoco Dam at this time, the anticipated smolt production and adult returns for steelhead trout were based on surface areas of available habitats during dry and wet years as discussed in Section 3.1.2.1 *Upper Ochoco Creek Watershed Habitat Conditions-Quantity*, and a generic smolt production factor arbitrarily modified for less than optimal habitat conditions. The estimated peak numbers of smolts per day, and total numbers for the various downstream collection points anticipated for this analysis, are provided in Table 4-8. These numbers are approximate, but they are sufficient to assist with defining the potential needs for downstream smolt collection and passage facilities.

**Table 4-8. Estimated numbers of juvenile and adult fish to be used for sizing fish passage facilities (total numbers of fish).**

| Location | Dry Year | Wet Year | Peak Monthly | Peak Daily |
|---|---|---|---|---|
| Total Reservoir Collection | 37,100 | 67,500 | 33,750 | 1,125 |
| Mill Creek Trap | 14,400 | 27,000 | 13,500 | 450 |
| Ochoco Creek Trap | 22,700 | 40,500 | 20,250 | 675 |
| Total Adult Returns (Estimated from Smolt Production numbers above) | 1,360 | 1,500 | 480 | 15 |

## 4.2. Fish Passage Criteria and Laws

A detailed listing of fish passage criteria and guidelines is outside the scope of this document. However, relevant criteria will be noted during the description of alternatives based on R2's experience with the planning and design of similar facilities. The following two sections provide the relevant criteria references for future use.

### 4.2.1. Fish Passage Laws

Some of the specific criteria for fish passage facilities are provided in codified form in the Oregon State laws. Oregon laws regarding fish passage are found in:

- ORS 509.580 through 910, and in
- Oregon Administrative Rules, Oregon Department of Fish and Wildlife, Division 412 Fish Passage (OAR, 2006).

### 4.2.2. Fish Passage Criteria and Guidelines

Established criteria and guidelines also exist for the design of fish passage facilities. The OAR, Division 412 contains relevant State of Oregon criteria. Relevant Federal criteria and fish passage design guidelines are found at:

- Anadromous Salmonid Passage Facility Design document, by the National Marine Fisheries Service, Northwest Region (NMFS 2011).

Specific criteria relevant to this study include the following references to the NMFS (2011) criteria and guideline document:

- Truck and Hopper Holding Volume: 0.15 cu ft/lb of fish (Section 6.7.2.1).
- Holding Pond Volume: 0.25 cu ft/lb of fish, based on water temperature less than 50° F, and dissolved oxygen between 6 and 7 parts per million (Section 6.5.1.2).
- Flow for short term holding: 0.67 gpm per adult fish (Section 6.5.1.3). However, this criterion is based on Senn's Compendium (Senn 1984), which is a bit more specific relative to fish size. We will use 0.067 gpm/pound of fish, and assume a spring Chinook average weight is 20 lbs, for a total of 1.34 gpm/fish for planning.

Fish passage design is typically very site specific, and these criteria are intended to help owners and designers provide facilities that will function well and meet the project goals. There are typically some negotiations related to project specific details for fish passage facilities, to meet specific project needs.

### 4.2.3. Fish Passage Design Flows

Per NMFS criteria, typical fish passage design flows provide for fish passage system operation between the 95 percent and 5 percent exceedence flows (NMFS 2011). In regulated systems, these flows typically are selected as the low and high normal operating flows from the regulated system. Additionally, facilities are designed to avoid any significant flood damage from the design flood level (typically selected by the owner and the regulatory body, such as the 100-year flood).

Based on the flow data and the anticipated run timing reported above, the following fish passage design flows are identified to help address various fish passage options.

#### 4.2.3.1. Upstream Fish Passage Design Flows in Ochoco Creek

Upstream fish passage facility locations will be considered in this study for Ochoco Creek from immediately below Ochoco Dam to Pelton Dam on the Deschutes River. Based on the fish run timing data provided in Section 3.2.1, the likely peak upstream migration seasons will be in January through March, which corresponds with the fall and winter operating scenario, and again in June and July, which reflects the summer operating scenario. Relevant fish passage design flows for Ochoco Creek below Ochoco Dam are listed in Table 4-9 and Table 4-10. These flows reflect the 95 percent low flow and 5 percent high fish passage design flow for the two peak fish migration seasons described above.

**Table 4-9. Suggested fish passage design flows for upstream migrating fish below Ochoco Dam, for winter peak migration season (January – March).**

| Flow Case | Flow (cfs) | Notes |
|---|---|---|
| Low Fish Passage Design Flow | 2 | Proposed design value based on regulated system. |
| 95% Exceedence Flow during migration season | 0 to 2 | For reference only based on Table 4-5. |
| 5% Exceedence Flow during migration season | 158 to 283 | For reference only based on Table 4-5. |
| High Fish Passage Design Flow | 300 | Proposed design value based on regulated system. |
| Flood Protection Flow | 1,000 | Based on regulated system, and spill data in Table 4-5. This is intended to be a maximum flow level to represent an approximate 100-yr design flood. This number should be verified in the future. |

**Table 4-10. Suggested fish passage design flows for upstream migrating fish below Ochoco Dam, for summer peak migration season (June – July)**

| Flow Case | Flow (cfs) | Notes |
|---|---|---|
| Low Fish Passage Design Flow | 9 | Proposed design value based on regulated system. |
| 95% Exceedence Flow during migration season | 9 to 10 | For reference only based on Table 4-5. |
| 5% Exceedence Flow during migration season | 35 to 100 | For reference only based on Table 4-5. |
| High Fish Passage Design Flow | 100 | Proposed design value based on regulated system. |
| Flood Protection Flow | 1,000 | Based on regulated system, and spill data in Table 4-5. This is intended to be a conservative value and will need future confirmation. |

#### 4.2.3.2. Downstream Fish Passage Design Flows above Ochoco Reservoir

Downstream fish passage facility locations will be considered in this study for Ochoco Creek within the reservoir, immediately upstream of the reservoir, or within the arms of Ochoco Creek and Mill Creek prior to their confluence near the reservoir. Based on the fish run timing data provided in Section 3.2.2, the peak smolt outmigration would likely occur in April and May, with collection facilities operating from February through June of each season. This collection period corresponds with the winter and summer irrigation operating scenarios. Relevant fish passage design flows for Ochoco Creek above Ochoco Dam are listed in

Table 4-11 through Table 4-13. These reflect the 95 percent low flow and 5 percent high fish passage design flow for the peak fish migration seasons at each location. Note that flows for fry collection are not included in this range, as the fry season is likely October through December per Section 3.2.2.

**Table 4-11. Suggested fish passage design flows for downstream migrating fish within or immediately upstream of Ochoco Reservoir, for February through June overall migration season.**

| Flow Case | Flow (cfs) | Notes |
|---|---|---|
| Low Fish Passage Design Flow | 14 | Proposed design value based on flow data in Table 4-3. |
| 95% Exceedence Flow during migration season | 14 to 43 | For reference only based on Table 4-3. |
| 5% Exceedence Flow during migration season | 366 to 653 | For reference only based on Table 4-3. |
| High Fish Passage Design Flow | 650 | Proposed design value based on regulated system. Table 4-3. |
| Flood Protection Flow | 1,000 | Proposed design value based on flow data Table 4-3. Intended to be conservative, will require future confirmation. |

**Table 4-12. Suggested fish passage design flows for downstream migrating fish near the mouth of Mill Creek, for February through June overall migration season.**

| Flow Case | Flow (cfs) | Notes |
|---|---|---|
| Low Fish Passage Design Flow | 5 | Proposed design value based on flow data in Table 4-1. |
| 95% Exceedence Flow during migration season | 5 to 17 | For reference only based flow data in Table 4-1. |
| 5% Exceedence Flow during migration season | 52 to 253 | For reference only based flow data in Table 4-1. |
| High Fish Passage Design Flow | 250 | Proposed design value based on flow data in Table 4-1. |
| Flood Protection Flow | 500 | Based on flow data in Table 4-1. Intended to be conservative, will require future confirmation. |

**Table 4-13. Suggested fish passage design flows for downstream migrating fish near the mouth of Ochoco Creek downstream of Marks Creek, for February through June overall migration season.**

| Flow Case | Flow (cfs) | Notes |
|---|---|---|
| Low Fish Passage Design Flow | 8 | Proposed design value based on flow data in Table 4-2. |
| 95% Exceedence Flow during migration season | 8 to 25 | For reference only based flow data in Table 4-2. |
| 5% Exceedence Flow during migration season | 73 to 359 | For reference only based flow data in Table 4-2. |
| High Fish Passage Design Flow | 360 | Proposed design value based on flow data in Table 4-2. |
| Flood Protection Flow | 600 | Based on flow data in Table 4-2. Intended to be conservative, will require future confirmation. |

# 5.0 Fish Passage Options

This section provides summary of upstream and downstream fish passage options that meet the goal of providing fish access past the Ochoco Dam and reservoir system. The scope of this study is to identify a full suite of feasible engineering alternatives based on the system understanding and the Design Team's experience with similar fish passage facilities in the region, without doing a full feasibility level design development.

The alternatives are organized into first upstream, and then downstream alternatives, and the following information is provided for each passage alternative:

- A general description of the each fish passage alternative, with photographs of similar facilities where appropriate to help communication the alternative. The description includes its location, design constraints, any technical limitations, and operational information.
- A description of the biological issues associated with each alternative, such as potential benefits (rates of survival, relative contribution to recovery, etc.), and risks (mortality, inefficiencies of passage, etc.).
- An Opinion of Probable Construction Cost, which provides an estimate of capital costs to implement the alterative in 2012 dollars. R2 maintains a database of recent and historical fish passage facility costs, and the numbers provided represent an analysis and professional judgment for the total construction cost for these facilities including any need for modification to existing facilities. Additional costs would be required for planning, permitting, engineering, construction contract procurement, construction management services, and compliance monitoring. The resulting cost estimates are reasonable for planning and comparison of alternatives; however, they should not be used for program budgeting. The Engineering News Record (ENR) 20-City Construction Cost Index (CCI) for October, 2012 is 9,375.52. Adjustments to this cost can be made in the future by applying the ratio of the current ENR CCI to this number.
- An estimate of annual Operation and Maintenance (O&M) costs, including labor, electricity for pumping, hoists, fuel, etc.
    - Electricity costs are based on an electricity commercial cost of $0.085 per kWh.
    - Fuel costs are assumed at $4.00 per gallon.
    - Labor costs are assumed at $40/hour for a Full Time Equivalent (FTE) employee for passage operation, maintenance, etc.
- Water (how much needed to operate, and when).
- Implications to OID operations. Short term implications during construction of any of these facilities are not addressed.

A summary of this information is provided in Section 6 for ease of review and comparison of alternatives.

## 5.1. Options for Upstream Passage

This section is organized beginning with upstream fish passage alternatives at Ochoco Dam, and moving downstream for other opportunities to capture and haul fish to a release point above the dam. Alternatives are designated by UP #1, UP #2, etc. to differentiate the upstream passage alternatives from the downstream. The suite of alternatives considered for upstream passage includes:

- UP #1 – Volitional Passage at Ochoco Dam, Fish Ladder
- UP #2 – Trap-and-Haul at Ochoco Dam
- UP #3 – Trap-and-Haul from Ochoco Creek
- UP #4 – Trap-and-Haul from Lower Crooked River

- UP #5 – Trap-and-Haul from Pelton Round Butte Project
- UP #6 – Annual Outplanting of Hatchery Stock (No Upstream Passage)

### 5.1.1. UP #1 – Volitional Passage at Ochoco Dam, Fish Ladder

#### 5.1.1.1. Description and Technical Considerations

A fish ladder at Ochoco Dam would provide for volitional passage from Ochoco Creek to a release point in the reservoir near the dam, as shown with the schematic alignment in Photo 5-1. The ladder would need to move fish from approximately EL 3,025 feet near the downstream side of the dam to potentially the full pool EL 3,131 feet, for a total lift of approximately 106 feet. This is a feasible height for the target species, but would be considered a high-head ladder relative to similar facilities in the Pacific Northwest. Note that we did not request a specific tailwater rating curve for this location, and these elevations should be confirmed if this option is to be pursued further.

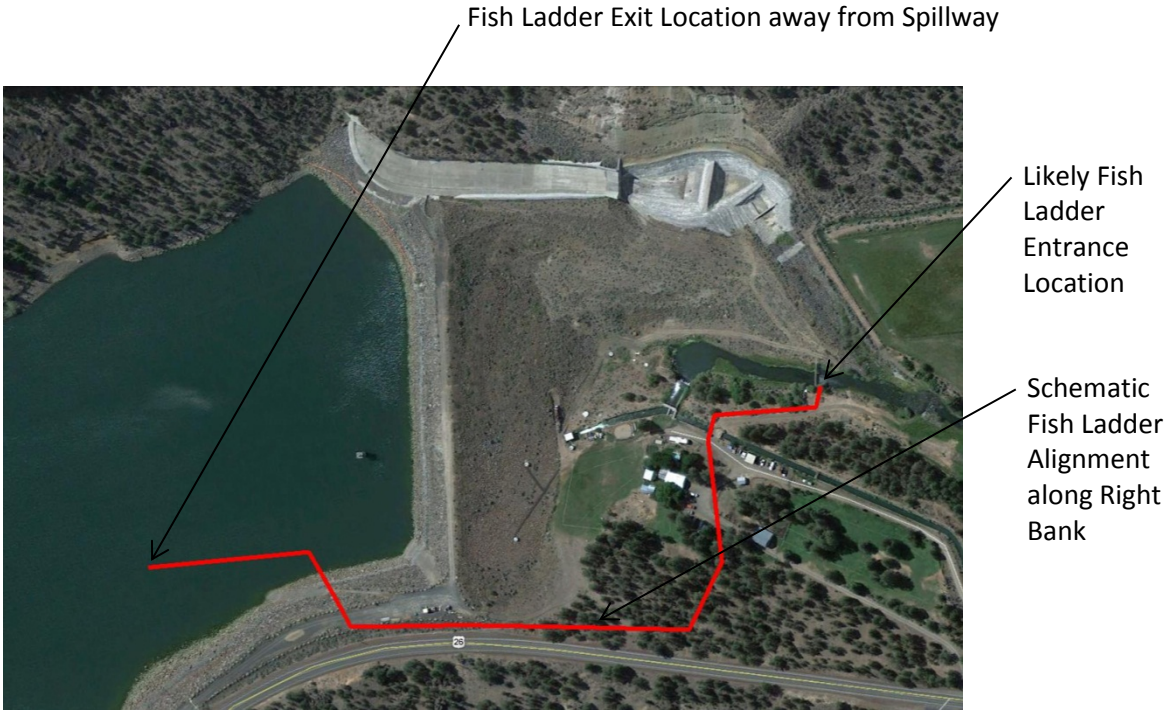


**Photo 5-1. Schematic fish ladder alignment at Ochoco Dam (route is approximate to illustrate concept only).**

A significant challenge for a ladder at Ochoco is the need to accommodate the large 81-foot reservoir fluctuation. This is an unusual situation for "conventional" fish ladders, which typically need to accommodate some pool level fluctuation, but 81 feet is an extreme case. As noted in Section 3.2.1, the peak migration seasons are expected in January through March for summer steelhead, and in June-July for spring Chinook, but fish could be migrating year round so the full fluctuation would likely need to be accommodated. Other facilities sometimes have an opportunity to design for more limited fluctuation associated with a specific run timing and

associated hydrologic parameters, so this assumption would need to be studied further. Additional information regarding this technical constraint is provided below in the "Fishway Exit" section.

A specific design of a potential fish ladder is beyond the scope of this document; however, the following features would be necessary for a fish ladder at Ochoco Dam.

### Fishway Entrance

A fishway entrance is typically the most important feature of a fish ladder. Key design issues with fishway entrance design include: entrance location, attraction flows, and entrance configuration. For Ochoco Dam, a reasonable entrance location would be directly below the Flow Measurement Weir, which could be modified to create a fish barrier that would help to guide fish into the entrance. The leakage and spill from the canal could also be utilized as attraction flow, which would complement the ladder entrance flow and could also be configured to replace the current gauge. This location would also be upstream of the spill return channel, which would help to protect the entrance site during spill events.

Attraction flow guidelines for facilities with mean annual stream flows less than 1,000 cfs suggest using all, or as much as possible of all the streamflow available for the fishway entrance (NMFS 2011). Additionally, NMFS guidelines recommend a minimum fishway entrance width of 4 feet, with an entrance depth of at least 6 feet, utilizing a submerged weir style entrance for these target species with a head drop over the submerged weir of 1.5 feet. This is a proven entrance configuration that would be applicable to this site. Based on the hydraulics of this entrance, an attraction flow required to meet the above entrance geometry would be about 130 cfs, which is higher than the system flows for a large part of the year. At this site, Table 4-9 indicates a low fish passage design flow of 2 cfs, and a high fish passage design flow of 300 cfs in the winter migration season, and Table 4-10 indicates a low fish passage design flow of 9 cfs, and a high fish passage design flow of 100 cfs in the summer migration season. A fishway entrance with an adjustable width weir could accommodate this flow range, and for this site we would recommend a maximum capacity of 130 cfs to meet the geometry requirements. An adjustable height weir could also help to reduce the minimum flow requirement to less than the 130 cfs, perhaps down to the likely minimum ladder flow of 20 cfs (see Fish Ladder section).

When normal spills range from 20 to the 130 cfs, or up to the Outlet Works existing capacity of 430 cfs or the anticipated future capacity of 1,100 cfs, an entrance configuration with a maximum capacity of 130 cfs would be reasonable, and would work well to attract fish at this confined location into the entrance when these higher flows occur. However, a significant ramification for a minimum attraction flow of 20 cfs would be the requirement for OID to provide this flow during times they would not normally release this much water, both for fish to enter and pass through the ladder, and to provide conveyance flow in the creek reach leading up to the ladder. This release would impact OID's ability to fill the reservoir, and could ultimately limit the availability of stored water to operate the fish ladder in subsequent seasons. For example, a constant release of 20 cfs year-round is about 14,500 acre-feet, which is about 1/3 of the total reservoir capacity. It may be possible to utilize a low-head pump-back system near the entrance to recycle some attraction flow water; however, a minimum ladder flow of 20 cfs would be required for this alternative.

### Ladder

A typical ladder style for this site and these target species would be a pool-and-weir with orifice ladder style, also called a "Half-Ice Harbor Ladder", similar to the new River Mill fish ladder completed on PGE's River Mill hydro project in 2006, with a total lift of 87 feet and a 1,000 foot length. The River Mill ladder has 1-foot drops at each weir, with an overflow/orifice arrangement requiring 20 cfs to operate. The ladder pool dimensions are 6 feet wide by 10 feet long and are 6 feet deep, and it is constructed of reinforced cast-in-place concrete. This results in a maximum slope of 10 percent when the ladder is ascending uniformly. Photo 5-2 and Photo 5-3 provide examples of the River Mill fish ladder, which is constructed into a rock abutment along that project's right bank below the powerhouse.

For Ochoco Dam, a decision would need to be made on overall ladder slope and pool heights, as some recent ladders are designed to accommodate resident species with a 0.75-foot step height, which typically results in smaller pool sizes and a maximum slope of about 8 percent. A 10 percent constant slope ladder similar to the River Mill site would result in a ladder length of at least 1,060 feet. Typically, ladders are longer than the minimum slope to accommodate the site constraints, so for planning the ladder would likely be in the range of 1,300 to 1,500 feet or longer to accommodate the site constraints.

**Photo 5-2. River Mill Dam and fish ladder.**

**Photo 5-3. Photo showing a side elevation of PGE's River Mill fish ladder. Note the flat slope at turning pools, and the fish return pipe to the tailrace.**

The schematic routing shown in Photo 5-1 shows a fish ladder connecting to an entrance pool near the Measurement Weir, and crossing the canal with a bridge section, then working along the right bank slope up into the reservoir. A ladder alignment would need to be engineered to accommodate any site needs, the necessary 10 percent or less ladder slope, utilities, and to safely penetrate the dam section. The routing shown in Photo 5-1 illustrates the concept for discussion. Dam safety is a concern at this site, and any alignment would need to be engineered to stay out of the impermeable section of the dam and coordinated with the Reclamation. It is feasible, but the potential for seepage through any earth-filled dam penetration is an issue that would require significant coordination and engineering. Given the history of slides and the geology of the dam area, additional geotechnical investigations would be recommended to provide a proper foundation for the ladder structure.

### Ladder Exit

There are two primary options to facilitate a fish ladder exit into the reservoir that could accommodate the 81 foot pool fluctuation.

The first approach would provide a ladder that ascends the entire hydraulic height of the dam, cuts through the dam or its abutment and releases fish at the full pool elevation. This ladder would be supplied with fully gravity flow water. As the reservoir falls, adjustable weirs could be provided with the ladder exit channel that follows the pool level down, and create an exit channel that would effectively track the falling water surface. The disadvantage to this approach is that an 81-foot deep ladder section with 81 adjustable weirs would be necessary to track this water surface, which is essentially not a feasible solution. A more realistic approach would be to provide multiple independent exit channels that could be constructed in a staggered layout along the right bank abutment slope. Each channel would be capable of accommodating a smaller water surface fluctuation range. For example five channels could each be constructed to accommodate about 15 feet of pool fluctuation. This would be a large

structure with multiple control gates, which is also essentially not feasible due to the size and cost of this approach.

A second and more cost-effective/feasible approach would be to construct a single ladder to the full pool height, which would operate by gravity at full pool, or at a designated elevation below full pool that would accommodate adjustable exit gates (assume about 15 feet for discussion). Once the pool dropped below the lowest gravity operation level, the exit would be perched above the pool level. In this situation, a pumped water supply from the reservoir could be provided to supply water to the highest ladder exit level. Fish would then ascend the full 106 feet of height, and then be released into the reservoir via a fish release pipe that functions as a slide. Because this approach could allow the ladder to fully ascend the hydraulic height necessary and stay out of the earth filled dam core, we will assume this approach for the analysis.

#### Water Supply

As noted above, the ladder could be supplied by gravity flow from the reservoir, until the pool dropped below the selected fixed exit elevation. To illustrate this point, we will assume an adjustable ladder exit elevation that would operate to EL 3,115.7 feet, which is 15 feet below full pool. As shown in Figure 4-4, this exit elevation would be able to function via gravity flow for about 4 months each year, about half the time based on the 50% exceedence flow. Therefore, on average pumped flow would be necessary for 10 out of every 12 months if the ladder operated for 12 months every year. Figure 4-4 also indicates that the approximate average pool elevation at the 50% exceedence flow during the months requiring pumping is about EL 3,100 feet. This would require pumping to lift an average height of about 31 feet for 10 months of the year. Additionally, the pumps would need to be designed to accommodate a vertical lift of 82 feet during lower water years when the pool would be operating at its lowest levels, which is a large range for efficient pumping.

Attraction flows could be solely from gravity flow originating from the Canal Spillway (when spilling), and could supplement fish ladder flows in the entrance pool. No cost of operations will be added for fish ladder attraction flow, based on the assumption that no additional attraction flow would be provided unless excess flows are spilling via the Canal Spillway.

### 5.1.1.2. Biological Considerations

The following biological pros and cons/risks were identified for the fish ladder alternative.

#### Pros

- Required ladder height is on the high side, but feasible for the target species. As an example, the new River Mill fish ladder on the Clackamas River near Estacada, Oregon has been very effective, and is 87 feet high.
- Fish ladders provide a true volitional passage system when operating, and fish can decide to enter/ascend the ladder, or can turn around at any stage if they have wandered into an area away from their natal spawning grounds. No human handling of fish is required for passage.
- A fish ladder at this site should provide for good survival from its likely entrance near the Outlet Works to the downstream end of the reservoir at the release

point, with little to no risk of fallback through the intake facility or spillway due to their configuration.

- A fish ladder alternative would provide for fish "self-sorting" in the tributaries upstream of the reservoir, as fish leaving the reservoir would be free to choose their final destination on their own volition.
- A fish ladder exit could be located well away from the spillway, to minimize any risk of fallback during spill.

**Cons/Risks**

- A ladder at this site would require more complexity than is usual. Multiple ladder outlets, and a pumped water supply and fish return slide would likely be needed to accommodate the 106-foot height and over 80-foot reservoir fluctuation. This is bordering on infeasible from a technical perspective.
- OID would need to provide at least 20 cfs to meet the fish ladder minimum operating flow. Much of this water may need pumping when the pool is at lower levels. This would amount to about 14,500 acre-feet per year assuming releasing 20 cfs year round (about 1/3 of the total reservoir capacity), or about 1,210 acre-feet per month when the ladder was running.
- The water temperature at the release point in the reservoir may be higher than a lower level pumped ladder supply flow that may be running a majority of the time. Fish exiting through a slide may have thermal delay or migration disruptions due to the potential difference in temperatures.
- Depending on temperature gradients and general fish behavior, there may be some minor delay for fish to migrate upstream through the 3.25-mile-long reservoir.
- Given the length and height of the ladder, there is some additional risk of migration delay.

#### 5.1.1.3. Opinion of Probable Construction Cost

A fish ladder alternative for Ochoco Dam would be similar in size and height to PGE's River Mill ladder completed in 2007, which is 87 feet high and approximately 1,000 feet long. That facility cost about $15 million, not including planning, permitting, engineering and administration. Given the different operating conditions, the need for an exit structure to accommodate a larger reservoir fluctuation, dam safety concerns, the alignment and foundation concerns, we estimate a similar ladder at Ochoco Dam would cost from $20 to $35 million.

#### 5.1.1.4. Opinion of Probable Annual O&M Costs

Annual costs were estimated as shown in Table 5-1. Note that the value of water necessary to operate the ladder has not been estimated.

**Table 5-1. Summary of annual operations & maintenance costs for UP #1 – Fish Ladder.**

| Item | Notes | Annual Cost |
|---|---|---|
| Power - Pumped fish ladder flow | Assume 20 cfs, 10 months/year, average 30 feet head. Assume all attraction flow is via gravity utilizing available spill amounts. | $44,000 |
| Power – Site lighting, security, instrumentation | Estimate | $10,000 |
| Labor – General operations | Assume ½ FTE / year for general inspection, daily observations, maintenance, etc. | $40,000 |
| Maintenance – Annual | Assume at 0.5% of total capital cost for planning. This is reasonable for a large structure with a 50-year design life, for concrete inspections/repair, etc. | $150,000 |
| Total Annual O&M Cost | | $244,000 |

**Note**: Does not include the value of water necessary to utilize for the ladder, which would impact the ability to fill the reservoir during dry years.

#### 5.1.1.5. Implications to OID operations

Notable implications to OID operations include:

- This alternative would require the release of up to 20 cfs from Ochoco Reservoir on a continuous basis outside the irrigation season for fish passage. OID is currently not authorized to release water from the reservoir for other than irrigation or flood control. Unless this restriction is removed, this alternative is not feasible.
- From an operational standpoint, the need to provide ladder flow when flows are typically not released would reduce the ability for OID to fill Ochoco Reservoir and meet its irrigation needs.
- As far as daily impacts to OID operations, the fish ladder would need daily inspection, monitoring, and general maintenance. Fish ladders are generally simple to operate, but maintenance would be needed on the adjustable gates, structure, etc. Additionally, daily inspections would be necessary to remove any trash that accumulates at the ladder exit (where flow enters) and within the pools, etc., confirm that pumps are operating correctly, and maintain general site security.

### 5.1.2. UP #2 – Trap and Haul at Ochoco Dam

#### 5.1.2.1. Description and Technical Considerations

A Trap-and-Haul facility at Ochoco Dam would provide for collection of fish from Ochoco Creek near the dam, and provisions to load fish into fish trucks for transport upstream. A schematic overview of a Trap-and-Haul facility location is shown in Photo 5-4. Fish could be collected near the dam, at the same entrance location as Alt UP #1, with a re-designed measurement weir / fish collection pool. After loading into fish trucks, the fish would be transported upstream of the dam, to a release point near the dam, or upstream of the reservoir. Major components of a trap-and-haul facility are described below.

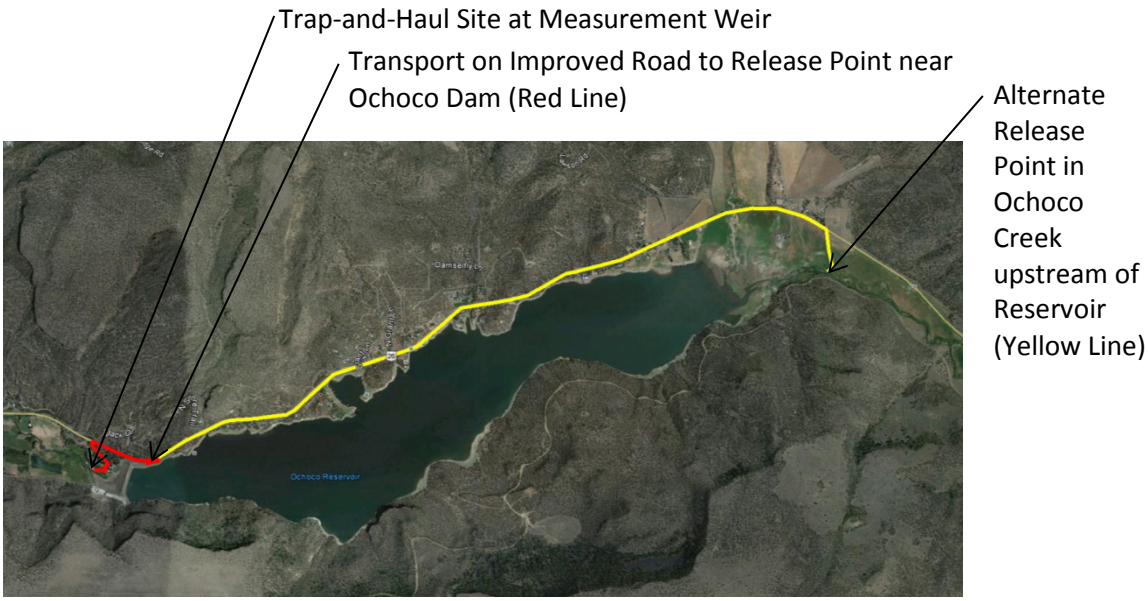


**Photo 5-4. Schematic Trap-and-Haul at Ochoco Dam, Overview.**

### Fishway Entrance / Collection Pool

A trap-and-haul facility would contain a fishway entrance, leading to a collection pool and holding facility. For the Ochoco site, the fishway entrance location, configuration, and attraction flows could be very similar to that described for the Alt UP #1 – the fish ladder. There is ample space available, and road access to the site. The water supply issue would also be similar to that described for Alt UP #1, with all of the typical lower Canal Spill Flows entering the fishway entrance.

### Fish Holding / Truck Loading Facility

After fish entered the fishway entrance noted above, they would negotiate a small ladder and enter a collection/holding area that would contain fish between truck transport cycles. The size and flow requirements for a holding facility are typically designed to accommodate the daily peak runs of fish expected to enter the facility. For this site, the data provided in Table 4-8 indicate a peak estimate of 15 adult fish per day. Because the peak runs for both spring Chinook and summer steelhead do not overlap (see Table 3-4), the 15 fish per day is a reasonable value for this stage of planning. It is also relevant to note that this is a relatively small number of fish, as compared to the sophisticated trap-and-haul facilities located on larger rivers. This observation would lead the design for this to be a relatively simple facility intended for manual operation rather than a fully automated facility.

The size of holding pond necessary is a function of the number of fish to be held at one time, the desired maximum fish holding time, the fish truck size, and the frequency of fish transport. To avoid any delay in natural migrations, recent trap-and-haul facility designs in the region plan for a maximum 24-hour holding in the trap facilities, and this is a requirement per the latest NMFS criteria (NMFS 2011, Section 6.3.1.4). This means that all fish collected in 1 day must be transported upstream within 24 hours.

The following preliminary calculations will help to size this facility:

- Maximum weight of fish: Assume 20 spring Chinook at 20 lb/fish = 400 lbs of fish/day
- Fish Truck Volume Needed: Assume maximum transport of 20 fish/day, in a single truck load. Volume required is calculated as 0.15 cu ft/lb X 400 lb = 60 cu ft, or about 450 gal. A typical fish truck is about 1,000 to 2,000 gallons, so a single trip per day is a reasonable assumption for truck transport.
- Fish Holding Capacity: Assume all fish will be transported once per day based on the truck sizing above. Therefore, a holding capacity of 0.25 cu ft/lb x 400 lb = 100 cu ft of holding volume would be required to accommodate a peak day. A holding pool sized at 5 feet square by 4 feet deep would be adequate for these needs, which is relatively small compared to other facilities. We would likely recommend upsizing this to a 10 foot by 5 foot pool and accommodate a hopper loading crowder type system to the holding pond.

Other considerations for designing fish holding facilities are the need or desire to sort fish. For example, in some restoration programs, various species are transported to different basins or facilities. Because the habitat upstream of Ochoco Dam is relatively limited, we will assume that all fish collected at an adult trap could be held, transported, and released at the same location, and no sorting facilities would be needed.

In addition to the holding facilities, at truck loading facility would be necessary to lift fish from the holding pond, and load them into a fish transport truck. There are several levels of complexity available for fish truck loading, but for a project of this scale a fish hopper that rests in the holding pool, and then lifts fish into the truck would be appropriate. A water-to-water fish transfer protocol is recommended to minimize fish handling and stress. Photo 5-5 provides an overview of a similar small scale trap-and-haul facility with the above features, and Photo 5-6 provides a more modern fish truck facility with a hopper style loading facility that would be appropriate for Ochoco Dam with a fish truck in the loading position.

General site improvements, road grading and surfacing, a small staff building with office space and restroom facilities, security fencing, lighting, and intrusion alarms are typical improvements provided for trap-and-haul facilities. The existing bridge over the canal would need to be checked for its capacity and long-term durability to accommodate full fish truck loads.

### Water Supply

Three water sources would be required for the trap-and-haul facility.

1) Attraction Flow: Water needed for the fish trap entrance attraction flows could be solely from gravity flow originating from the Canal Spillway, and could supplement fish trap entrance flows in the trap entrance pool. No cost of operations will be added for fish trap attraction flow, based on the assumption that no additional flow would be provided at the trap entrance unless the project was spilling.
2) Fish Trap Flow: The fish trap would utilize a short fish ladder to bring fish from the creek level up to a holding pond, protected from the flood levels. Flow for this ladder would be the same as Alt UP #1, at about 20 cfs. This flow would be required any time the trapping facility is operating, and for equal comparison to the ladder it is assumed to occur all year. It would likely be feasible to utilize some pump-back flow from below the entrance to supply some of this water.

3) Circulation water would be needed in the holding pool, with flow sized to meet the maximum daily holding capacity. Using the 1.34 gpm per fish, a 20 fish per day peak run would require about 27 gpm for the holding pool. We will assume 30 gpm supply required for the fish holding period on a daily basis. This should be good quality first-pass water, to maintain fish health in the holding pool.

### Fish Release Site

A trap-and-haul program has the advantage that fish can be released upstream of the dam at any location. Four basic sites are applicable to the Ochoco facility:

- Immediately upstream of the dam, along the right bank near the existing parking area.
- At any location within the reservoir.
- Near the upstream end of the reservoir.
- Upstream in either Ochoco Creek, Mill Creek, or within any of their tributaries.

The actual release facilities required are basically a boat launch ramp that can accommodate a fish truck. The fish truck can back down the ramp, and release fish through an exit gate that can also be supplemented with an extendable chute to assure fish are released at a deeper pool in the receiving water. At lower pool elevations, the ramp would need to be accessible for vehicles, and sometimes a winch anchor point is provided to allow use at extreme low pools with a winch provided on the front of the truck. A fixed open channel release chute along the launch ramp can also be used to limit the truck access to only the higher pools.

**Photo 5-5. Sample trap-and-haul facility (Kalama Fish Hatchery, Washington).**

**Photo 5-6. Truck loading facility with hopper (Landsburg Facility, Washington).**

Each of the above locations has its own advantages and disadvantages, which basically relate to the overall program. For example, fish released near the dam would need to negotiate the entire reservoir that could have warm temperatures, predators, may cause migration delay, etc. Fish released at the head of the reservoir or in the creeks upstream may find cooler water and better access to habitat. A thorough discussion of these variables can be developed outside of this study; however, an advantage of the trap-and-haul over the ladder is the flexibility of the desired release point.

#### 5.1.2.2. Biological Considerations

The following biological pros and cons/risks were identified for this alternative.

**Pros**

- A trap-and-haul would be technically feasible at this site for the target species, and would be more cost effective than a ladder.
- Modern fish handling protocols and facilities result in a 99 percent or better fish survival after collection and hauling, which should be about equal in performance to a properly-designed fish ladder.
- Because fish could be released upstream of Ochoco Reservoir, a trap-and-haul would have less potential than a fish ladder for migration delay, except for the time between transport cycles that are a function of the operational protocol.
- Trap-and-haul would provide flexibility to release fish upstream of the dam at any desired location.

- Releasing the fish near the upstream end of the reservoir would provide a riverine environment for ease of access that is not affected by the fluctuating reservoir elevation.

**Cons/Risks**

- Fish would not be able to turn around of their own volition once they entered the trap.
- Human handling of fish is required for passage.
- There is the potential for accidents during handling and transport. For example, a traffic accident or truck breakdown could result in the loss of one load of fish.
- OID would need to provide at least 10 to 20 cfs year-round to meet the fish ladder minimum operating flow. Much of this water may need pumping when the pool is at lower levels.
- The water temperature at the potential release points in the reservoir may be higher than a lower level pumped trap supply flow that may be running a majority of the time. Fish exiting through a fish truck slide may have thermal delay or migration disruptions due to the potential difference in temperatures, although the number of release points may be able to mitigate this concern.

#### 5.1.2.3. Opinion of Probable Construction Cost

A trap-and-haul facility for this site would likely cost between $750,000 and $3 million. Much of the costs will depend on how automated the facility would be. A dedicated fish truck would likely cost between $130,000 and $300,000, depending on the size and complexity of features. This cost could be reduced, however, by sharing a truck with other fish-handling operations in the basin.

The facilities could be all provided during an initial construction, or a phased approach could be utilized that could begin with more modest facilities requiring manual fish handling, and more permanent and automated facilities added in the future depending on the program success.

#### 5.1.2.4. Opinion of Probable Annual O&M Costs

Annual costs were estimated as shown in Table 5-2. Note that the value of water necessary to operate the ladder has not been estimated.

**Table 5-2. Summary of annual operations & maintenance costs for UP #2 – Trap-and-Haul from Ochoco Dam.**

| Item | Notes | Annual Cost |
|---|---|---|
| Power - Pumped fish ladder flow | Assume 20 cfs, 10 months/year, average 30 feet head. Assume all attraction flow is via gravity utilizing available spill amounts. This flow would be required to pass through the Outlet Works. | $44,000 |
| Power – Site lighting, security, instrumentation, hopper loading. | Estimate, includes hopper costs | $30,000 |
| Labor – General operations | Assume 1½ FTE / year for general inspection, daily observations, maintenance, etc. | $120,000 |
| Trucking | Once per day round trip, approximately 10 miles total x 365 days = 3,650 miles/yr. Assuming 10 mpg for the fish truck = 365 gal X $4.00/gal = $1,460/year fuel. Say $10,000/year including maintenance, other travel associated with project, etc. | $10,000 |
| Maintenance – Annual | Assumed cost | $40,000 |
| Total Annual O&M Cost | | $244,000 |

**Note**: Does not include the value of water necessary to utilize for the ladder, which would impact the ability to fill the reservoir during dry years.

#### 5.1.2.5. Implications to OID operations

Notable implications to OID operations include:

- From an operational standpoint, the need to provide entrance ladder flow when flows are typically not released from reservoir would reduce the ability for OID to fill Ochoco Reservoir and meet its irrigation needs.
- As far as daily impacts to OID operations, a trap-and-haul would require daily operation and trucking, plus daily inspection, monitoring, and general maintenance. The trap-and-haul facility would take substantially more effort than a fish ladder.

### 5.1.3. UP #3 – Trap-and-Haul from Ochoco Creek Upstream of Crooked River (at Red Granary Diversion)

#### 5.1.3.1. Description and Technical Considerations

A Trap-and-Haul facility within Ochoco Creek, between Ochoco Dam and the confluence with the Crooked River would be feasible, and would provide an opportunity to capture adult fish in the creek at lower flows compare to sites located downstream in the Crooked River. One site examined for this location is the Red Granary diversion at River Mile 10.4. This facility was completed in 2002 by OID and ODFW and has a criteria flat plate fish screens designed to divert 30 cfs, and a 4-foot high inflatable Obermeyer Weir. A pool-and-weir (possibly with orifice) style fish ladder is constructed at the facility to accommodate upstream fish passage, which

terminates at the downstream end of the juvenile screens. Photo 5-7 and provides a view of the diversion weir and the entrance to the fish ladder, and Photo 5-8 provides a view showing the downstream end of the fish screens. Photo 5-9 shows an aerial view of the facility.

**Photo 5-7. Red Granary Diversion at RM 10.4 on the Ochoco Creek, view looking upstream at the weir and ladder entrance.**

This site provides an opportunity to collect adult fish at the existing diversion, which would function as an upstream migration barrier and diversion to the fish ladder during the normal lower flows in the creek. Other sites could be examined in this creek reach, but would now have any obvious advantage over the Red Granary site, and would require land acquisition, construction of more facilities, and are not believe to have any clear advantages over the Red Granary site or Alt UP #2.

**Photo 5-8. Red Granary Diversion, view looking downstream at the screen bypass.**

**Photo 5-9. Red Granary Diversion, aerial view.**

A collection / holding pool could be excavated in the area between the equipment shed and the downstream end of the fish screen, and a bar rack diverter added to route upstream migrating fish into the pool that would still allow outmigrants to exit the screen system. There is sufficient space, power, and property available at this site, and this location would require less construction than the Ochoco Dam site. A similar truck loading facility to that described for Alt UP #2 would be necessary, and fish release sites opportunities are the same as Alt UP #2.

However, one disadvantage to this site would be its inability to operate properly at higher flows (from 430 to 1,100 cfs in the creek), as at these flows the Obermeyer Weirs is typically deflated to allow the higher flows to pass without flooding the surrounding areas and facilities. It is unlikely that this site would function well to divert adult fish at the higher flows, and those fish would likely continue to migrate the approximately 0.9 mile upstream to the Alt UP #1 and #2 entrance location at the Flow Measurement Weir.

Features of this alternative include the following:

#### Fishway Entrance / Collection Pool

This alternative would utilize the existing fish ladder entrance, without any changes for the entrance. This would operate well for Ochoco Creek flows ranging from the minimum to about 20 cfs past the ladder. At higher flows, with the existing configuration the Obermeyer Weir could be modified to allow the panel near the ladder to deflate first; however, as flow increased beyond the ladder capacity it is likely that fish would bypass the facility and continue on upstream without a major redesign and construction of a larger barrier weir. It is assumed for this analysis that a larger weir would not be desirable as part of this alternative.

Alternately, a larger collection pool at the ladder could be constructed, with an Auxiliary Water Supply to divert some flows from the creek and route them into flow diffusers in an enlarged fish ladder entrance. This flow would need to be screened, so for this analysis will not be considered further.

#### Fish Holding / Truck Loading Facility

As noted above, a collection pool could be constructed between the storage shed and the downstream end of the ladder. This facility would be identical in principal to the holding pool and truck loading facility described in Alt UP #2.

#### Water Supply

Two water sources would be required for this trap-and-haul facility.

1) Attraction Flow: Water needed for the trap fishway entrance attraction flows could be solely from gravity flow originating from the creek, up to the maximum 30 cfs screen diversion and the ladder capacity of about 20 cfs. All attraction flow would be delivered through the existing fish ladder. When the diverted flow is not needed, the 30 cfs from the existing screens could be routed into the fish ladder entrance pool.
2) Circulation water would be needed in the holding pool, with flow sized to meet the maximum daily holding capacity. Using the same criteria as Alt UP #2, a 30-gpm supply could be diverted from the screened water to reliably supply the holding pool.
3) Releases from Ochoco Reservoir may be necessary outside of the irrigation season to provide flows to operate the trap at Red Granary.

### 5.1.3.2. Biological Considerations

The pros and cons/risks for this alternative are the same as Alt UP #2, with the following exceptions.

**Pros**

- The existing diversion could be retrofit to accommodate a fish trap and holding/transport facilities.

**Cons/Risks**

- This facility would not be able to reliably function as a migration barrier at creek flows downstream of the existing diversion weir greater than the ladder capacity of about 20 cfs, or an increased entrance pool ladder capacity of about 50 cfs.

#### 5.1.3.3. Opinion of Probable Construction Cost

A trap-and-haul facility for this site would likely cost between $400,000 and $1.5 million. Much of the costs will depend on how automated the facility would be. A single fish truck would likely cost between $130,000 to $300,000, depending on the size and complexity of features.

#### 5.1.3.4. Opinion of Probable Annual O&M Costs

Annual costs for this alternative would be roughly the same as Alt UP #2 at $244,000. Water would still need to be provided in the creek, and maintenance costs for trucking would be similar. The mileage costs for trucking would be slightly higher due to the increased travel distance. Note that the value of water necessary to operate the ladder has not been estimated.

#### 5.1.3.5. Implications to OID operations

Notable implications to OID operations are the same as Alt UP #2, except this facility is located about 1 mile downstream of the Ochoco Dam facilities, so some travel time would need to be included from normal maintenance activities.

### 5.1.4. UP #4 – Trap-and-Haul from Lower Crooked River (at Crooked River Central Diversion)

#### 5.1.4.1. Description and Technical Considerations

A Trap-and-Haul facility in the Crooked River (downstream of the confluence with Ochoco Creek) is another option to be considered. One of the most upstream sites available in this reach is located just downstream of McKay Creek at the Crooked River Central Diversion. This facility was completed in 2010 and has criteria rotating-drum screens on the canal diversion, and a 4-foot high inflatable Obermeyer Weir that is similar to the Red Granary site, but longer to accommodate the higher river flows. A vertical slot style fish ladder is constructed at the facility to accommodate upstream fish passage, which terminates before the canal diversion. Photo 5-10 provides a view of the diversion weir and a view of the fish ladder, and Photo 5-11 provides a view looking downstream toward the diversion showing the fish ladder exit. Photo 5-12 shows an aerial view of the facility to help understand the overall configuration.

This site provides an opportunity to collect adult fish at the existing diversion, which would function as an upstream migration barrier and diversion to the fish ladder during the normal lower flows in the creek. While other sites could be examined downstream of this location, they

would require completely new facilities and would result in less usable river habitat between the trap and the release site upstream of the dam, therefore we will only consider this site.

This study does not report on the actual flows available at the site; however, it is generally understood that there is more water typically available in the river due to the Crooked River flows, so fish would have more reliable flows to reach the trap site. This same advantage is also a disadvantage, as the higher flows would likely eliminate the fish barrier function when they reached a level that the weirs would need to be lowered to prevent flooding of the facilities and surrounding area. This situation could be resolved to some level with construction of an auxiliary water intake for the fish ladder entrance pool; however, at some level during higher flows fish would likely be able to migrate past the entrance.

An additional complication is the likely need to sort fish to help determine whether upmigrating fish captured at this site are targeting spawning in McKay Creek, the Crooked River, or Ochoco Creek. This is a significant issue, and any sorting program such as this would require capture and marking of outmigrating juveniles so they could be identified at the various facilities when they return as adults.

**Photo 5-10. Crooked River Central Diversion (Below McKay Creek), view looking upstream at the diversion weir.**

**Photo 5-11. Crooked River Central Diversion, view looking downstream at fish ladder.**

**Photo 5-12. Crooked River Central Diversion, aerial view.**

Similar to the trap-and-haul facility described for Alt UP #3, a collection / holding pool could be excavated in the area adjacent to the most upstream pool of the fish ladder. In this case, due to the sorting needs notes above, multiple holding pools may be necessary. There is ample space available in this location for a fish sorting facility, holding ponds, truck loading truck turn-around areas, and for the associated site improvements and personnel provisions.

Features of this alternative would all be the same as Alt UP #3, with more flow available at this location because due to flows from the Prineville Reservoir.

#### 5.1.4.2. Biological Considerations

The pros and cons/risks for this alternative are the same as Alt UP #3, with the following exceptions.

**Pros**

- The existing diversion could be retrofit to accommodate a fish trap and holding/transport facilities.
- Due to minimum flows available from the Crooked River, there would typically be more flow in the primary river reach so fish could access the site without providing any additional flows from Ochoco Dam.

**Cons/Risks**

- This facility would not be able to reliably function as a migration barrier at creek flows downstream of the existing diversion weir greater than the ladder capacity or an increased entrance pool capacity.
- A fish sorter would likely be necessary to help determine whether upmigrating fish are heading to McKay Creek, the Crooked River, or Ochoco Creek. This is significant, and any sorting program such as this would require capture and marking of outmigrating juveniles so they could be identified when they return as adults.

#### 5.1.4.3. Opinion of Probable Construction Cost

A trap-and-haul facility for this site would likely cost between $700,000 and $4 million, including upstream sorting and holding facilities.

#### 5.1.4.4. Opinion of Probable Annual O&M Costs

Annual costs for this alternative would be the similar to Alt UP #2 and #3, with additional staff required to operate the sorting facilities and additional power and flow associated with the sorting and holding facilities as shown in Table 5-3. Note that no estimate has been included in this table for the design and implementation of a fish marking program, assuming some level of sorting is needed.

**Table 5-3. Summary of annual operations & maintenance costs for UP #4 – Trap-and-Haul from Lower Crooked River.**

| Item | Notes | Annual Cost |
|---|---|---|
| Power - Pumped fish ladder flow | Assume no extra flow from Ochoco is necessary due to minimum flows from the Crooked River. | $0 |
| Power – Site lighting, security, instrumentation, hopper loading. | Estimate, includes fish sorters, pumped supply for holding ponds, and hopper costs. | $50,000 |
| Labor – General operations | Assume 2 FTE / year for general inspection, daily observations, maintenance, etc. | $160,000 |
| Trucking | Once per day round trip, approximately 40 miles total x 365 days = 14,600 miles/yr. Assuming 10 mpg for the fish truck = 1,460 gal X $4.00/gal = $5,840/year for fuel. Say $15,000/year including maintenance. | $15,000 |
| Maintenance – Annual | Assumed cost | $60,000 |
| Total Annual O&M Cost | | $285,000 |

**Note**: Does not include an estimate for the design and implementation of a fish marking program on juveniles.

#### 5.1.4.5. Implications to OID operations

Notable implications to OID operations are the same as Alt UP #2 and UP #3, except this facility is located several miles downstream of Ochoco Dam, so some travel time would need to be included from normal maintenance activities. This would also require coordination and likely joint funding, access easements, etc. to allow access to the Crooked River Central Diversion facility. Operational impacts of a downstream fish marking program would need further definition, and would need to be accounted for either in the upstream or downstream program operations and costs.

### 5.1.5. UP #5 – Trap-and-Haul from Pelton Round Butte Project

#### 5.1.5.1. Description and Technical Considerations

A Trap-and-Haul facility at the Pelton Round Butte Project represents another opportunity to collect fish and pass them via fish trucks to the upper basin above Ochoco Dam. There are existing facilities at PGE's Pelton Round Butte project to collect adult fish as they ascend the Deschutes River downstream of the Crooked River and Ochoco Creek, which have recently been put back in service following that project's relicensing and the addition of downstream fish passage facilities. The addition of an Ochoco Creek fish trap-and-haul program would require coordination with PGE's existing operations and possibly their facilities to add additional sorting capabilities at their facility to separate Ochoco Creek fish from fish migrating to other drainages within the basin. Further research would need to be conducted with PGE to clarify exact facility and staffing needs; however, we anticipate new facilities at the Pelton Round Butte project would be minimal in comparison to constructing new facilities at the other sites noted above. If space is available to accommodate new facilities, they would likely include additional sorting flumes and holding ponds for the Ochoco Creek fish.

A more significant facility and operational need associated with this alternative is the same as described with Alt UP #4 with the need for a juvenile marking program on the outmigrants so fish targeting the Ochoco Creek system could be identified and separated from others.

#### 5.1.5.2. Biological Considerations

The pros and cons/risks for this alternative are the same as Alt UP #4, with the following exceptions.

**Pros**

- The addition of one more sorting requirement at the Round Butte Project is feasible, and would require minimal capital facilities to implement.
- Minimum flow concerns at the Ochoco Creek adult collection alternatives would be avoided by collecting the fish further downstream where more regulated flow is available all year.
- A reliable fish barrier exists that would accommodate collection at the Round Butte Facility without risk of fish passing the system.

**Cons/Risks**

- Fish sorting would be necessary at the Pelton Round Butte Project to determine whether upmigrating fish are heading to Ochoco Creek. This is significant, and any sorting program such as this would require capture and marking of outmigrating juveniles so they could be identified when they return as adults.
- Depending on the effectiveness of the marking program, fish intending to spawn between the Round Butte Project and Ochoco Dam may not have access to that reach of river, so this could represent a loss of habitat and natural migration into to desired river reaches.

#### 5.1.5.3. Opinion of Probable Construction Cost

A trap-and-haul facility for this site would likely cost less than Alt UP #4, as fewer facilities would be required. The unknown at this point in time is how extensive the outmigrant marking program would need to be. An estimate of between $400,000 and $2 million is reasonable, assuming the addition of upstream sorting and holding facilities would be needed, and a fish transport truck (unless the truck is provided for downstream alternatives, where costs could be shared).

#### 5.1.5.4. Opinion of Probable Annual O&M Costs

Annual costs for this alternative would be the similar to Alt UP #4; however, we assume that there would be some efficiencies with staff with the existing facility, so only 1 FTE would be required to support the trucking each day. Additional costs as shown in Table 5-4 include more fuel and truck maintenance due to the approximate 100 mile round trip. Note that no estimate has been included in this table for the design and implementation of a fish marking program assuming some level of sorting is needed.

**Table 5-4. Summary of annual operations & maintenance costs for UP #5 – Trap-and-Haul at Round Butte Dam.**

| Item | Notes | Annual Cost |
|---|---|---|
| Power - Pumped fish ladder flow | Assume now extra flow from Ochoco is necessary due to minimum flows from the Crooked River. | $0 |
| Power – Site lighting, security, instrumentation, hopper loading. | Estimate, includes fish sorters, pumped supply for holding ponds, and hopper costs. | $50,000 |
| Labor – General operations | Assume 1 FTE / year for general inspection, daily observations, maintenance, etc. | $80,000 |
| Trucking | Once per day round trip, approximately 100 miles total x 365 days = 36,500 miles/yr. Assuming 10 mpg for the fish truck = 3,650 gal X $4.00/gal = $14,600/year fuel. Say $25,000/year including maintenance, etc. | $25,000 |
| Maintenance – Annual | Assumed cost | $60,000 |
| Total Annual O&M Cost | | $215,000 |

**Note**: Does not include an estimate for the design and implementation of a fish marking program on juveniles.

#### 5.1.5.5. Implications to OID operations

Notable implications to OID operations are the same as Alt UP #4, with additional travel costs necessary for the 100-mile round trip fish trucking. This alternative would also require coordination and likely joint funding, operational protocols, access easements, etc. to allow access and use of PGE's Pelton Round Butte facility. Operational impacts of a downstream fish marking program would need further definition, and would need to be accounted for either in the upstream or downstream program operations and costs.

### 5.1.6. UP #6 – Annual Outplanting of Hatchery Stock (No Upstream Passage)

#### 5.1.6.1. Description and Technical Considerations

This alternative provides an alternate approach to providing upstream fish passage at Ochoco Dam to complete the suite of alternatives for this study. Rather than collecting adults for passage, additional fish for outplanting could be contracted at existing hatcheries, and a program established to create an outplanting protocol to utilize habitat above Ochoco Dam. Options for outplanting could involve releasing hatchery fry or smolts at the following locations:

- Into acclimation ponds in the upper watershed, for release into the system or downstream of Ochoco Dam (or any alternate release site that is more beneficial)
- Into acclimation ponds located downstream of Ochoco Dam.
- Dispersed fry outplants throughout the upper Ochoco Basin.

A thorough analysis of this alternative is outside the scope of this study; however, it is important to note as a viable alternative for further consideration.

#### 5.1.6.2. Biological Considerations

The pros and cons/risks for this alternative are unique compared to the other alternatives.

**Pros**

- Programs for outplanting juvenile hatchery fish could use the biological rearing capacity of the upper watershed to produce outmigrating smolts without the expense of adult upstream passage facilities.
- Outplanting juvenile fish may be a more productive approach to a given rearing stage by avoiding undesirable losses associated with spawning, incubation, or early life history stages.

**Cons/Risks**

- Hatcheries are subject to disease risks, human error and mechanical failure.
- Hatchery fish are not considered by all stakeholders to be equal to wild fish, so consultations would be necessary to develop specific program goals and protocols.
- This approach may garner less local support and perceived value without anadromous adult fish in the upper watershed.
- Similar risks with transportation and logistics of the trap-and-haul programs.
- Would still require downstream fish passage accommodations

#### 5.1.6.3. Opinion of Probable Construction Cost

The range of options for preparing a cost estimate includes the following for the production component:

- Contracting with an existing hatchery production program in the basin.
- Possible expansion or modifications to an existing hatchery in the basin to accommodate more production and transport capabilities.
- As a worst-case, construction of an entirely new mitigation hatchery for this alternative.

Other issues concern transportation costs, and possible construction of an acclimation pond facility to receive the outmigrants prior to their release into the river. Because the numbers of fish identified for passage are relatively small compared with some of the larger hatcheries in the region, we assume there is adequate capacity available in the region that could accommodate more production with some relatively moderate costs to expand the facilities. An estimate of $100,000 to $250,000 is assumed for this point in the study, and will assume this is not the driver for decisions at this point of the analysis. If this alternative is carried forward, additional study is recommended to identify specific hatchery programs that may be able to accommodate the production numbers and meet program goals for basin interaction. If a new hatchery is required, the estimate could be more in the range of $750,000 to $3 million or more, depending on water supply, land acquisition and/or use costs, and facility design development and construction specifics.

#### 5.1.6.4. Opinion of Probable Annual O&M Costs

Annual costs for an outplanting program are estimated at $50,000 per year, but have not been confirmed. Use of existing program facilities, transportation, and outplanting services could minimize annual costs. We recommend further refinement of this cost if this alternative is carried forward.

#### 5.1.6.5. Implications to OID operations

Implications to OID operations for upstream passage would be minimal with this alternative, assuming specific new facilities would not need to be constructed or operated for the hatchery production and outplanting. A majority of the implications would be more administratively focused to negotiate annual fish production, release methods/locations, and contracts to meet the obligations as defined with any outplanting program. Downstream passage facilities would need to be addressed.

## 5.2. Options for Downstream Passage

This section is organized beginning with downstream fish passage alternatives at Ochoco Dam, and moving upstream for other opportunities to capture and haul downstream migrating fish to a release point below the dam. Alternatives are designated by DN #1, DN #2, etc. to designate "Downstream" passage alternatives, and differentiate these from the upstream alternatives. The suite of alternatives considered for downstream passage includes:

- DN #1 – Volitional Passage through Existing Ochoco Dam Outlet
- DN #2 – Volitional Passage through Modified Ochoco Dam Outlet (Multi-Port Bypass)
- DN #3 – Volitional Passage through Screened Intake and Bypass at Ochoco Dam
- DN #4 – Floating Surface Collector in Ochoco Reservoir
- DN #5 – Collector in Upper End of Ochoco Reservoir
- DN #6 – Screw Traps near Mouth of Mill Creek and Ochoco Creek
- DN #7 – Tributary Collectors in Ochoco Creek and Mill Creek

### 5.2.1. DN #1 – Volitional Passage through the Existing Ochoco Dam Outlet

#### 5.2.1.1. Description and Technical Considerations

This alternative describes using the existing Ochoco Dam Outlet Works with no fish passage modifications prior to the canal diversion as a baseline condition for comparison and discussion, and to recognize the fact that some fish currently pass through the system. A description of the Outlet Works is provided in Section 4.1.2., which describes the intake, flow route through the dam, and the outlet facilities including the regulating gate. It is known that some smaller fish currently survive this passage route, but to date there have been no studies quantifying the survival or injury rate through the system.

Based on a preliminary review of the system, we believe the passage effectiveness and survival rate will likely vary depending on the: flows amount, reservoir level, the ability of outmigrating

fish to negotiate the reservoir and find the intake when it has gravity flow, and on the regulating gate opening. At the low pool elevations when flow must be pumped into the intake there will likely be no fish passage that has significant survival.

Additionally, in the current configuration any fish that survive through the Outlet Works would either pass through the canal spill back to the creek (likely encouraged to some level to avoid the canal due to the existing trashrack), or would continue on through the trashrack and down the canal. For sake of comparison with other alternatives, we assume that an exclusionary screen would need to be provided at the inlet to the canal with a bypass back to the creek to prevent desired species from being diverted into the canal flow. OID is currently planning to construct a criteria plate screen with a bypass in this location, which would provide for some fish passage. The screen would be designed to accommodate the full 160-cfs canal capacity, and the bypass system would take the first flow instead of the Canal Spill flow up to its capacity.

#### 5.2.1.2. Biological Considerations

Fish injury or mortality could be high for this alternative, and could occur at the following locations in this system given their current configuration:

- At the intake, depending on water level and flows.
- Through the regulating gate, depending on reservoir level and flow.
- At the Canal Spillway, again depending on flows.
- Without canal screening, some fish surviving this system may be lost to the canal flow because the trash rack does not provide a full exclusionary fish block. For sake of completeness, as noted above we assume that an exclusionary screen with a bypass to the creek will be provided at the inlet to the canal.

#### 5.2.1.3. Opinion of Probable Construction Cost

There are no capital costs associated with this alternative, except for the 160-cfs canal screen located downstream of the regulating gate. A screen of this flow capacity in a canal type setting could cost from $300,000 to over $1 million.

#### 5.2.1.4. Opinion of Probable Annual O&M Costs

The only annual costs associated with this alternative are the operation of the screen facility at the canal. Table 5-5 provides an estimate of the annual O&M costs for this alternative. The value of water to operate the fish bypass and provide creek flows during the non-irrigation season is not included.

**Table 5-5. Summary of annual operations & maintenance costs for DN #1 (Existing System with Canal Screen Operation).**

| Item | Notes | Annual Cost |
|---|---|---|
| Power – Site lighting, security, instrumentation | Estimate | $20,000 |
| Labor – General operations | Assume ½ FTE / year for general inspection, daily observations, maintenance, etc. | $40,000 |
| Maintenance – Annual | Assume at 2% of $1 million capital cost for planning. | $20,000 |
| Total Annual O&M Cost | | $80,000 |

#### 5.2.1.5. Implications to OID Operations

Implications to the OID operations are the need to monitor, operate, and maintain a canal screen, and fish bypass system with associated bypass flows, even during the non-irrigation season. Although bypass flow could be pumped from the tailrace to meet the bypass system needs to the creek, without transporting the fish by truck some flow amount would need to be maintained in the creek for the fish to migrate downstream. The exact amount of flow would need to be determined, but it is likely in the 5 cfs to 20 cfs range. As noted in the upstream passage alternatives, this would affect OID's ability to fill the reservoir and meet their project needs.

One potential opportunity would be to monitor ongoing passage survival rates and system performance, with a possible goal of modifying existing system operations to maximize fish survival in the future.

### 5.2.2. DN #2 – Volitional Passage through Modified Ochoco Dam Outlet (Multi-Port Bypass)

#### 5.2.2.1. Description and Technical Considerations

As noted with Alt DN #1, there is currently some level of fish passage and survival through the Outlet Works; however, there are no data to determine the fish passage efficiency or survival through the current system. This alternative provides concepts for improvement to the existing system that would improve fish passage performance. There are two opportunities to be explored with this approach that could result in a successful system:

- Improve attraction and passage at the existing intake structure.
- Reduce the turbulence and likely source of injury/mortality at the flow regulating gate.

With both of these options, the 160-cfs canal screen and bypass system would be required to divert fish from the outlet works back into the creek.

### Fish Attraction and Passage Improvements

The outmigration period is estimated to be from February through June each year, with the peak in April and May (per Table 3-5). This is also the typical period where the reservoir is filled each year, which means very little flow is released during this period except during seasonal high flow or floods, or after the reservoir is full. As noted in

Table 4-5, the 95% exceedence flows for this period range from 1 to 10 cfs, and the 5% range from 97 to 341 cfs, but the 50% exceedence flows only range from 4 to 30 cfs, and are in the range of 20 to 30 cfs during the peak outmigration months. This alternative would require more flow release through the Outlet Works to facilitate fish passage and bypass, which would affect the ability to fill the reservoir and meet their irrigation obligations.

Average calculated velocities at the trash rack are as shown in Table 5-6, based on an assumption of average velocity across the entire area of the trashrack. Because of the arrangement there will be some localized flow that is higher than these reported values, but this is a reasonable average for discussion.

**Table 5-6. Calculated velocities at existing Ochoco Dam trashrack.**

| Flow (cfs) | Velocity (fps) |
|---|---|
| 10 | 0.05 |
| 20 | 0.10 |
| 30 | 0.16 |
| 160 | 0.83 |
| 430 | 2.24 |
| 1,100 | 5.70 |

**Note**: 1,100 cfs row is included for reference only, but is not likely as the existing system would not support this capacity.

This information indicates that the attraction to the tower outlet due to flow cues will be minimal at the normal flows during the fish outmigration season. At the higher flows, fish will have more sense of guidance and attraction to the system; however at the lower flows behavioral cues will be more important to passage than the flows. The use of guide nets, pumped directed flow jets, a pumped attraction flow system with low-head pump back, possibly combined with a new arrangement for the tower would be options to explore if fish passage performance at the intake indicated poor attraction at the lower flows. For this alternative, it will be assumed that the intake tower would be used with its current configuration.

### Reducing Turbulence due to Energy Dissipation at Regulating Gate

For the outmigrating smolts that successfully find and negotiate the entrance to the tower, they would likely follow the flow into the intake pipe, down the vertical shaft, through the 44-inch

outlet pipe, and through the regulating gate into the canal. At flows up to 20 cfs, the regulating gate would typically be closed and all flow routed through the 14-inch bypass pipe and butterfly valve. Table 5-7 provides a reference of these velocities for discussion, based simply on the area available at the various flows. Actual velocities will vary based on the reservoir elevation.

**Table 5-7. Calculated water velocities at selected locations in the Ochoco Dam outlet works.**

| Flow (cfs) | Water Velocity (fps) | | | | |
|---|---|---|---|---|---|
| | 60-inch Diameter Intake Pipe | 44-inch Diameter Outlet Pipe | Regulating Gate Full open | Regulating Gate Half Open | 14-inch Bypass Gate Full Open |
| 10 | 0.5 | 0.9 | 0.9 | 1.4 | 9.3 |
| 20 | 1.0 | 1.9 | 1.9 | 3.8 | 18.7 |
| 160 | 8.1 | 15.2 | 15.1 | 30.2 | n/a |
| 430 | 21.9 | 40.7 | 40.7 | 81.4 | n/a |

At the majority of flows expected during the outmigration season, the velocities in the system are reasonable for fish survival. The one area of concern is at the regulating gate, and with any flow through the 14-inch bypass in throttled conditions, which could cause fish injury at the existing valve. A means to eliminate this high-energy area would be to replace the regulating gate and valve with a multiple orifice pipe that would be routed up the dam face, and release flow through full-port open valves at various heights. Flow could then cascade down a smaller open channel, and then flow back into the canal entrance.

This approach has been examined at other facilities to address a more fish-friendly means of energy dissipation, and would allow for all flow to pass through the system unscreened. An alternate approach would be to select specific design flows, and add an in-pipe screen such as an Eicher Screen to divert fish to a safe bypass, and screen the remaining higher flows.

In both cases, this would require extensive modifications to the outlet works, and would be expensive to construct and would require automated operations and ongoing maintenance. A decision on the ultimate desired design flow would help to better refine this alternative. If the existing 430-cfs capacity were utilized, this could be an effective alternative worth further study. If the 1,100-cfs capacity is desired, additional study would be necessary, and integration of this concept with the increased capacity design would be recommended.

#### 5.2.2.2. Biological Considerations

This alternative would likely require an established minimum flow to create an attraction flow to the system. Another likely outcome would be to provide pump back at the surface that would be similar to Floating Surface Collector described in Section 5.2.4.

The following biological pros and cons/risks were identified for this alternative:

**Pros**

- Fish would have the full access to the reservoir for rearing.
- If fish are attracted, and a bypass system could be installed, this would provide for effective passage.
- No major alterations are necessary for the facilities through the dam.

**Cons/Risks**

- Range in flow rate is extreme; from 1 to 430 cfs in the existing configuration, with future potential for 1,100 cfs. Effectiveness and safety may vary depending on the flow, and further concept development would be needed to refine this alternative.
- At very low flows, fish could reject or delay in the bypass system.
- At high flows, bypass would be difficult. Consideration should be given to an Eicher screen in-line with the bypass pipe to handle higher flows. Additional refinement of design flows would be necessary to refine this alternative.
- Operation of multiple gates is simple, but has many opportunities for problems and would require close monitoring and instrumentation/automation.

#### 5.2.2.3. Opinion of Probable Construction Cost

Estimating the cost of this alternative would require more refined development of the design flows, system components, and overall design definition. Improvements to the intake and flow regulation system for flows up to 430 cfs would be desirable, but would require large facility changes. There may be opportunities to optimize the passage system for a reduced flow based on the 5% exceedence values. The future 1,100 cfs capacity would be very difficult to accommodate with this approach. A rough estimate for discussion based on our knowledge with other systems that have considered this approach would range from $2 to $5 million, but could be more.

#### 5.2.2.4. Opinion of Probable Annual O&M Costs

Annual O&M costs would include more active trash rack cleaning on the intake in the reservoir, operating and monitoring of the discharge valves and bypass system, and screen cleaning on the canal screen. This is not a simple cleaner at this site due to the amount of aquatic vegetation at the low pool elevation lack of a bypass current to sweep debris away, etc. An estimate for this alternative is provided in Table 5-8.

**Table 5-8. Summary of annual operations & maintenance costs for DN #2 (Multi-port Outlet).**

| Item | Notes | Annual Cost |
|---|---|---|
| Power – Site lighting, security, instrumentation | Estimate double Alt DN #1 for additional site lighting. | $20,000 |
| Labor – General operations | Assume 1 FTE / year for general inspection, daily observations, maintenance, etc. | $80,000 |
| Maintenance – Annual | Assume at 2% of $5 million capital cost for planning. | $100,000 |
| Total Annual O&M Cost | | $200,000 |

#### 5.2.2.5. Implications to OID Operations

The first step with this style of a bypass system would be to agree on total flow capacity of intake and outlet works. At a minimum, a normal bypass flow of about 10 to 20 cfs would be necessary to attract and pass fish through the system, which would also work with the canal screen. Based on the fish migration season, additional flow would need to be released to facilitate passage which would affect OID's ability to fill the reservoir and meet their irrigation flow obligations.

Depending on the selected flow, implementation of this alternative would likely limit the future expansion capacity of the tunnel and 44-inch diameter pipe, which would impact OID's desire to return this capacity to the original 1,100 cfs.

An automated control system would be desirable for the bypass system, canal screen cleaner, and all controls. The automated system would likely need daily monitoring and maintenance.

### 5.2.3. DN #3 – Volitional Passage through Screened Intake and Bypass at Ochoco Dam

#### 5.2.3.1. Description and Technical Considerations

This alternative represents an upper bounding cost case for conventional and feasible downstream passage alternatives, and would provide for a full criteria screen and fish bypass system designed to meet NMFS (2011) criteria for screen velocities, attraction flow and bypass flows. Similar to Alt DN #2, early agreement on flows would be necessary to develop this approach. We have assumed an exclusionary screening capacity of 430 cfs for this discussion, and that a minimum flow of 10 to 20 cfs would be provided for an effective bypass system.

A screen and bypass facility similar to PGE's Pelton Round Butte Tower would be required, and we would assume the bypass would lead to pumped bypass pipe similar to Pelton Round Butte. The challenge with the Ochoco Dam site is the screen facility would need to be floating or movable on a new tower structure, so the screened intake could track with the water level given the high level of fluctuation. A V-screen structure designed to operate between a minimum flow of 10 to 20 cfs is a typical item for reasonable for discussion, with a maximum capacity of 430 cfs to match the current Outlet Works capacity. This is a wide range of flows, and can be considered somewhat impractical for this type of screen.

All fish that entered the system would be diverted from the flow passing through the Outlet Works, and routed to a pumped bypass system similar to the Pelton Round Butte facility. The bypass system would most likely be a collection-and-haul operation, with juvenile fish transported via truck, as a gravity bypass would be difficult given the range of reservoir elevations.

Construction of a large fixed screen facility that can follow an 81.7-foot (or less) design elevation is a complicated facility, and is not considered practical or desirable. Restriction of fish passage operations to a lower range of fluctuation would be desirable. If the full 430 cfs is desired, it is likely that the entire tower would need replacement to accommodate this new structure.

Supplementation of attraction flows at low flow is a possibility as described in Alt DN #2 above.

Based on the fish passage design flows, it may be worth considering a smaller screen facility, in the range of 50 to 150 cfs to cover a large majority of the operational period. This could be arranged similar to the Pelton Round Butte facility with multi-level flow gates that could supplement higher flows from the bottom of the reservoir. The one disadvantage to that approach at this sits is the large pool fluctuation, which would not allow lower lever gates to be opened when the pool is low.

Additional discussions are recommended for the attraction flow.

#### 5.2.3.2. Biological Considerations

This system is similar to Alt DN #2, but it screens the fish prior to entering the tower at the existing intake location. The following biological pros and cons/risks were identified for this alternative.

**Pros**

- Fish have the full access to the reservoir for rearing due to the location near the dam (note this may also be considered a con based on concerns such as predator, temperature, and lack of guiding currents).
- If fish are able to be attracted into the system, the screen and bypass system would prevent fish from entering any of the Outlet Works features with its anticipated losses.

**Cons/Risks**

- Range in flow rate is extreme; from 1 to 430 cfs in the existing configuration, with future potential for 1,100 cfs. Effectiveness and safety may vary depending on the flow, and further concept development would be needed to refine this alternative. At very low flows, fish could reject entry to the system.
- Would need to determine a minimum bypass flow for system operation to design the flow regulation system.

#### 5.2.3.3. Opinion of Probable Construction Cost

A movable, exclusionary screen alternative for 430 cfs flow could cost from $25 to $75 million or more.

#### 5.2.3.4. Opinion of Probable Annual O&M Costs

Based on the high capital cost, an annual operational cost of $0.5 to 1.5 million is reasonable, considering long term maintenance of the facility.

#### 5.2.3.5. Implications to OID Operations

This alternative is not considered practical for Ochoco Dam; however, we have kept it in the analysis for sake of completeness as this type of system is typically analyzed for fish passage studies.

Implications for a full exclusionary screen option are similar to Alt DN #2.

- The first step with this style of a bypass system would be to agree on total flow capacity of intake and outlet works. At a minimum, a normal bypass flow of about 10 to 20 cfs would be necessary to pass fish through the system, and higher flows (that could be pumped) would likely be needed to attract fish into the system.
- A canal screen downstream of the dam would not be necessary with this alternative.
- Maintenance of minimum flows of 10 to 20 cfs when the bypass system is operating would reduce OID's ability to fill the reservoir and meet its irrigation needs.
- Depending on the selected flow, implementation of this alternative would likely limit the future expansion capacity of the tunnel and 44-inch diameter pipe, which would impact OID's desire to increase this capacity to 1,100 cfs.
- An automated control system would be desirable for the bypass system, canal screen cleaner, and all controls. The automated system would likely need daily monitoring and maintenance.

### 5.2.4. DN #4 – Floating Surface Collector in Ochoco Reservoir

#### 5.2.4.1. Description and Technical Considerations

A Floating Surface Collector (FSC) is considered a partial screening facility that floats on the surface, and creates an attraction flow by pumping flow into a V-screen, and returning the release flow through pumps in the floating structure back into the reservoir. Fish are attracted into the facility, and then captured in holding tanks on the floating barge structure. This concept is based on the "gulper" utilized and improved upon at the Puget Sound Energy (PSE) Baker River Project in western Washington for several decades. Currently there are state of the art FSC's in place at PSE's Upper Baker Dam and at PacifiCorp's Swift Hydroelectric Project on the Lewis River in Washington. Similar facilities are planned for PGE's North Fork Project, PSE's Lower Baker Dam, Tacoma Power's Cushman Dam, and the Cougar Project operated by the US Army Corps of Engineers.

With the configuration of Ochoco Dam, an FSC could be located upstream of the intake and exclusionary nets could be deployed upstream of the FSC to prevent fish from entering the existing intake tower. Exclusionary nets at Ochoco Reservoir may not be as difficult as at other sites in the region due to the more limited spillway and flood flows expected at this site; however, these net systems have proven to be expensive and difficult to maintain. It is anticipated that exclusionary nets could be installed for the full outmigration season; their

location would need to be sited to accommodate spillway flows as well as adult release facilities so upstream migrants are not reintroduced into the reservoir downstream of the nets. If the nets could be kept in year round, it could eliminate the need for the canal screen downstream of the dam; however, they are not desirable due to ongoing maintenance necessary for debris, algae, and vegetation problems. Additionally, they may not be feasible in the winter months due to ice issues on and in the reservoir.

Fish passing the screens would enter a holding/transport facility on the FSC, and could then be transferred to shore via a trestle (like Swift), or a floating shuttle barge (like Baker) to a fish truck loading/transport facility on the dam. Photo 5-13 provides an illustration of the Swift FSC and Trestle, which is designed for 600-cfs attraction flow.

This system would likely be highly effective as a fish collection system, and would be relatively easy to operate. For Ochoco, if there was a biological desire to limit migratory juvenile fish access to the reservoir, the FSC could be located further upstream when sufficient pool depth allowed, as long as fish transfer facilities could be provided to trucks. One issue to consider if the FSC were located upstream is the recreational impacts of a barrier net and floats.

**Photo 5-13. Swift FSC shown moored at trestle while under construction (from PacifiCorp web site).**

### 5.2.4.2. Biological Considerations

This system would likely be located upstream of the Intake Tower near Ochoco Dam, so would have similar considerations to Alts DN #2 and DN #3. Assuming exclusionary nets are used, it would effectively screen fish from the intake, and the existing intake system could remain unchanged. The following biological pros and cons/risks were identified for this alternative.

#### Pros

- Fish would have the full access to the reservoir for rearing, foraging, etc. (may also be a con as noted above).

- The FCS would have strong fish attraction due to the pumped flow.
- An exclusionary net and screen system on the FSC would prevent fish from entering any of the Outlet Works features, and the bypass/transport system would be fish friendly.
- An FSC approach could be designed to accommodate the full 430-cfs intake flow, or future 1,100-cfs flow.
- An FSC could be located near the dam, or further upstream in the reservoir.
- A 70 to 95% or higher collection effectiveness is anticipated for this alternative.

**Cons/Risks**

- Some fish may get through the nets.
- Attraction flows would need to be studied further in this system to assure effective collection of outmigrants.

#### 5.2.4.3. Opinion of Probable Construction Cost

The cost for a 150-cfs range FSC, net, and mooring system, would likely range from $15 to $40 million, based on recent experience in the industry.

#### 5.2.4.4. Opinion of Probable Annual O&M Costs

Annual O&M costs our estimated as shown in Table 5-9.

**Table 5-9. Summary of annual operations & maintenance costs for DN #4 (FSC).**

| Item | Notes | Annual Cost |
|---|---|---|
| Power - Pumped FSC flow | Assume 150 cfs low-head pumping on FSC. Assume 6 months/year, average 6 feet head. | $40,000 |
| Power – FSC lighting, security, instrumentation | Estimate. | $10,000 |
| Net maintenance | Estimate for install, removal, repairs annually. | $50,000 |
| Labor – General operations | Assume 1.5 FTE / year for general inspection, daily observations, maintenance, etc. | $120,000 |
| Maintenance – Annual | Assume at 1% of $25 m. | $250,000 |
| Total Annual O&M Cost | | $470,000 |

#### 5.2.4.5. Implications to OID Operations

Implications for an FSC at Ochoco Dam are as follows:

- Definition of the Outlet Works flow is not as critical for this system. The existing capacity of 430 cfs, or a future capacity of 1,100 cfs could be easily accommodated.
- Because no bypass flow is needed with a transport program, this option does not affect the ability to fill the reservoir or conflict with OID's restriction on releasing water for fish.
- The system would be automated, and would need daily monitoring and maintenance for the FSC and net system.
- An active debris management program in the reservoir could help to reduce maintenance (cleaning and repair) work on the nets; however, the use of exclusionary nets would be a difficult, ongoing annual maintenance issue due to algae, ice, etc.
- The need for a canal screen downstream of the Outlet Works would depend on the reliability of an exclusionary net system to prevent any fish from entering the bypass. If a net is not reliable or feasible, the canal screen may still be desired.

### 5.2.5. DN #5 – Collector in Upper End of Ochoco Reservoir

#### 5.2.5.1. Description and Technical Considerations

A smaller FSC could be constructed near the upstream end of the reservoir, with the goal of collecting outmigrants as they enter the pool and avoid possible predation and water quality issues downstream. Given the design flows provided in

Table 4-11, a 20- to 50-cfs collector may be sufficient if lead nets could be maintained during higher flows to help prevent fish from bypassing the facility and direct them into the FSC.

A bank of motorized screw traps could also be effective at this location, and would cost significantly less than the FSC approach. The advantage of the FSC is the addition of pumps to help create an attraction flow that would help to draw fish into the facility.

This smaller facility could be relocated within the upper reaches of the reservoir, with the goal of maintaining a collector location as close as feasible to the mouths of Ochoco and Mill Creek. As the pool level transitioned from low to full and back down, the facility and any associated lead nets would need to be relocated, likely at multiple intervals, to maintain adequate depth. This would also affect the fish transport method, so transport by boat or a floating barge type system is anticipated.

#### 5.2.5.2. Biological Considerations

- Similar to Alt DN #4, with the loss of lake habitat that would be restricted by nets in the upper reservoir. This could also be a benefit to enhance fish collection and avoid predation and potential water quality issues.
- There would be lost collection time during any facility relocation associated with changing pool elevations.

- This alternative would need to be integrated with upstream passage facilities that would release adult fish upstream of the nets.

#### 5.2.5.3. Opinion of Probable Construction Cost

A smaller FSC with nets would likely cost in the range of $3 to $10 million.

#### 5.2.5.4. Opinion of Probable Annual O&M Costs

Annual O&M costs our estimated as shown in Table 5-10.

**Table 5-10. Summary of Annual Operations & Maintenance Costs for DN #4 (FSC).**

| Item | Notes | Annual Cost |
|---|---|---|
| Power - Pumped FSC flow | Assume 50 cfs low-head pumping on FSC. Assume 6 months/year, average 6 feet head. | $15,000 |
| Power – FSC lighting, security, instrumentation | Estimate. | $5,000 |
| Net maintenance | Estimate for install, removal, repairs annually. | $50,000 |
| Labor – General operations | Assume 1.5 FTE / year for general inspection, daily observations, maintenance, etc. | $120,000 |
| Maintenance – Annual | Assume at 1% of $10 m. | $100,000 |
| Total Annual O&M Cost | | $290,000 |

#### 5.2.5.5. Implications to OID Operations

Implications for an FSC at the upper end of Ochoco Reservoir are similar to Alt DN #4, with a smaller facility.

- More debris management and maintenance of the nets would be expected, and debris would not be able to settle out or be managed in the reservoir.
- The FSC would need to be moved as the pool drops, to provide enough draft for the barge to float. This could be an extensive operation, as relocating the exclusionary nets is a labor intensive process.

### 5.2.6. DN #6 – Screw Traps near mouth of Mill Creek and Ochoco Creek

#### 5.2.6.1. Description and Technical Considerations

This alternative would provide for one or two screw traps in Mill Creek, Ochoco Creek, or both creeks to maximize the habitat. Several sites are available in these locations, as shown in Photo 5-14, that would have road access, an area that could be developed for personnel access, and a location to deploy and retrieve the screw traps with truck access.

**Photo 5-14. Mill Creek and Ochoco Creek mouths at upper end of Ochoco Reservoir.**

This concept utilizes commercially available screw traps deployed for the entire fish collection season, as shown in Photo 5-15. These facilities are self-powered traps that use the flowing water to help clean the screen on the rotating drum, and trap fish in a live box at the downstream end of the collector. Access in the smaller creeks would be available via a walkway, and fish could be collected daily by personnel and hand carried to trucks for transport.

Performance of the traps can be improved by adding lead nets or lead guide pickets in the creek, or by more permanent measures such as pouring a concrete sill or abutments to help guide the flow and fish into the facility.

Given the design flows in these creeks as shown in Table 4-12 and Table 4-13, the range of operation needed is about 5 to 300 cfs. At the lower flows, the traps should be highly efficient. The higher flows may cause some damage to lead nets or pickets that would require repair following high flow events.

**Photo 5-15. Screw trap shown in active fishing mode with walkway access (photo courtesy of E.G. Solutions, Inc.).**

### 5.2.6.2. Biological Considerations

Screw traps are a proven method to collect fish, and are relatively inexpensive relative to other alternatives examined in this study. Collection at lower flows should be high with lead nets, estimated at >80 % collection efficiency. Depending on the exact site conditions selected and any improvements, the efficiency could still be in the range of 20 to 50% or better. On these size creeks, efficiency can be increased by running two traps in series (one behind the other) for each site.

- This alternative represents a relatively inexpensive alternative to collect a potentially significant number of fish with a labor intensive program.
- Fish can be released at any location downstream of the dam. It is assumed a release point immediately downstream of the Measurement Weir for this alternative.

### 5.2.6.3. Opinion of Probable Construction Cost

Eight-foot Screw traps with trailers cost less than $40,000. Assuming minimal nets, pickets, and site grading, an effective screw trap could be installed on each creek for less than $100,000. For this exercise, we will assume a single screw trap on one site on each creek, for a total of $250,000. Additional costs for land acquisition, construction and/or maintenance easements, and permitting would be likely costs to consider. Operation of a screw trap would also require a truck to transport fish, which could cost from $130,000 to $300,000, depending on the size and complexity of features. A truck purchased for hauling upstream migrants under Alternatives UP #2, UP #3, UP #4, or UP #5 could function for hauling downstream migrants as well.

#### 5.2.6.4. Opinion of Probable Annual O&M Costs

Annual O&M costs include annual deployment, daily fish collection, transfer, and maintenance for the operating season, likely multiple repairs each season due to high flows, and annual removal after the migration season.

#### 5.2.6.5. Implications to OID Operations

Implications for installation of screw traps at Ochoco Dam are similar to Alt DN #5, with a less permanent style facility. Activities would include:

- Annual delivery, set up and removal of the screw traps for the fish collection season.
- Daily inspection, fish transfer, debris management and maintenance of pickets or lead nets would be expected.
- Repairs or modifications to improve collection mid-season depending on flows.
- Land purchase or construction and/or access easements may be required and would require further analysis.

**Table 5-11. Summary of annual operations & maintenance costs for DN #6 – Screw Traps in Mill and Ochoco Creeks.**

| Item | Notes | Annual Cost |
|---|---|---|
| Labor – General operations | Assume 2 FTE / for 6 months each year for general inspection, daily observations, maintenance, etc. | $80,000 |
| Trucking | Once per day round trip, approximately 10 miles total x 365 days = 3,650 miles/yr. Assuming 10 mpg for the fish truck = 365 gal X $4.00/gal = $1,460/year fuel. Say $10,000/year including maintenance, other travel associated with project, etc. | $10,000 |
| Maintenance – Annual | Assumed cost | $40,000 |
| Total Annual O&M Cost | | $130,000 |

**Note**: Does not include an estimate for the design and implementation of a fish marking program on juveniles.

### 5.2.7. DN #7 – Tributary Collectors in Ochoco Creek and Mill Creek

#### 5.2.7.1. Description and Technical Considerations

A tributary collector approach would be similar to the screw traps described in Alt DN #6, but would be more permanent facilities set into the creek beds. This style of trap can be installed in the stream without any foundation (see Photo 5-16), which requires seasonal installation of steel pipe pickets and the live box. Given the range of flows expected at Mill and Ochoco Creeks, the pickets would likely collapse due to hydraulic loading or heavy debris loads during high flow events, and would need to be reinstalled following the high flow events. When the pickets are damaged, fish collection is typically not effective, so routine maintenance is

important. This concept can also be constructed in a more permanent manner, with concrete sills, abutments, and collapsible pickets on hinges that can be designed to drop during high flows, and winched back into place immediately following the floods (see Photo 5-17).

Both of these systems require at least daily inspection and removal of fish from the live box, and attention to any problems observed. These systems would typically be more effective than the screw trap alternative, depending on the foundation and severity of high flow events each season.

**Photo 5-16. Tributary trap with pickets and live box.**

**Photo 5-17. Tributary trap with concrete sill and abutments (shown during construction without pickets).**

The Keystone Dam site at Ochoco Creek would be a reasonable location, and a site near Highway 26 has potential for a Mill Creek collector.

#### 5.2.7.2. Biological Considerations

These picket-based tributary collectors are similar to the screw trap alternative, with more permanent pickets and collection facilities. Collection efficiencies at lower flows should be similar to the screw trap alternative estimated at >80 percent. Depending on the exact site conditions and design of the facilities, they should maintain that high level of efficiency except during extreme high flows when the pickets drop or are otherwise rendered ineffective. Estimated collection efficiency during high flows could range from 40% to 80% based on the exceedence flows for the creeks.

- This alternative represents a relatively inexpensive alternative to collect a potentially significant number of fish with a labor intensive program.
- Fish can be released at any location downstream of the dam. It is assumed a release point immediately downstream of the Measurement Weir for this alternative.

#### 5.2.7.3. Opinion of Probable Construction Cost

Construction of a tributary trap with a concrete sill and abutment, site access improvements, and truck loading provisions would be in the range of $200,000 to $500,000 per site. Assuming one trap on each creek would cost in the range of $0.4 to $1.0 million, not including design, permitting, land acquisition, easements, etc. Operation of tributary traps would also require a truck to transport fish, which could cost from $130,000 to $300,000, depending on the size and complexity of features. A truck purchased for hauling upstream migrants under Alternatives UP #2, UP #3, UP #4, or UP #5 could function for hauling downstream migrants as well.

#### 5.2.7.4. Opinion of Probable Annual O&M Costs

Annual operating costs would be similar to Alt DN #6, at about $130,000/year or more given the two traps.

#### 5.2.7.5. Implications to OID Operations

Implications for installation of screw traps at Ochoco Dam are similar to Alt DN #6, but would be more permanent. Activities would include:

- Annual set up and removal of key components for the collection fish season.
- Daily inspection, fish transfer, debris management and maintenance of pickets or lead nets would be expected.
- Land purchase or construction and/or access easements may be required and would require further analysis.

# 6.0 Summary of Alternatives

Table 6-1 and Table 6-2 provide summaries of the upstream and downstream passage alternatives described in Section 5. Categories summarized in these tables include:

- **Modifications Needed to Existing Structures.** This category provides an overview of necessary changes or new construction to Ochoco Dam and other structures.
- **Technical limitations.** Captures limitations for various options, such as the ability of a downstream tributary collector to capture fish during high flows, limitations on alternative due to high stream flows, channel morphology, dam height, etc.
- **Biological Benefits.** Addresses an opinion on rates of survival of an alternative, relative contribution to recovery, etc.
- **Biological Costs/Risks.** Provides an overview of likely fish survival or mortality, inefficiencies of passage, etc.
- **Capital Cost.** This column provides an estimate of the capital cost necessary to design, bid, and construct an alternative. Its intent is to reflect the total project cost to implement an alternative, as described in Section 5.0.
- **O&M cost.** This category provides an estimate of the annual operation and maintenance costs necessary to operate the facility, as described in Section 5.0.
- **Water requirements.** Lists the estimated amount of flow over what period would be necessary to operate the various fish passage facilities.
- **Implications to OID operations.** Impacts and requirements to the OID's operation are noted in this column.

**Table 6-1. Ochoco Dam upstream passage alternative summary.**

| Alternative / Characteristic | Modifications to Existing Structures | Technical Limitations | Biological Benefits | Biological Costs/Risks | Capital Cost Range (estimate) | Annual Operation and Maintenance Cost (estimate) | Water Requirements | Implications to OID Operations |
|---|---|---|---|---|---|---|---|---|
| **UP #1. Volitional Passage at Ochoco Dam (Fish Ladder).** | • Entrance pool near Flow Measurement Weir<br>• Ladder ascending and penetrating the dam.<br>• Exit facilities to accommodate the 81-foot fluctuation.<br>• Water supply and ancillary support site. | • Dam penetration.<br>• 81-foot reservoir fluctuation requires complex exit structure or pumped flow to release slide.<br>• Water needed to run ladder would not be available outside irrigation season due to Federal restrictions on use of stored water.<br>• Not a typical fish ladder due to exit conditions. | • Full volitional system does not need any human interaction.<br>• Habitat is available up to the dam base, and immediately upstream of the dam.<br>• Fish can self-select their migration route once they enter the reservoir. | • Complex ladder outlet operation due to large pool fluctuation.<br>• Potential for migration delay and warm temperatures in 3.25-mile long reservoir.<br>• Possible migration delay in ladder at warmer temperatures. | $20 to $35 million | $244,000 | • 20 cfs minimum year round for ladder operation.<br>• Assume higher attraction flows only necessary when spilling via gravity flow.<br>• 30 gpm for holding ponds (pumped or gravity). | • Generally a passive operation. Daily monitoring, maintenance, etc.<br>• Water needs for ladder would reduce ability to fill reservoir and meet irrigation needs. |
| **UP #2. Trap-and-Haul at Ochoco Dam.** | • Fishway entrance facility near Flow Measurement Weir.<br>• Short fish ladder to holding pool, truck loading facilities.<br>• Water supply and ancillary support site improvements and support facilities. | • Water needed to run ladder would not be available outside irrigation season due to Federal restrictions on use of stored water.<br>• Personnel requirements to operate and maintain facility. | • Habitat is available up to the dam base, and immediately upstream of the dam.<br>• Flexibility of various release points.<br>• Less potential for delay in ladder, and in reservoir depending on fish release point. | • Potential for migration delay in reservoir.<br>• No ability for fish to self-sort or return to lower creek after straying into trap.<br>• Dependent on human operations.<br>• Potential for human error and accidents in operations / maintenance. | $0.75 to $3 million.<br>Could Phase the facility to start small and expand/automate facilities depending on numbers of fish. | $234,000 | • 10 to 20 cfs minimum year round for ladder operation.<br>• Assume higher attraction flows only necessary when spilling via gravity flow.<br>• 30 gpm for holding ponds (pumped or gravity). | • Staffing for daily operations, monitoring and inspection.<br>• Water needs for ladder would reduce ability to fill reservoir and meet irrigation needs. |
| **UP #3. Trap-and-Haul from Ochoco Creek Upstream of the Crooked River Confluence (at Red Granary Diversion).** | • Modify Red Granary site to add diverter rack and holding/transport pool, with truck loading facilities. | • Same is UP #2.<br>• Could not divert fish during higher flows, fish would likely bypass the facility. | • Same as UP #2. | • Same as UP #2, plus:<br>• Could not collect fish at higher flows in Ochoco Creek. | $0.4 to $1.5 million.<br>Less than UP #2 due to use of existing facilities. | $234,000 | • Same as UP #2. | • Same as UP #2 but at the Red Granary site about 1 mile downstream of Ochoco Dam. |
| **UP #4. Trap-and-Haul from Lower Crooked River (at Crooked River Central Diversion).** | • Modify the Crooked River Central Diversion to add a fish trap, sorter, and holding facilities.<br>• Add downstream marking facilities for outmigrants at Ochoco Dam/Reservoir. | • Could not divert fish during higher flows, fish would likely bypass the facility.<br>• Not located on OID property. | • Same as UP #2.<br>• More flow typically available in Crooked River so fish can reliably access site. | • Same as UP #2, plus:<br>• Could not collect fish at higher flows in Ochoco Creek.<br>• Would need to sort and differentiate fish from the three upstream basins. | $0.7 to $4 million | $270,000 | • Likely no pumped or minimum release flow needed from Ochoco Reservoir (confirm).<br>• 100 gpm for 3 holding ponds (pumped or gravity). | • Same as UP #2 and UP #3, but at the Crooked River Central Diversion several miles downstream of Ochoco Dam.<br>• Likely need to provide juvenile marking facilities in downstream migrants collected in the Ochoco system. |

| Alternative / Characteristic | Modifications to Existing Structures | Technical Limitations | Biological Benefits | Biological Costs/Risks | Capital Cost Range (estimate) | Annual Operation and Maintenance Cost (estimate) | Water Requirements | Implications to OID Operations |
|---|---|---|---|---|---|---|---|---|
| **UP #5. Trap and Transport from Pelton Round Butte Project.** | • Modify the Pelton Round Butte adult fish collection and sorting facility to accommodate sorting and holding facilities for Ochoco Creek fish.<br>• Add downstream marking facilities for outmigrants at Ochoco Dam/Reservoir. | • Not located on OID property.<br>• Needs further study, but assume provisions could be added at Pelton Round Butte to support another basin program. | • Flexibility of various release points.<br>• Same as UP #2. | • No ability for fish to self-sort or return to lower creek after straying into trap.<br>• Habitat between Pelton Round Butte and Ochoco Dam would not be available.<br>• Dependent on human operations.<br>• Potential for human error and accidents in operations / maintenance. | $0.4 to $2 million | $215,000<br>More mileage and transport costs, but less new facility operation and maintenance costs than above alternatives. | • No pumped or minimum release flow needed from Ochoco Reservoir.<br>• Assume some additional flow needed at Pelton Round Butte for holding facilities (100 gpm for 3 small ponds). | • Same as UP #2, #3 and #4, but at the Pelton Round Butte Project about 50 miles by road downstream of Ochoco Dam.<br>• Likely need to provide juvenile marking facilities in downstream migrants collected in the Ochoco system. |
| **UP #6. Annual Outplanting of Hatchery Stock (No Upstream Passage).** | • See Table 6-2. | • No technical limitations for facilities. | • Uses the biological rearing capacity of the upper watershed to produce outmigrating smolts.<br>• Increases smolt productivity by avoiding undesirable losses during spawning, incubation and early life histories | • Typical hatchery disease and human error risks.<br>• No adult fish in the upper basin. | $100,000 to $250,000 depending upon the ability to use the capacity of existing hatchery and transportation facilities; plus possible cost of any acclimation facilities. | $50,000 (confirm use of existing facilities) | • Possible extra water needed for existing hatchery facility. Would require further study to confirm. | • None, other than administrative coordination with hatchery production entity. |

Note: Fish marking program costs are not included in upstream alternatives, and this issue would need further study if an upstream alternative is preferred that requires the downstream fish marking program.

**Table 6-2. Ochoco Dam downstream passage alternative summary.**

| Alternative / Characteristic | Modifications to Existing Structures | Technical Limitations | Biological Benefits | Biological Costs/ Risks | Capital Cost (estimate) | Annual Operation and Maintenance Cost (estimate) | Water Requirements | Implications to OID Operations |
|---|---|---|---|---|---|---|---|---|
| **DN #1. Volitional Passage through Existing Ochoco Dam Outlet.** | • None to Dam, this alternative utilizes existing facilities with no changes to canal.<br>• New 160-cfs Canal Screen and Bypass at Canal Inlet. | • Fish attraction concerns given wide flow range during outmigration season.<br>• Energy dissipation concerns at regulating gate and stilling basin.<br>• Water needed transport fish would not be available outside irrigation season due to Federal restrictions on use of stored water. | • Some successful fish passage expected.<br>• Currently there are no data that quantify survival or injury rates through the existing system. | • Some mortality and injury rates expected, dependent on reservoir level, regulating gate settings, and size of fish.<br>• Attraction to intake a concern depending on flows.<br>• Outmigrants must negotiate full reservoir prior to bypass. Risk of predation and residualization in reservoir, and potential exposure to warm water temperatures at times. | $0.3 to $1 million<br>(for 160-cfs canal screen) | $81,000 | • Depends on minimum flow in gate, assume no changes to existing operations for comparison.<br>• Canal screen bypass flow would be required. | • May need to run/stop intake to pass fish when migrating. Could pulse on hourly or daily basis when fish are known to be migrating.<br>• Adds operation & maintenance activities for canal screen. |
| **DN #2. Volitional Passage through Modified Ochoco Dam Outlet (Multi-Port Bypass).** | • Rework regulating gate to multi-port bypass to open channel flow for primary and bypass pipes.<br>• Possible to provide multiple full port bypass pipes.<br>• New 160-cfs Canal Screen and Bypass at Canal Inlet. | • Very dependent on desired design flow.<br>• Routing of multi-port pipe and open channel flow return conduit.<br>• Water needed transport fish would not be available outside irrigation season due to Federal restrictions on use of stored water. | • Passive, full volitional system for fish.<br>• Fish friendly energy dissipation for Outlet Works, would greatly reduce potential for injuries and mortality.<br>• Depends on design flow. | • Attraction to intake a concern depending on flows and pool elevation.<br>• Outmigrants must negotiate full reservoir prior to bypass. Risk of predation and residualization in reservoir, and potential exposure to warm water temperatures at times. | $2 to $5 million | $211,000 | • Would depend on minimum flow through orifice.<br>• Assume size to match 20-cfs fish entrance flow as a minimum. | • Adds operation & maintenance activities for multi-gate bypass pipe(s) and return conduit.<br>• Adds operation & maintenance activities for canal screen. |

| Alternative / Characteristic | Modifications to Existing Structures | Technical Limitations | Biological Benefits | Biological Costs/ Risks | Capital Cost (estimate) | Annual Operation and Maintenance Cost (estimate) | Water Requirements | Implications to OID Operations |
|---|---|---|---|---|---|---|---|---|
| **DN #3. Volitional Passage through Screened Intake and Bypass at Ochoco Dam.** | • Add criteria, exclusionary screens and bypass to intake tower. Similar to Pelton Round Butte Project, but movable to accommodate variable reservoir levels.<br>• Assume 430-cfs capacity screens.<br>• Discuss potential for 1,100 cfs capacity.<br>• No major changes to pipe through dam unless capacity increased.<br>• Don't need canal screens. | • Design flow, must agree on flow first; 430 cfs assumed for analysis.<br>• Water needed transport fish would not be available outside irrigation season due to Federal restrictions on use of stored water.<br>• Rework of tower, new bypass, and likely improvements to tunnel.<br>• Fish bypass assumed to be pumped like Pelton Round Butte or floating barge shuttle conveyance like Baker FSC. | • Provides for full exclusionary screening to prevent all target species from passing through outlet works. | • Outmigrants must negotiate full reservoir prior to bypass. Risk of predation and residualization in reservoir, and potential exposure to warm water temperatures at times.<br>• Effective attraction to screen and bypass system. | $25 -$75 million.<br>Depends on flow, more analysis needed to tighten range | $0.5 to $1 million | • Minimum flows needed when operating. | • Maintain minimum flows for bypass and collection when operating.<br>• Addition of major facilities to operate and maintain. |
| **DN #4. Floating Surface Collector in Ochoco Reservoir.** | • Addition of new FSC for partial screening alternative.<br>• Provide for moorage and fish transfer.<br>• Need for exclusionary nets.<br>• Likely won't need canal screens.<br>• No changes to existing outlet works required. | • Agree on design flow. Suggest 50 to 150 cfs capacity for discussion.<br>• Could make flow amount phased for future expansion. | • Provides proven method to collect fish, without full exclusionary screening.<br>• Floating structure would operate at any flow and/or pool elevation to attract fish.<br>• Could relocate FSC for maximum collection.<br>• Likely performance of 70% to 95% fish collection efficiency. | • Barrier nets likely will improve collection efficiency.<br>• Some fish may be lost in nets.<br>• Attraction flow amount may need to be optimized.<br>• Likely won't collect all outmigrants. | $15 - $40 million | $470,000 | • Only provisions for holding / transport of collected juveniles. Assume 50 gpm.<br>• Would not require release of stored water outside irrigation season. | • Adds Operation and Maintenance of a floating fish collection facility.<br>• Safety of access at all times.<br>• Does not affect ability to fill reservoir.<br>• Retains ability to increase Outlet Works flow to 1,100 cfs.<br>• Net maintenance required, and monitoring during spill.<br>• Active debris management in reservoir could help with net maintenance.<br>• Likely no canal screen needed. |

| Alternative / Characteristic | Modifications to Existing Structures | Technical Limitations | Biological Benefits | Biological Costs/ Risks | Capital Cost (estimate) | Annual Operation and Maintenance Cost (estimate) | Water Requirements | Implications to OID Operations |
|---|---|---|---|---|---|---|---|---|
| **DN #5. Collector in Upper End of Ochoco Reservoir.** | • None to major facilities.<br>• Minor road improvements and boat launch ramps near screw trap deployment site. | • Ability to collect fish at higher flows.<br>• Ability to access and maintain facility at higher flows.<br>• Daily maintenance and fish transport needed. Assume a manual biased fish transport protocol to load trucks from live box.<br>• Debris management after high flows. | • Likely performance from 25% to >75% collection efficiency, depending on flows, use of lead nets, debris, etc. | • Loss of fish during higher flows, heavy debris load.<br>• Lost operational time during planned moves of the system as the pool elevation changes. | $3 to 10 million | $290,000 | • Minimal pumped flow from creek for truck filling station.<br>• Would not require release of stored water outside irrigation season. | • Similar to DN #4, with smaller facility.<br>• Staffing for operations at upper end of reservoir for daily maintenance and transport.<br>• Need to move facility more often as pool elevation varies. |
| **DN #6. Screw Traps near Mouth of Mill Creek and Ochoco Creek.** | • None to major facilities.<br>• Minor road access improvements to access site.<br>• Picket leads installed for collector box annually. | • Same as DN #5. | • Likely performance from 20% to >80% collection efficiency, depending on flows, use of lead nets, pickets, debris, etc.<br>• Likely better performance than DN #5 due to confined channels. | • Loss of fish during higher flows, heavy debris load.<br>• More dependent on daily or hourly monitoring to keep system functioning.<br>• Lost performance time to replace nets and pickets after high flow events. | $250,000<br>(doesn't include land or access easements) | $130,000 | • None; use existing natural flows from the creek. Would not require release of stored water outside irrigation season.<br>• Minimal portable pumped flow from creek for truck filling station. | • Annual setup and removal operations.<br>• Staffing for operations at upper end of reservoir for daily maintenance, repairs and transport.<br>• Likely monitoring and minor repairs, debris removal after high flow events.<br>• May need land purchase or access easements. |
| **DN #7. Tributary Collectors in Ochoco Creek and Mill Creek.** | • None to major facilities.<br>• Minor road access improvements to access site.<br>• Permanent concrete weir and/or picket leads installed for collector box annually. | • Same as DN #5. | • Same as DN #6, with better performance during a wider range of flows due to more permanent facilities and streambank shaping. | • Same as DN #6, with less risk and opportunity for fish loss.<br>• Faster to reset after high flows than DN #6. | $0.4 to $1 million | $130,000 | • Same as DN #6. | • Same as DN #6. |

Note: Fish marking program costs are not included in downstream alternatives, and needs to be addressed outside of this study depending on preference of upstream passage alternative.

# 7.0 Conclusions and Recommendations

Roughly 81 miles of stream habitat area are available for summer steelhead trout and spring Chinook salmon spawning and rearing upstream of Ochoco Reservoir. These habitats are of limited quality due to historical management practices that have altered riparian vegetation, degraded stream channels and diverted flows, but a number of recent and ongoing habitat improvement projects have reversed this trend. Most useable salmonid habitats are already occupied by resident rainbow trout, which could be expected to compete with reintroduced anadromous species. Nevertheless, passage of anadromous salmonid fishes above Ochoco Dam could make measurable contributions to the conservation and recovery of these species in the Deschutes Basin. Based on life history strategies and behavior characteristics, it is assumed steelhead trout would be more successful and productive in these habitats than Chinook salmon.

We have identified six alternative means of providing upstream passage at Ochoco Dam, and seven alternatives for downstream passage. All alternatives are conceptual in nature, and would require considerable technical and biological evaluation before they could be considered feasible. The preliminary evaluations provided here are based on a cursory understanding of the structure and operation of Ochoco Dam, and professional experience designing and constructing fish passage facilities at similar dams in the Pacific Northwest.

The 13 fish passage alternatives vary widely in terms of technical complexity, cost, and effectiveness. The primary constraints, particularly with regard to volitional passage in both directions, are the height of the dam, the wide seasonal fluctuations in reservoir elevation, and the limited availability of flow to attract and convey fish. As a condition of its current contract with Reclamation, OID is unable to release stored irrigation water from Ochoco Reservoir for any purpose other than irrigation or flood control. The operating regime of the dam and reservoir would result in conveyance flows during the irrigation season, but flows outside the irrigation season would be quite limited. Alternatives involving trap and haul would avoid some of these constraints, but they would have higher O&M costs, involve additional handling of fish. Some alternatives would also require the cooperation of third-party landowners, utilities, tribes, and irrigators.

It is anticipated the DBHCP applicants, in coordination with the Working Group, will use the information provided in this report to determine whether to include fish passage at Ochoco Dam as a conservation measure in the DBHCP. This decision will be based on a number of factors, including the costs of constructing and operating fish passage facilities relative to the financial resources of the applicants, the feasibility of providing passage without materially reducing the ability of OID to conduct the covered activities, and the effectiveness of fish passage at minimizing and mitigating the impacts of the covered activities on the covered species. Another important consideration will be the implication to landowners and irrigators above of Ochoco Dam of allowing listed or potentially-listed fish to access their properties.

# 8.0 References


Ackerman, N. K., C. Justice, and S. Cramer. 2007. Juvenile steelhead carrying capacity of the upper Deschutes Basin 2007 update. Report prepared by Cramer Fish Sciences for Portland General Electric Company, Portland, Oregon.

Courter, I. 2011. Utility of the Crooked River Steelhead Life-Cycle Model for predicting probability of successful steelhead reintroduction. Technical Memorandum to Julie Keil, Portland General Electric, Portland, OR by Ian Courter, Cramer Fish Sciences, Gresham, OR. January 28, 2011. 19p.

Cramer, S. P. and R. C. Beamesderfer. 2006. Population dynamics, habitat capacity and life history simulation model for steelhead in the Deschutes River, Oregon. Report prepared for Portland General Electric Company. Portland, OR. 83p. + app. March.

E.G. Solutions, Inc. 2013. Screw Trap Price List. http://www.screwtraps.com. E.G. Solutions, Corvallis, OR.

Frey. 1942. Summary of field notes as cited in Nehlsen (1995)

Lindsay R.B., B.C. Jonasson, R.K. Schroeder, and B.C. Cates. 1989. Spring Chinook salmon in the Deschutes River, Oregon. Information Reports No. 89-4. Oregon Department of Fish and Wildlife. 92 p.

Marx, S. 2003. Anadromous fish and bull trout management in the Upper Deschutes, Crooked, and Metolius River Subbasins. Oregon Department of Fish & Wildlife. Salem, Oregon.

National Marine Fisheries Service (NMFS). 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region. Information available on line at: http://www.nwr.noaa.gov. July 2011.

Nehlsen, W. 1995. Historical salmon and steelhead runs of the Upper Deschutes River and their environments. Report to Portland General Electric Company, Portland, OR.

Northwest Power and Conservation Council (NPCC). 2004. Final Deschutes Subbasin Plan. The Deschutes Coordinating Group (DCG), Northwest Power and Conservation Council, Portland OR. 668 p. May.

Oregon Department of Environmental Quality (ODEQ). 2002. State of Oregon 303(d) list for water quality limited streams.

Oregon Department of Environmental Quality (ODEQ). 2012. LASAR database retrieval. Information available on line at: http://deq12.deq.state.or.us/lasar2/SearchLasar.aspx?page=1&dt=0. Last accessed September 12, 2012.

Oregon State Game Commission (OSGC). 1950 - 1959. Fishery Management District Annual Reports between 1950-1959. Central Region, Bend, OR as cited in Marx (2003).

Oregon Water Resources Board (OWRB). 2012. Statistical summaries of streamflow. Information available on line at: http://apps.wrd.state.or.us/apps/sw/hydro_report/ Salem, Oregon.

Portland General Electric (PGE). 2012. Adult fish counts at the Pelton Reregulating Dam trap and sorting facility. Information available on line at: http://www.portlandgeneral.com/community_environment/initiatives/protecting_fish/deschutes_river/daily_fish_counts.aspx. Last accessed September 2012.

Quesada, C., M. Bennett, and M. Hill. 2012. Native Fish Monitoring: Biological Component. 2011 Annual Report and 2012 Work Plan. Portland General Electric. Portland, Oregon.

Senn, H., Mack, J. and L. Rothfus. 1984. Compendium of Low-cost Pacific Salmon and Steelhead Trout Production Facilities and Practices in the Pacific Northwest. Project No. 83-353. Prepared for Bonneville Power Administration, Portland, Oregon.

Spateholts, B. 2012. Pelton Round Butte Project (FERC 2030) Native Fish Monitoring Plan (Habitat Component) License Article 421: 2011 Annual Report and 2012 Work Plan. Portland General Electric Company. Portland, Oregon.

Stuart, A.M., D. Grover, and S. Thiesfeld. 1996. Redband trout investigations in the Crooked River Basin. Oregon Department of Fish and Wildlife.

Stuart, A.M., D. Grover, T.K. Nelson, and S.L. Thiesfeld. 2007. Redband trout investigations in the Crooked River Basin *in*: Schroeder and Hall (eds.) (2007) Redband Trout: Resilience and Challenge in a Changing Landscape. Oregon Chapter, American Fisheries Society.

U.S. Geological Survey (USGS). 2012. Surface water daily data for Oregon. Statistical summaries of streamflow. Information available on line at: http://nwis.waterdata.usgs.gov/or/nwis/dv?referred_module=sw&site_tp_cd=OC&site_tp_cd=OC-CO&site_tp_cd=ES&site_tp_cd=LK&site_tp_cd=ST&site_tp_cd=ST-CA&site_tp_cd=ST-DCH&site_tp_cd=ST-TS&format=station_list&sort_key=site_no&group_key= NONE&range_selection=days&period=365&date_format=YYYY-MM DD&rdb_compression= file&list_of_search_criteria=site_tp_cd%2Crealtime_parameter_selection. Last accessed September 2012.

Walter, P. 2000. Channel habitat type, riparian and channel condition assessment for Ochoco, Mill, McKay, and Marks creeks, Crooked River Basin, Oregon Master's Thesis. Department of Planning, Public Policy, and Management. University of Oregon: Eugene, Oregon.

Watershed Sciences, Inc. 2006. Airborne thermal infrared remote sensing, Crooked River, OR. Prepared for Oregon Department of Environmental Quality, Portland, OR.

Whitman, T. 2002. Crooked River Watershed Assessment. Crooked River Watershed Council, Prineville, OR. July 2002, 155 p + app.

# Appendix A

# Potential Habitat Length and Surface Area of Mainstem and Tributary Streams Available to Anadromous Fish Species in the Upper Ochoco Creek Basin

# Appendix A-1
# Summer Steelhead Trout

**Table A-1. Total Available Habitat Estimate for Summer Steelhead upstream of Ochoco Reservoir.**

| Basin | Length RM | Area Wet | Area Dry | Units |
|---|---|---|---|---|
| Ochoco Creek | 41.0 | 324,449 | 168,132 | $m^2$ |
| Marks Creek | 16.0 | 168,889 | 95,202 | $m^2$ |
| Mill Creek | 23.5 | 214,498 | 114,071 | $m^2$ |
| | | | | |
| Total | 81 | 707,836 | 377,406 | $m^2$ |
| | | 175 | 93 | acres |

## Table A-2. Total Available Habitat Estimate for Summer Steelhead upstream of Ochoco Reservoir.

**Ochoco Creek Basin**

| | RM | BFW | WW | Q | Sub | Riparian | Comments | Location | Width BFW | Width WW | Area BFW | Area WW | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ochoco Creek Mainstem** | | | | | | Willow present in Ochoco but more sporadic and open then in Mill and Marks creeks | | | | | | | |
| | | | | | | | No obvious obstructions to passage | **0 - 6 miles** | 20.7 | 5.4 | 654,720 | 171,977 | |
| USGS Site | 1.5 | | | | | | Upstream from Keystone Ranch diversion | **6 - 10 miles** | 19.2 | 5.3 | 405,504 | 111,936 | |
| Old Wolf Cr. Road off Rhoeden Property | 3.0 | | | | | | Large 10' x 40' corregated culvert under crossing; perched 1' or so above d/s pool | **More then 10 mi** | 5.5 | 4.0 | 290,400 | 211,200 | |
| upstream | | 28 | 6 | 0.5 | | | Cattle damaged creekbed; no riparian enclosures | | | | | | |
| downstream | | 18 | 8 | 0.5 | | | Wide pool downstream; looks like sudden expansion; difficult passage but not impossible; some work needed | | | | | | |
| Duncan Cr. Rd Crossing | 3.5 | | | | | | | | | | | | |
| upstream | | 17 | 8 | 0.5 | | | | | | | | | |
| downstream | | 15 | 6 | | | | | | | | | | |
| Other | | | 10 | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Hwy Crossing of Ochoco Cr. | 5.0 | | | | | | 8' High Bottomless Arch - Passable | | | | | | |
| upstream | | 21 | 0 | 0 | | | No flow | | | | | | |
| downstream | | 25 | 0 | 0 | | | | | | | | | |
| D/S of Walton and U/S of HDQrs | 10.0 | | | | | | Offroad campsite; site of lod debris flow channel now trying to find a way through the bulge; multiple distributory channels | | | | | | |
| upstream | | 5 | 3 | 0.5 | C, G, S | Alder, Willow | | | | | | | |
| downstream | | 6 | 5 | | | | | | | | | | |
| **Available Conditions** | **20.0** | **17** | **5** | **0.33** | | | | | **Width BFW** | **Width WW** | **Area BFW** | **Area WW** | |
| Lawson Cr | 4.0 | | | | | | No obvious obstructions to passage | **6 - 12 miles** | 24.9 | 15.1 | 525653 | 318912 | |
| Veazie Cr. | 4.0 | | | | | | No obvious obstructions to passage | **6 - 12 miles** | 24.9 | 15.1 | 525653 | 318912 | |
| Wolf Cr. | 5.2 | | | | | | | **6 - 12 miles** | 24.9 | 15.1 | 683349 | 414586 | |
| Boardtree Cr. | 1.0 | | | | | | | **> 12 miles** | 9.0 | 6.0 | 47520 | 31680 | |
| Sheep Cr. | 1.0 | | | | | | | **> 12 miles** | 9.0 | 6.0 | 47520 | 31680 | |
| **Available Conditions** | **15.2** | | | | | | | **Total Surface Area** | | | 3,180,320 | 1,610,883 | $ft^2$ |
| | | | | | | | | | Smolts | | 14,772 | 7,482 | fish |
| **Duncan Cr.** | | | | | | | | | | | | | |
| Confluence | 0.0 | 6 | 3 | 0.1 | | | Trickle; not much of any Habitat; channel is incised into pastureland; rated as not steelhead habitat | | | | | | |
| **Canyon Cr** | | | | | | | In National Forest Land; Reference Stream | | | | | | |
| 1 mi. U/S on HWY 42 | 1.0 | 12 | 6 | 0.1 | B, C | Overgrown willows; 100% cover but not choaked | Turnout; little to no flow; 3" salmonids in stagnant water | Canyon Creek | **Width BFW** | **Width WW** | **Area BFW** | **Area WW** | |
| further upstream | 2.4 | 7 | | 0 | | | Dry channel; entrenched through | | | | | | |

| Marks Creek Basin | RM | BFW | WW | Q | Sub | Riparian | Comments |
|---|---|---|---|---|---|---|---|
| **Marks Creek** | | | | | | | |
| Hwy 26 Crossing at Mouth | 0.1 | 12 | 10 | 3 | | Solid | Continuous CRWC TempMentor Site |
| Lesser's Property - CREP Project | 3.0 | | | 1 | | | Approx 1 mile of active stream Restoration - recharged groundwater |
| | | 35 | 3 | | | | Sculpted restoration varies between constrictions - widening into pools |
| | | 40 | 30 | | | | Meanders introduced - side channel development |
| | | 25 | 8 | | | Willows coming back in | |
| | | 25 | 8 | | | | |
| | | 35 | 6 | | | | |
| | | 25 | 7 | 2 | | | |
| Restoration Site-CRWC | 4.0 | 15 | 10 | | B,C,S | | Groundwater table connection downtream; upstream dry; very cool waters |
| Meadow Section | 4-6 | | | 0 | | | Dry for extensive section upstream |
| New Bridge Crossing | 8.0 | 16 | 14 | 1 | Fines | | upstream pooled; rocks piled up under bridge to make a backwater |
| ODOT Bdg Crossing; Hwy 41 MP 39.08; | 10.0 | 30 | 18 | 1 | | | |
| upstream | | 25 | 14 | 2 | | | |
| downstream | | 30 | 15 | | | | Beaver Dam downstream backs up water below crossing; Deep hole w/ RBT - 4.5' deep. |
| ODOT Bdg Crossing; Hwy 41 MP 39.43 | 10.5 | 30 | 18 | 1 | | | |
| downstream | | 25 | 14 | 1 | | Good riparian on FS Land; including grazing allotments | |
| FS Rd 2610; Reference Reach; u/s | 11.0 | 30 | 18 | 2 | | | Major pool 5' deep; silted in |
| downstream | | 20 | 10 | 2 | | | Outside exposed banks sloughing downstream of grazing enclosures |
| range 5-30' | | | 18 | | | | Major riparian changes with grazing enclosures |
| 4 mile downstream of Dam; | 12.0 | | | | | | Narrow constriction through bedrock; potential barrier location but none observed; further assessment would be warranted |
| range 15-20' | | 18 | 12 | 2.5 | | | Pinched Channel constrained; but about the same channel width; unstable south bank - bedrock north bank; plenty of sediment eroding into channel. |
| Downstream of Dam | 15.8 | 10 | 6 | 0.3 | | Choaked | No real STLH use anticipated at this location |
| | | | | | | | |
| Earthfilled Dam ~ 25' high with ~ 16" outfall | 16.0 | | | | | | |
| FS Rd 2620 Crossing; u/s | 16.2 | | | | | | Upstream of Lake; and Mt Bachleor Academy |
| upstream | | 8 | 6 | 0.05 | | | |
| | | | | | | | |
| **Available Conditions** | **15.0** | **24** | **12** | **1.35** | | | |
| | | | | | | | |
| **Salmon Cr.** | **1.0** | | | | | | |
| | | | | | | | |
| **Wildcat Cr.** | | | | | | Choaked | Small; some water but no real stealhead habitat; concrete boxed culvert 60' across Hwy 126 |
| upstream | | 6 | 3 | 0.00 | | | No depth of the water to speak of; stagnant upstream; rated as not steelhead habitat |
| downstream | | 6 | 1 | 0.10 | | | |
| | | | | | | | |
| **Cornez Cr.** | | | | | | | Double culvert @ Cornez crossing; Barrier - no steelhead habitat |

| Marks Creek | Width | | Area | |
|---|---|---|---|---|
| | BFW | WW | BFW | WW |
| **0 - 6 miles** | 26.5 | 10.3 | 839520 | 324720 |
| **6 - 12 miles** | 24.9 | 15.1 | 788480 | 478368 |
| **> 12 miles** | 9.0 | 6.0 | 142560 | 190080 |
| **> 12 miles** | 9.0 | 6.0 | 47520 | 31680 |

**Legend:**

| | |
|---|---|
| RM = | River Mile |
| BFW = | Bankfull channel width (Active Channel Width) in feet |
| WW = | Wetted width in feet |
| Q = | Stream Discharge, cfs |
| Sub = | Substratum |
| Riparian = | Streamside vegetation compositon/characteristics |
| B = | Boulder |
| C = | Cobble |
| L-C = | Large Cobble |
| G = | Gravel |
| S = | Sand |

**MARKS CREEK**

| | | | | |
|---|---|---|---|---|
| **Total Stream Miles Available to Summer Steelhead** | | | **16.0** | **mi** |
| **Total Surface Area** | | **1,818,080** | **1,024,848** | **$ft^2$** |
| | | **168,889** | **95,202** | **$m^2$** |
| **Fish Density** | **$Parr/m^2$** | **0.25** | **0.25** | **$f/m^2$** |
| | **Parr** | **42,222** | **23,801** | **fish** |
| | **Smolts** | **21,111** | **11,900** | **fish** |

| Mill Creek Basin | RM Avail. | BFW | WW | Q | Sub | Riparian | Comments | | Width BFW | Width WW | Area BFW | Area WW | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Senior water right at the lower end so at least the lowest reach get water. | | | | | | |
| Mill Creek | 6.0 | | | | | Plenty of riparian, wetland, and | Partial barrier on Lower Mill Creek, passable to STH | 0 - 6 miles | 26.5 | 10.3 | 839520 | 324720 | |
| Mill Creek | 5.4 | | | | | stream-bed restoration occurring | Cattle fencing from Res. To USFS boundary | 6 - 12 miles | 24.9 | 15.1 | 709632 | 430531.2 | |
| | | | | | | | 96 and '98 flood damage; new meander belt | | | | | | |
| Evans Creek | 1.4 | | | | | | | > 12 miles | 9.0 | 6.0 | 66528 | 44352 | |
| Lemon Creek | 0.5 | | | | | | | > 12 miles | 9.0 | 6.0 | 23760 | 15840 | |
| WF Mill Creek | 2.6 | | | | | | | 6 - 12 miles | 24.9 | 15.1 | 341675 | 207293 | |
| EF Mill Creek | 1.7 | | | | | | | 6 - 12 miles | 24.9 | 15.1 | 223403 | 135538 | |
| EF Mill Creek | 2.2 | | | | | | | > 12 miles | 9.0 | 6.0 | 104544 | 69696 | |
| **Available Conditions** | **19.8** | | | | | | | Total Surface Area | | | 2,309,061 | 1,227,970 | $ft^2$ |
| | | | | | | | | | | | 214,498 | 114,071 | $m^2$ |
| | | | | | | | | Fish Density | Parr/m2 | | 0.25 | 0.25 | $f/m^2$ |
| | | | | | | | | | Parr | | 53,624 | 28,518 | fish |
| | | | | | | | | | Smolts | | 26,812 | 14,259 | fish |
| Polly Creek Basin | | | | | | | | | | | | | |
| Polly Creek | **3.7** | | | | | | | > 12 miles | 9.0 | 6.0 | 175824 | 117216 | |

**Legend:**

RM = River Mile
BFW = Bankfull channel width (Active Channel Width) in feet
WW = Wetted width in feet
Q = Stream Discharge, cfs
Sub = Substratum
Riparian = Streamside vegetation compositon/characteristics
B = Boulder
C = Cobble
L-C = Large Cobble
G = Gravel
S = Sand

**MILL CREEK**

| | | | | | |
|---|---|---|---|---|---|
| **Total Stream Miles Available to Summer Steelhead** | | | | **23.5** | **mi** |
| **Total Surface Area** | | | **2,484,885** | **1,345,186** | **$ft^2$** |
| | | | **230,831** | **124,960** | **$m^2$** |
| **Fish Density** | **Parr/$m^2$** | | **0.25** | **0.25** | **$f/m^2$** |
| | **Parr** | | **57,708** | **31,240** | **fish** |
| | **Smolts** | | **28,854** | **15,620** | **fish** |

**Total Available Habitat for Summer Steelhead upstream of Ochoco Reservoir**

| Basin | Length RM | Area Wet | Area Dry | Units |
|---|---|---|---|---|
| **Ochoco Creek** | **41.0** | **324,449** | **168,132** | **$m^2$** |
| **Marks Creek** | **16.0** | **168,889** | **95,202** | **$m^2$** |
| **Mill Creek** | **23.5** | **214,498** | **114,071** | **$m^2$** |
| **Total** | **81** | **707,836** | **377,406** | **$m^2$** |
| | | **175** | **93** | **acres** |

# Appendix A-2
# Spring Chinook Salmon

**Table A-2. Total Available Habitat Estimate for Summer Steelhead upstream of Ochoco Reservoir.**

| Basin | Length | Area | | |
|---|---|---|---|---|
| | RM | Wet | Dry | Units |
| Ochoco Creek | 14.3 | 150,981 | 58,221 | $m^2$ |
| Marks Creek | 12.0 | 151,231 | 74,602 | $m^2$ |
| Mill Creek | 13.4 | 168,322 | 84,971 | $m^2$ |
| | | | | |
| Total | 40 | 470,534 | 217,794 | $m^2$ |
| | | 116 | 54 | acres |

## Ochoco Creek Basin

| | RM | BFW | WW | Q | Sub | Riparian | Comments |
|---|---|---|---|---|---|---|---|
| **Ochoco Creek Mainstem** | | | | | | | Willow present in Ochoco but more sporadic and open then in Mill and Marks creeks |
| | | | | | | | No obvious obstructions to passage |
| USGS Site | 1.5 | | | | | | Upstream from Keystone Ranch diversion |
| Old Wolf Cr. Road off Rhoeden Property | 3.0 | | | | | | Large 10' x 40' corregated culvert under crossing; perched 1' or so above d/s pool |
| upstream | | 28 | 6 | 0.5 | | | Cattle damaged creekbed; no riparian enclosures |
| downstream | | 18 | 8 | 0.5 | | | Wide pool downstream; looks like sudden expansion; difficult passage but not impossible; some work needed |
| Duncan Cr. Rd Crossing | 3.5 | | | | | | |
| upstream | | 17 | 8 | 0.5 | | | |
| downstream | | 15 | 6 | | | | |
| Other | | | 10 | | | | |
| | | | | | | | |
| Hwy Crossing of Ochoco Cr. | 5.0 | | | | | | 8' High Bottomless Arch - Passable |
| upstream | | 21 | 0 | 0 | | | No flow |
| downstream | | 25 | 0 | 0 | | | |
| D/S of Walton and U/S of HDQrs | 10.0 | | | | | | Offroad campsite; site of lod debris flow channel now trying to find a way through the bulge; multiple distributory channels |
| upstream | | 5 | 3 | 0.5 | C, G, S | Alder, Willow | |
| downstream | | 6 | 5 | | | | |
| **Available Conditions** | **10.0** | **17** | **5** | **0.33** | | | |

| Channel Location | Width BFW | Width WW | Area BFW | Area WW |
|---|---|---|---|---|
| **0 - 6 miles** | 20.7 | 5.4 | 654,720 | 171,977 |
| **6 - 10 miles** | 19.2 | 5.3 | 405,504 | 111,936 |
| **More then 10 mi** | | | | |

| | RM | | | | | | |
|---|---|---|---|---|---|---|---|
| Lawson Cr | 1.0 | | | | | | No obvious obstructions to passage |
| | | | | | | | |
| Veazie Cr. | 1.0 | | | | | | No obvious obstructions to passage |
| | | | | | | | |
| Wolf Cr. | 2.3 | | | | | | |
| | | | | | | | |
| Boardtree Cr. | 0.0 | | | | | | |
| | | | | | | | |
| Sheep Cr. | 0.0 | | | | | | |
| **Available Conditions** | **4.3** | | | | | | |

| Channel Location | Width BFW | Width WW | Area BFW | Area WW | |
|---|---|---|---|---|---|
| **6 - 12 miles** | 24.9 | 15.1 | 131413 | 79728 | |
| **6 - 12 miles** | 24.9 | 15.1 | 131413 | 79728 | |
| **6 - 12 miles** | 24.9 | 15.1 | 302251 | 183374 | |
| **> 12 miles** | 9.0 | 6.0 | 0 | 0 | |
| **> 12 miles** | 9.0 | 6.0 | 0 | 0 | |
| **Total Surface Area** | | | 1,625,301 | 626,744 | $ft^2$ |
| | | | 150,981 | 58,221 | $m^2$ |
| **Fish Density** | $Parr/m^2$ | | 0.04 | 0.08 | $f/m^2$ |
| | Parr | | 6,039 | 4,658 | fish |
| | Smolts | | 2,114 | 1,630 | fish |

| | RM | BFW | WW | Q | Sub | Riparian | Comments |
|---|---|---|---|---|---|---|---|
| **Duncan Cr.** | | | | | | | |
| Confluence | 0.0 | 6 | 3 | 0.1 | | | Trickle; not much of any Habitat; channel is incised into pastureland; rated as not steelhead habitat |
| **Canyon Cr** | | | | | | | In National Forest Land; Reference Stream |
| 1 mi. U/S on HWY 42 | 0.0 | 12 | 6 | 0.1 | B, C | Overgrown | Turnout; little to no flow; 3" salmonids in stagnant water |
| further upstream | 0.0 | 7 | | 0 | | | Dry channel; entrenched through |
| Spur Rd Crossing - nr dispersed Campgr. | 0.0 | | | | | | |
| upstream | | 10 | 2 | 0 | | | Standing water; |
| downstream | | 10 | 6 | 0 | B,C,G, S | Alder, Pine | |
| User Dammed water | | 12 | 12 | 0 | | | Backs up watering Hole - Standing water; 6 - 8" deep |
| **Available Conditions** | **0** | **10** | **7** | **0.02** | | | |

| Canyon Creek | Width BFW | Width WW | Area BFW | Area WW | |
|---|---|---|---|---|---|
| **0 - 6 miles** | 10.2 | 6.5 | - | - | |
| | | | - | - | |
| | | | - | - | |
| **Total Surface Area** | | | - | - | $ft^2$ |
| | | | - | - | $m^2$ |
| **Fish Density** | $Parr/m^2$ | | | | $f/m^2$ |
| | Parr | | - | - | fish |
| | Smolts | | - | - | fish |

| | RM | BFW | WW | Q | Sub | Riparian | Comments |
|---|---|---|---|---|---|---|---|
| **Cady Creek** | | | | | | | |
| Stanley Lake | | | | | | | Nice reservoir - behind earthenfilled dam; maybe 60' sloped embankment height |
| Outlet | | | | | B, L-C | Pine-filled | Narrow canyon - tightly confined due to shading can't make out channel features; rated as not steelhead habitat |

**Legend:** RM = River Mile

BFW = Bankfull channel width (Active Channel Width) in feet

| Marks Creek Basin | RM | BFW | WW | Q | Sub | Riparian | Comments | Marks Creek | Width | | Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Marks Creek** | | | | | | | | | BFW | WW | BFW | WW |
| Hwy 26 Crossing at Mouth | 0.1 | 12 | 10 | 3 | | Solid | Continuous CRWC TempMentor Site | **0 - 6 miles** | 26.5 | 10.3 | 839520 | 324720 |
| Lesser's Property - CREP Project | 3.0 | | | 1 | | | Approx 1 mile of active stream Restoration - recharged groundwater | **6 - 12 miles** | 24.9 | 15.1 | 788480 | 478368 |
| | | 35 | 3 | | | | Sculpted restoration varies between constrictions - widening into pools | **> 12 miles** | | | | |
| | | 40 | 30 | | | | Meanders introduced - side channel development | | | | | |
| | | 25 | 8 | | | Willows coming back in | | | | | | |
| | | 25 | 8 | | | | | | | | | |
| | | 35 | 6 | | | | | | | | | |
| | | 25 | 7 | 2 | | | | | | | | |
| Restoration Site-CRWC | 4.0 | 15 | 10 | | B,C,S | | Groundwater table connection downtream; upstream dry; very cool waters | | | | | |
| Meadow Section | 4-6 | | | 0 | | | Dry for extensive section upstream | | | | | |
| New Bridge Crossing | 8.0 | 16 | 14 | 1 | Fines | | upstream pooled; rocks piled up under bridge to make a backwater | | | | | |
| ODOT Bdg Crossing; Hwy 41 MP 39.08; | 10.0 | 30 | 18 | 1 | | | | | | | | |
| upstream | | 25 | 14 | 2 | | | | | | | | |
| downstream | | 30 | 15 | | | | Beaver Dam downstream backs up water below crossing; Deep hole w/ RBT - 4.5' deep. | | | | | |
| ODOT Bdg Crossing; Hwy 41 MP 39.43 | 10.5 | 30 | 18 | 1 | | | | | | | | |
| downstream | | 25 | 14 | 1 | | Good riparian on FS Land; including grazing allotments | | | | | | |
| FS Rd 2610; Reference Reach; u/s | 11.0 | 30 | 18 | 2 | | | Major pool 5' deep; silted in | | | | | |
| downstream | | 20 | 10 | 2 | | | Outside exposed banks sloughing downstream of grazing enclosures | | | | | |
| range 5-30' | | | 18 | | | | Major riparian changes with grazing enclosures | | | | | |
| 4 mile downstream of Dam; | 12.0 | | | | | | Narrow constriction through bedrock; potential barrier location but none observed; further assessment would be warranted | | | | | |
| range 15-20' | | 18 | 12 | 2.5 | | | Pinched Channel constrained; but about the same channel width; unstable south bank - bedrock north bank; plenty of sediment eroding into channel. | | | | | |
| Downstream of Dam | 15.8 | 10 | 6 | 0.3 | | Choaked | No real STLH use anticipated at this location | | | | | |
| | | | | | | | | | | | | |
| Earthfilled Dam ~ 25' high with ~ 16" outfall | 16.0 | | | | | | | | | | | |
| FS Rd 2620 Crossing; u/s | 16.2 | | | | | | Upstream of Lake; and Mt Bachleor Academy | | | | | |
| upstream | | 8 | 6 | 0.05 | | | | | | | | |
| | | | | | | | | | | | | |
| **Available Conditions** | **12.0** | **24** | **12** | **1.35** | | | | | | | | |
| | | | | | | | | | | | | |
| **Salmon Cr.** | **0.0** | | | | | | | **> 12 miles** | 9.0 | 6.0 | 0 | 0 |
| | | | | | | | | | | | | |
| **Wildcat Cr.** | | | | | | Choaked | Small; some water but no real stealhead habitat; concrete boxed culvert 60' across Hwy 126 | | | | | |
| upstream | 0.0 | 6 | 3 | 0.00 | | | No depth of the water to speak of; stagnant upstream; rated as not steelhead habitat | | | | | |
| downstream | | 6 | 1 | 0.10 | | | | | | | | |
| | | | | | | | | | | | | |
| **Cornez Cr.** | 0.0 | | | | | | Double culvert @ Cornez crossing; Barrier - no steelhead habitat | | | | | |

**Legend:**

| | |
|---|---|
| RM = | River Mile |
| BFW = | Bankfull channel width (Active Channel Width) in feet |
| WW = | Wetted width in feet |
| Q = | Stream Discharge, cfs |
| Sub = | Substratum |
| Riparian = | Streamside vegetation compositon/characteristics |
| B = | Boulder |
| C = | Cobble |
| L-C = | Large Cobble |
| G = | Gravel |
| S = | Sand |

**MARKS CREEK**

| | | | | | |
|---|---|---|---|---|---|
| **Total Stream Miles Available to Summer Steelhead** | | | | **12.0** | **mi** |
| **Total Surface Area** | | **1,628,000** | **803,088** | **$ft^2$** | |
| | | **151,231** | **74,602** | **$m^2$** | |
| **Fish Density** | **$Parr/m^2$** | **0.04** | **0.08** | **$f/m^2$** | |
| | **Parr** | **6,049** | **5,968** | **fish** | |
| | **Smolts** | **2,117** | **2,089** | **fish** | |

| Mill Creek Basin | RM Avail. | BFW | WW | Q | Sub | Riparian | Comments | | Width BFW | Width WW | Area BFW | Area WW | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Senior water right at the lower end so at least the lowest reach get water. | | | | | | |
| Mill Creek | 6.0 | | | | | Plenty of riparian, wetland, and | Partial barrier on Lower Mill Creek, passable to STH | 0 - 6 miles | 26.5 | 10.3 | 839520 | 324720 | |
| Mill Creek | 5.4 | | | | | stream-bed restoration occurring | Cattle fencing from Res. To USFS boundary | 6 - 12 miles | 24.9 | 15.1 | 709632 | 430531.2 | |
| | | | | | | | 96 and '98 flood damage; new meander belt | | | | | | |
| Evans Creek | 0.0 | | | | | | | > 12 miles | 9.0 | 6.0 | 0 | 0 | |
| Lemon Creek | 0.0 | | | | | | | > 12 miles | 9.0 | 6.0 | 0 | 0 | |
| WF Mill Creek | 1.0 | | | | | | | 6 - 12 miles | 24.9 | 15.1 | 131413 | 79728 | |
| EF Mill Creek | 1.0 | | | | | | | 6 - 12 miles | 24.9 | 15.1 | 131413 | 79728 | |
| EF Mill Creek | 0.0 | | | | | | | > 12 miles | 9.0 | 6.0 | 0 | 0 | |
| **Available Conditions** | **13.4** | | | | | | | Total Surface Area | | | 1,811,979 | 914,707 | $ft^2$ |
| | | | | | | | | | | | 168,322 | 84,971 | $m^2$ |
| | | | | | | | | Fish Density | Parr/m2 | | 0.04 | 0.08 | $f/m^2$ |
| | | | | | | | | | Parr | | 6,733 | 6,798 | fish |
| | | | | | | | | | Smolts | | 2,357 | 2,379 | fish |
| Polly Creek Basin | | | | | | | | | | | | | |
| Polly Creek | **0.0** | | | | | | | > 12 miles | 9.0 | 6.0 | 0 | 0 | |

**Legend:**

RM = River Mile
BFW = Bankfull channel width (Active Channel Width) in feet
WW = Wetted width in feet
Q = Stream Discharge, cfs
Sub = Substratum
Riparian = Streamside vegetation compositon/characteristics
B = Boulder
C = Cobble
L-C = Large Cobble
G = Gravel
S = Sand

**MILL CREEK**

| | | | | | |
|---|---|---|---|---|---|
| **Total Stream Miles Available to Summer Steelhead** | | | | **13.4** | **mi** |
| **Total Surface Area** | | | **1,811,979** | **914,707** | **$ft^2$** |
| | | | **168,322** | **84,971** | **$m^2$** |
| **Fish Density** | **Parr/$m^2$** | | **0.04** | **0.08** | **$f/m^2$** |
| | **Parr** | | **6,733** | **6,798** | **fish** |
| | **Smolts** | | **2,357** | **2,379** | **fish** |

**Total Available Habitat for Summer Steelhead upstream of Ochoco Reservoir**

| Basin | Length RM | Area Wet | Area Dry | Units |
|---|---|---|---|---|
| **Ochoco Creek** | **14.3** | **150,981** | **58,221** | **$m^2$** |
| **Marks Creek** | **12.0** | **151,231** | **74,602** | **$m^2$** |
| **Mill Creek** | **13.4** | **168,322** | **84,971** | **$m^2$** |
| **Total** | **40** | **470,534** | **217,794** | **$m^2$** |
| | | **116** | **54** | **acres** |